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CONDUCTED BY E. L. YOUMANS.

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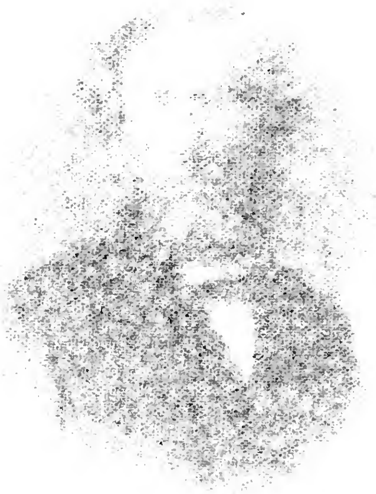

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THE STUDY OF SOCIOLOGY.

By HERBERT SPENCER.

V. *Objective Difficulties* (*continued*).

ANOTHER common cause of very serious perversion of evidence is the unconscious confounding of observation with inference. Everywhere, a fertile source of error is the putting down as something perceived what is really a conclusion drawn from something perceived; and this is a more than usually fertile source of error in Sociology. Here is an instance:

A few years ago Dr. Stark published the results of comparisons he had made between the rates of mortality among the married and among the celibate; showing, as it seemed, the greater healthfulness of married life. Some criticisms made upon his argument did not seriously shake it; and he has been since referred to as having conclusively proved the alleged relation. More recently I have seen quoted from the *Medical Press and Circular* the following summary of results supposed to tell the same tale:

"M. Bertillon has made a communication on this subject (the Influence of Marriage) to the Brussels Academy of Medicine, which has been published in the *Revue Scientifique*. From 25 to 30 years of age the mortality per 1,000 in France amounts to 6.2 in married men, 10.2 in bachelors, and 21.8 in widows. In Brussels the mortality of married women is 9 per 1,000, girls the same, and widows as high as 16.9. In Belgium, from 7 per 1,000 among married men, the number rises to 8.5 in bachelors and 24.6 in widows. The proportion is the same in Holland. From 8.2 in married men, it rises to 11.7 in bachelors, and 16.9 in widowers, or 12.8 among married women, 8.5 in spinsters, and 13.8 in widows. The result of all the calculations is that from 25 to 30 years of age the mortality per 1,000 is 4 in married men, 10.4 in bachelors, and 22 in widowers. This beneficial influence of marriage is manifested at all ages, being always more strongly marked in men than in women."

I will not dwell on the fallacy of the above conclusions as referring to the relative mortality of widows—a fallacy sufficiently obvious to any one who thinks awhile. I will confine myself to the less-conspicuous fallacy in the comparison between the mortalities of married and celibate, fallen into by M. Bertillon as well as Dr. Stark. Clearly as their figures seem to furnish proof of some direct causal relation between marriage and longevity, they really furnish no proof whatever. There may be such a relation; but the evidence assigned forms no warrant for inferring it.

We have but to consider a little the circumstances which in many cases determine marriage, and those which in other cases prevent marriage, to see that the connection which the figures apparently imply is not the real connection. Where attachments exist, what most frequently decides the question for or against marriage? The possession of adequate means. While some are so reckless as to marry without means, yet it is undeniable that in very many instances marriage is delayed by the man, or forbidden by the parents, or not assented to by the woman, until there is reasonable evidence of ability to meet the responsibilities. Of those men whose marriages depend on getting the needful income, which are the most likely to get the needful income? Those who are best, physically and mentally—the strong, the intellectually capable, the morally well-balanced. Often bodily vigor achieves a success, and therefore a revenue, which bodily weakness, unable to bear the stress of competition, cannot achieve. Often superior intelligence brings promotion and increase of salary, while stupidity lags behind in ill-paid posts. Often caution, self-control, and a far-seeing sacrifice of present to future, secure remunerative offices that are never given to the impulsive or the reckless. But, what are the effects of bodily vigor, of intelligence, of prudence, on longevity, when compared with the effects of feebleness, of stupidity, of deficient self-control? Obviously the first further the maintenance of life, and the second tend toward premature death. That is, the qualities which, on the average of cases, give a man an advantage in getting the means of marrying, are the qualities which make him likely to be a long liver; and conversely.

There is even a more direct relation of the same general nature. In all creatures of high type, it is only when individual growth and development are nearly complete that the production of new individuals becomes possible; and the power of producing and bringing up new individuals is measured by the amount of vital power in excess of that needful for self-maintenance. The reproductive instincts, and all their accompanying emotions, become dominant when the demands for individual evolution are diminishing, and there is arising a surplus of energy which makes possible the rearing of offspring as well as the preservation of self; and, speaking generally, these instincts and emotions are strong in proportion as this surplus vital energy is great.

But to have a large surplus of vital energy implies a good organization, which is on the average of cases likely to last long. So that, in fact, the superiority of *physique* which is accompanied by strength of the instincts and emotions causing marriage is a superiority of *physique* also conducive to longevity.

One further influence tells in the same direction. Marriage is not altogether determined by the desires of men; it is determined in part by the preferences of women. Other things equal, women are attracted toward men of power—physical, emotional, intellectual; and obviously their freedom of choice leads them in many cases to refuse inferior samples of men; especially the malformed, the diseased, and those who are ill-developed, physically and mentally. So that, in so far as marriage is determined by female selection, the average result on men is that, while the best easily get wives, a certain proportion of the worst are left without wives. This influence, therefore, joins in bringing into the ranks of married men those most likely to be long-lived, and keeping in bachelorhood those least likely to be long-lived.

In three ways, then, does that superiority of organization which conduces to long life also conduce to marriage. It is normally accompanied by a predominance of the instincts and emotions prompting marriage; there goes along with it that power which can secure the means of making marriage practicable; and it increases the probability of success in courtship. The figures given afford no proof that marriage and longevity are cause and consequence; but they simply verify the inference which might be drawn *a priori*, that marriage and longevity are concomitant results of the same cause.

This striking instance of the way in which inference may be mistaken for fact, will sufficiently serve as a warning against another of the dangers that await us in dealing with sociological data. Statistics having shown that married men live longer than single men, it seems an irresistible implication that married life is healthier than single life. And yet we see that the implication is not at all irresistible: though such a connection may exist, it is not demonstrated by the evidence assigned. Judge, then, how difficult it must be, among those social phenomena where the dependencies are more entangled, to distinguish between the seeming relations and the real relations.

Once more, we are ever liable to be led away by superficial, trivial facts, from those deep-seated and really important facts which they indicate. Always the small details of social life, the interesting events, the curious things which serve for gossip, will, if we allow them, hide from us the vital connections and the vital actions underneath. Every social phenomenon results from an immense aggregate of general and special causes; and we may either take the phenomenon itself as intrinsically momentous, or, along with other phenomena, may take it as indicating some inconspicuous truth of real significance. Let us contrast the two courses.

Some months ago a correspondent of the *Times*, writing from Calcutta, said:

"The Calcutta University examinations of any year would supply curious material for reflection on the value of our educational systems. The prose test in the entrance examination this year includes 'Ivanhoe.' Here are a few of the answers which I have picked up. The spelling is bad, but that I have not cared to give:

"Question: 'Dapper man?' (Answer 1.) 'Man of superfluous knowledge.' (A. 2.) 'Mad.' (Q.) 'Democrat?' (A. 1.) 'Petticoat Government.' (A. 2.) 'Witchcraft.' (A. 3.) 'Half turning of the horse.' (Q.) 'Babylonish jargon?' (A. 1.) 'A vessel made at Babylon.' (A. 2.) 'A kind of drink made at Jerusalem.' (A. 3.) 'A kind of coat worn by Babylonians.' (Q.) 'Lay brother?' (A. 1.) 'A bishop.' (A. 2.) 'A step-brother.' (A. 3.) 'A scholar of the same godfather.' (Q.) 'Sumpter-mule?' (A.) 'A stubborn Jew.' (Q.) 'Bilious-looking fellow?' (A. 1.) 'A man of strict character.' (A. 2.) 'A person having a nose like the bill of an eagle.' (Q.) 'Cloister?' (A.) 'A kind of shell.' (Q.) 'Tavern politicians?' (A. 1.) 'Politicians in charge of the alehouse.' (A. 2.) 'Mere vulgars.' (A. 3.) 'Managers of the priestly church.' (Q.) 'A pair of cast-off galligaskins?' (A.) 'Two gallons of wine.'"

The fact here drawn attention to as significant is, that these Hindoo youths, during their matriculation examination, betrayed so much ignorance of the meanings of words and expressions contained in an English work they had read. And the intended implication appears to be that they were proved unfit to begin their college careers. If, now, instead of accepting that which is presented to us, we look a little below it, that which may strike us as more noteworthy is the amazing folly of an examiner who proposes to test the fitness of youths for commencing their higher education, by seeing how much they know of the technical terms, cant-phrases, slang, and even extinct slang, talked by the people of another nation. Instead of the unfitness of the boys, which is pointed out to us, we may see rather the unfitness of those concerned in educating them.

If, again, not dwelling on the particular fact underlying the one offered to our notice, we consider it along with others of the same class, our attention is arrested by the general fact that examiners, and more especially those appointed under recent systems of administration, habitually put questions of which a large proportion are utterly inappropriate. As I learn from his son, one of our judges not long since found himself unable to answer an examination-paper that had been put before law-students. A well-known Greek scholar, editor of a Greek play, who was appointed examiner, found that the examination-paper set by his predecessor was too difficult for him. Mr. Froude, in his inaugural address at St. Andrews, describing a paper set by an examiner in English history, said, "I could myself have answered two questions out of a dozen. And I learn from Mr. G. H. Lewes that he could not give replies to the questions on English literature which the Civil Service examiners had put to his son. Joining which testimonies with kindred ones coming from students and professors on all sides, we find the really noteworthy thing to be that examiners are concerned not so much to set questions fit for students as to set questions which make manifest their own extensive learning. Especially if they are young, and have reputations to make or to justify, they seize the occasion for displaying their erudition, regardless of the interests of those they examine.

If we look through this more significant and general fact for the still deeper fact it grows out of, there rises before us the question—Who examines the examiners? How happens it that men, competent in their special knowledge but so incompetent in their general judgment, should occupy the places they do? This prevailing faultiness of the examiners shows conclusively that the administration is faulty at its centre. Somewhere or other, the power of ultimate decision is exercised by those who are unfit to exercise it. If the examiners of the examiners were set to fill up an examination-paper which had for its subject the right conduct of examinations, and the proper qualifications for examiners, there would come out very unsatisfactory answers.

Having seen through the small details and the wider facts down to these deeper facts, we may, on contemplating them, perceive that these, too, are not the deepest or most significant. It becomes clear that those having supreme authority suppose, as men in general do, that the sole essential thing for a teacher or examiner is complete knowledge of that which he has to teach, or respecting which he has to examine. Whereas a coessential thing is a knowledge of Psychology; and especially that part of Psychology which deals with the evolution of the faculties. Unless, either by special study or by daily observation and quick insight, he has gained an approximately-true conception of how minds perceive, and reflect, and generalize, and by what processes their ideas grow from concrete to abstract, and from simple to complex, no one is competent to give lessons that will effectually teach, or to ask questions which will effectually measure the efficiency of teaching. Further, it becomes manifest that, in common with the public at large, those in authority assume that the goodness of education is to be tested by the quantity of knowledge acquired. Whereas it is to be much more truly tested by the capacity for using knowledge—by the extent to which the knowledge gained has been turned into faculty, so as to be available both for the purposes of life and for the purposes of independent investigation. Though there is a growing consciousness that a mass of unorganized information is, after all, of but small value, and that there is more value in less information well organized, yet the noteworthy truth is that this consciousness has not got itself officially embodied; and that our educational administration is working, and will long continue to work, in pursuance of a crude and outworn belief.

As here, then, so in other cases meeting us in the present and all through the past, we have to contend with the difficulty that the greater part of the evidence supplied to us, as of chief interest and importance, is really of value only for what it indicates. We have to resist the temptation to dwell in those trivialities which make up nine-tenths of our records and histories; and which are worthy of attention solely because of the things they indirectly imply or the things tacitly asserted along with them.

Beyond those vitiations of evidence due to random observations, to the subjective states of the observers, to their enthusiasms, or prepossessions, or self-interests—beyond those that arise from the general tendency to set down as a fact observed what is really an inference from an observation, and also those that arise from the general tendency to omit the dissection by which small surface results are traced to large interior causes—there come those vitiations of evidence consequent on its distribution in Space. Of whatever class, political, moral, religious, commercial, etc., may be the phenomena we have to consider, a society presents them in so diffused and multitudinous a way, and under such various relations to us, that the conceptions we can frame are at best extremely inadequate.

Consider how impossible it is truly to conceive so relatively simple a thing as the territory which a society covers. Even by the aid of maps, geographical and geological, slowly elaborated by multitudes of surveyors—even by the aid of descriptions of towns, counties, mountainous and rural districts—even by the aid of such personal observations as we have made here and there in journeys during life; we can reach nothing approaching to a true idea of the actual varied surface —arable, grass-covered, wooded; flat, undulating, rocky; drained by rills, brooks, and slow rivers; sprinkled with cottages, farms, villas, cities. Imagination simply rambles hither and thither, and fails utterly to frame an adequate thought of the whole. How, then, shall we frame an adequate thought of a diffused moral feeling, of an intellectual state, of a commercial activity, pervading this territory; unaided by maps, and aided only by the careless statements of careless observers? Respecting most of the phenomena, considered as displayed by a whole nation, only the dimmest apprehensions are possible; and how untrustworthy they are, is shown by every parliamentary debate, by every day's newspapers, and by every evening's conversations; which severally disclose quite conflicting estimates.

See how various are the statements made respecting any nation in its character and actions by each traveller visiting it. There is a story, apt if not true, of a Frenchman who, having been three weeks here, proposed to write a book on England; who, after three months, found that he was not quite ready; and who, after three years, concluded that he knew nothing about it. And every one, who looks back and compares his early impressions respecting states of things in his own society with the impressions he now has, will see how erroneous were the beliefs once so decided, and how probable it is that even his revised beliefs are but very partially true. On remembering how wrong he was in his preconceptions of the people and the life in some unvisited part of the kingdom—on remembering how different, from those he had imagined, were the characters he actually found in certain alien classes and along with certain alien creeds—he will see how greatly this wide diffusion of social facts impedes true appreciation of them.

Moreover, there are illusions consequent on what we may call moral perspective, which we do not habitually correct in thought, as we correct in perception the illusions of physical perspective. A small object close to, occupies a larger visual area than a mountain afar off; but here our well-organized experiences enable us instantly to rectify a false inference suggested by the subtended angles. No such prompt rectification for the perspective is made in sociological observations. A small event next door, producing a larger impression than a great event in another country, is over-estimated. Conclusions, prematurely drawn from social experiences daily occurring around us, are difficult to displace by clear proofs that elsewhere wider social experiences point to quite opposite conclusions.

A further great difficulty to which we are thus introduced is, that the comparisons of experiences, by which alone we can finally establish relations of cause and effect among social phenomena, can rarely be made between cases in all respects fit for comparison. Every society differs specifically, if not generically, from every other. Hence it is a peculiarity of the Social Science that parallels drawn between different societies do not afford grounds for decided conclusions—will not, for instance, show us with certainty what is an essential phenomenon in a given society and what is a non-essential one. Biology deals with numerous individuals of a species, and with many species of a genus, and by comparing them can see what traits are specifically constant and what generically constant; and the like holds more or less with the other concrete sciences. But comparisons between societies, among which we may almost say that each individual is a species by itself, y eld much less definite results: the necessary characters are not thus readily distinguishable from the accidental characters.

So that, even supposing we have perfectly valid data for our sociological generalizations, there still lies before us the difficulty that these data are, in many cases, so multitudinous and diffused that we cannot adequately consolidate them into true conceptions; the additional difficulty, that the moral perspective under which they are presented can scarcely ever be so allowed for as to secure true ideas of proportions; and the further difficulty, that comparisons of our vague and incorrect conceptions concerning one society with our kindred conceptions concerning another society, have always to be taken with the qualification that the comparisons are only partially justifiable, because the compared things are only partially alike in their other traits.

An objective difficulty, even greater still, which the Social Science presents, arises from the distribution of its facts in Time. Those who look on a society as either supernaturally created or created by Acts of Parliament, and who consequently consider successive stages of its existence as having no necessary dependence on one another, will not be deterred from drawing political conclusions from passing facts, by a consciousness of the slow genesis of social phenomena. But those who have risen to the belief that societies are gradually evolved in structure and function, as in growth, will be made to hesitate on contemplating the long unfolding through which early causes work out late results.

Even true appreciation of the successive facts which an individual life presents, is very generally hindered by inability to grasp the long-drawn processes by which ultimate effects are produced; as we may see in the foolish mother who, yielding to her perverse child, gains the immediate benefit of peace, and cannot be made to realize the evil of chronic dissension which her policy will hereafter bring about. And in the life of a nation, which, if of high type, lasts at least a hundred individual lives, correct estimation of results is still more hindered by this immense duration of the processes through which antecedents bring their consequents. In judging of political good and evil, the average legislator thinks much after the manner of the mother dealing with the spoiled child: if a course is productive of immediate benefit, that is considered sufficient justification. Quite recently an inquiry has been made into the results of an administration which had been in action some five years only, with the tacit assumption that, supposing the results were proved good, the administration would be justified.

And yet to those who look into the records of the past not to revel in narratives of battles or to gloat over court-scandals, but to find how institutions and laws have arisen and how they have worked, there is no truth more obvious than that generation after generation must pass before you can see what is the outcome of an action that has been set up. Take the example furnished us by our Poor-Laws. When villeinage had passed away and serfs had no longer to be maintained by their owners—when, in the absence of any one to control and take care of serfs, there arose an increasing class of mendicants and "sturdy rogues, preferring robbery to labor"—when, in Richard the Second's time, authority over such was given to justices and sheriffs, out of which there presently grew the binding of servants, laborers, and beggars, to their respective localities—when, to meet the case of beggars, "impotent to serve," the people of the districts in which they were found were made in some measure responsible for them (so, re-introducing in a more general form the feudal arrangement of attachment to the soil, and reciprocal claim on the soil)—it was not suspected that the foundations were laid for a system which would, in after-times, bring about a demoralization threatening general ruin. When, in subsequent centuries, to meet the evils of again-increasing vagrancy which punishment failed to repress, these measures, reënacted with modifications, ended in making the people of each parish chargeable with the maintenance of their poor, while it reëstablished the severest penalties on vagabondage, even to death without benefit of clergy, no one ever anticipated that, while the penal elements of this legislation would by-and-by become so mollified as to have little practical effect in checking idleness, the accompanying arrangements would eventually take such forms as immensely to encourage idleness. Neither legislators nor others foresaw that in 230 years the poor's-rate, having grown to seven millions, would become a public spoil of which we read that—

> "The ignorant believed it an inexhaustible fund which belonged to them. To obtain their share the brutal bullied the administrators, the profligate exhibited their bastards which must be fed, the idle folded their arms and waited till they got it; ignorant boys and girls married upon it; poachers, thieves, and prostitutes, extorted it by intimidation; country justices lavished it for popularity, and guardians for convenience. . . . Better men sank down among the worse; the rate-paying cottager, after a vain struggle, went to the pay-table to seek relief; the modest girl might starve while her bolder neighbor received 1*s*. 6*d*. per week for every illegitimate child."

As sequences of the law of Elizabeth, no one imagined that, in rural districts, farmers, becoming chief administrators, would pay part of their men's wages out of the rates (so taxing the rest of the rate-payers for the cultivation of their fields); and that this abnormal relation of master and man would entail bad cultivation. No one imagined that, to escape poor's-rates, landlords would avoid building cottages, and would even clear cottages away; so causing overcrowding, with consequent evils, bodily and mental. No one imagined that workhouses, so called, would become places for idling in; and places where married couples, habitually residing, displayed their "elective affinities" time after time.[1] Yet these, and detrimental results which it would take pages to enumerate, culminating in that general result most detrimental of all—helping the worthless to multiply at the expense of the worthy—finally came out of these measures taken ages ago merely to mitigate certain immediate evils.

Is it not obvious, then, that only in the course of those long periods

[1] In one case, "out of thirty married couples, there was not one man then living with his own wife, and some of them had exchanged wives two or three times since their entrance." This, along with various kindred illustrations, will be found in tracts on the Poor-Law, by a late uncle of mine, the Rev. Thomas Spencer, of Hinton Charterhouse, who was chairman of the Bath Union during its first six years.

required to mould national characters and habits and sentiments, will the truly important results of a public policy show themselves? Let us consider the question a little further.

In a society living, growing, changing, every new factor becomes a permanent force; modifying more or less the direction of movement determined by the aggregate of forces. Never simple and direct, but, by the coöperation of so many causes, made irregular, involved, and always rhythmical, the course of social change can never be judged of in its general direction by inspecting any small portion of it. Each action will inevitably be followed, after a while, by some direct or indirect reaction, and this again by a re-reaction; and, until the successive effects have shown themselves, it is impossible to say how the total motion will be modified. You must compare positions at great distances from one another in time, before you can perceive rightly where things are tending. Even so simple a thing as a curve of single curvature cannot have its nature determined unless there is a considerable length of it. See here these four points close together. The curve passing through them may be a circle, an ellipse, a parabola, an hyperbola; or it may be a catenarian, a cycloid, a spiral. Let the points be farther apart, and it becomes possible to form some opinion of the nature of the curve—it is obviously not a circle. Let them be more remote still, and it may be seen that it is neither an ellipse nor a parabola. And, when the distances are relatively great, the mathematician can say with certainity what curve alone will pass through them all. Surely, then, in such complex and slowly-evolving movements as those of a nation's life, all the smaller and greater rhythms of which fall within certain general directions, it is impossible that such general directions can be traced by looking at stages that are close together—it is impossible that the effect wrought on any general direction, by some additional force, can be truly computed from observations extending over but a few years, or but a few generations.

For, in the case of these most-involved of all movements, there is the difficulty, paralleled in no other movements (being only approached in those of individual evolution), that each new factor, besides affecting in an immediate way the course of a movement, affects it also in a remote way by changing the amounts and directions of all other factors. A fresh influence brought into play on a society not only affects its members directly in their acts, but also indirectly in their characters. Continuing to work on their characters generation after generation, and modifying by inheritance the feelings which they bring into social life at large, this influence alters the intensities and bearings of all other influences throughout the society. By slowly initiating modifications of Nature, it brings into play forces of many kinds, incalculable in their strengths and tendencies, that act without regard to the original influence, and may produce quite opposite effects.

Fully to exhibit this objective difficulty, and to show more clearly still how important it is to take as our data for sociological conclusions, not the brief sequences, but the sequences that extend over centuries or are traceable throughout civilization, let us draw a lesson from a trait which all regulative agencies in all nations have displayed.

The original meaning of human sacrifices, which is otherwise tolerably clear, becomes quite clear on finding that where cannibalism is still rampant, and where the largest consumers of human flesh are the chiefs, these chiefs, undergoing apotheosis when they die, are believed thereafter to feed on the souls of the departed—the souls being regarded as duplicates equally material with the bodies they belong to. And, should any doubt remain, it must be dissipated by the accounts we have of the ancient Mexicans, whose priests, when war had not lately furnished a victim, complained to the king that the god was hungry; and who, when a victim was sacrificed, offered his heart to the idol (bathing its lips with his blood, and even putting portions of the heart into its mouth), and then cooked and ate the rest of the body themselves. Here the fact of significance to which attention is drawn, and which various civilizations show us, is that the sacrificing of prisoners or others, once a general usage among cannibal ancestry, continues as an ecclesiastical usage long after having died out in the ordinary life of a society. Two facts, closely allied with this fact, have like general implications. Cutting implements of stone remain in use for sacrificial purposes when implements of bronze, and even of iron, are used for all other purposes. Further, the primitive method of obtaining fire, by the friction of pieces of wood, survives in religious ceremonies ages after its abandonment in the household; and even now, among the Hindoos, the flame for the altar is kindled by the "fire-drill." These are striking instances of the pertinacity with which the oldest part of the regulative organization maintains its original traits in the teeth of influences that modify things around it.

The like holds in respect of the language, spoken and written, which it employs. Among the Egyptians the most ancient form of hieroglyphics was retained for sacred records, when more developed forms were adopted for other purposes. The continued use of Hebrew for religious services among the Jews, and the continued use of Latin for the Roman Catholic service, show us how strong this tendency is, apart from the particular creed. Among ourselves, too, a less dominant ecclesiasticism exhibits a kindred trait. The English of the Bible is of an older style than the English of the date at which the translation was made; and in the church service various words retain obsolete meanings, and others are pronounced in obsolete ways. Even the typography, with its illuminated letters of the rubric, shows traces of the same tendency; while Puseyites and ritualists, aiming to reënforce ecclesiasticism, betray a decided leaning toward archaic print, as well as archaic ornaments. In the æsthetic direction, indeed, their movement has brought back the most primitive type of sculpture for monumental purposes; as may be seen in Canterbury Cathedral, where, in two new monuments to ecclesiastics, one being Archbishop Sumner, the robed figures recline on their backs, with hands joined, after the manner of the mailed knights on early tombs—presenting complete symmetry of attitude, which is a distinctive trait of barbaric art, as every child's drawing of a man and every idol carved by a savage shows us.

A conscious as well as an unconscious adhesion to the old in usage and doctrine is shown. Not only among Roman Catholics, but among many Protestants, to ascertain what the Fathers said, is to ascertain what should be believed. In the pending controversy respecting the Athanasian Creed, we see how much authority attaches to an antique document. The antagonism between Convocation and the lay members of the Church—the one as a body wishing to retain the cursing clauses and the other to exclude them—further shows that official Protestantism adheres to antiquity much more than non-official Protestantism: a contrast equally displayed not long since between the opinions of the lay part and the clerical part of the Protestant Irish Church.

Throughout political organizations the like tendency, though less dominant, is very strong. The gradual establishment of law, by the consolidation of custom, is the formation of something fixed in the midst of things that are changing; and, regarded under its most general aspect as the agency which maintains a permanent order, it is in the very nature of a State-organization to be relatively rigid. The way in which primitive principles and practices, no longer fully in force among individuals ruled, survive in the actions of ruling agents, is curiously illustrated by the long retention between nobles of a right of feud after it had been disallowed between citizens. Chief vassals, too, retained this power to secure justice for themselves after smaller vassals lost it: not only was a right of war with one another recognized, but also a right of defence against the king. And we see that even now, in the relations between Governments, there persists that use of force to remedy injuries, which originally existed between all individuals. As bearing in the same direction, it is significant that the right of trial by battle, which was a regulated form of the aboriginal system under which men administered justice in their own cases, survived among the ruling classes when no longer legal among inferior classes. Even on behalf of religious communities judicial duels were fought. Here the thing it concerns us to note is, that the system of fighting in person and fighting by deputy, when no longer otherwise lawful, remained in force, actually or formally, in various parts of the regulative organization. Up to the reign of George III., trial by battle could be claimed as an alternative of trial by jury. Duels continued till quite recently between members of the ruling classes, and especially between officers; and even now in Continental armies duelling is not only recognized as proper, but is, in some cases, imperative. And then, showing most curiously how in connection with the oldest part of the governing organization these oldest usages survive longest, we have, in the coronation ceremony, a champion in armor uttering by herald a challenge to all comers on behalf of the monarch.

If, from the agencies by which law is enforced, we pass to legal forms, language, documents, etc., the like tendency is everywhere conspicuous. Parchment is retained for law-deeds, though paper has replaced it for other purposes. The form of writing is an old form. Latin and Norman-French terms are still in use for legal purposes, though not otherwise in use; and even old English words, such as "seize," retain, in Law, meanings which they have lost in current speech. In the execution of documents, too, the same truth is illustrated; for the seal, which was originally the signature, continues, though the written signature now practically replaces it—nay, we retain a symbol of the symbol, as may be seen in every share-transfer, where there is a paper-wafer to represent the seal. Even still more antique usages survive in legal transactions; as in the form extant in Scotland of handing over a portion of rock when an estate is sold, which evidently answers to the ceremony among the ancient nations of sending earth and water as a sign of yielding territory.

From the working of State-departments, too, many kindred illustrations might be given. Even under the peremptory requirements of national safety, the flint-lock for muskets was but tardily replaced by the percussion-lock; and it was generations after the rifle had been commonly in use for sporting purposes before it came into more than sparing use for military purposes. Book-keeping by double entry had long been permanently established in the mercantile world before it superseded book-keeping by single entry in Government offices—its adoption dating back only to 1834, when a still more antique system of keeping accounts, by notches cut on sticks, was put an end to by the conflagration that resulted from the burning of the Exchequer tallies.

The like holds with apparel, in general and in detail. Cocked hats are yet to be seen on the heads of officers. An extinct form of dress still holds its ground as the court-dress; and the sword once habitually worn by gentlemen has become the dress-sword worn only on State-occasions. Everywhere officialism has its established uniforms, which may be traced back to old fashions that have disappeared from ordinary life. Some of these antique articles of costume we see surmounting the heads of judges; others there are which still hang round the necks of the clergy; and others which linger on the legs of bishops.

Thus, from the use of a flint-knife by the Jews for the religious ceremony of circumcision, down to the pronunciation of the terminal syllable of the præterite in our Church service, down to the *oyez* shouted in a law-court to secure attention, down to the retention of epaulets for officers, and down to the Norman-French words in which the royal assent is given, this persistence is everywhere traceable. And when we find this persistence manifested throughout all ages in all departments of the regulative organization—when we see it to be the natural accompaniment of the function of that organization, which is essentially restraining—when we estimate the future action of the organization in any case, by observing the general sweep of its curve throughout long periods of the past—we shall see how misleading may be the conclusions drawn from recent facts taken by themselves. Where the regulative organization is anywhere made to undertake additional functions, we shall not form sanguine anticipations on the strength of immediate results of the desired kind; but we shall suspect that, after the phase of early activity has passed by, the plasticity of the new structure will rapidly diminish, the characteristic tendency toward rigidity will begin to show itself, and in place of a progressive effect there will come a restrictive effect.

The reader will now understand more clearly the meaning of the assertion that true conceptions of sociological changes are to be reached only by contemplating their slow genesis through centuries; and that basing inferences on results shown in short periods is as illusory as would be judging of the Earth's curvature by observing whether we are walking up or down hill. After recognizing which truth he will perceive how great is another of the obstacles in the way of the Social Science.

"But does not all this prove too much? If it is so difficult to get sociological evidence that is not vitiated by the subjective states of the witnesses, by their prejudices, enthusiasms, interests, etc.—if, where there is impartial examination, the conditions of the inquiry are of themselves so apt to falsify the result—if there is so general a proneness to assert as facts observed what were really inferences from observations, and so great a tendency also to be blinded by exterior trivialities to interior essentials—if, even where accurate data are accessible, their multitudinousness and diffusion in Space make it impracticable clearly to grasp them as wholes, while their unfolding in Time is so slow that antecedents and consequents cannot be mentally represented in their true relations—is it not manifestly impossible that a Social Science can be framed?"

It must be admitted that the array of objective difficulties thus brought together is formidable; and were it the aim of the Social Science to draw quite special and definite conclusions, which must depend for their truth upon exact data accurately coördinated, it would obviously have to be abandoned. But there are certain classes of general facts which remain after all errors in detail, however produced, have been allowed for. Whatever conflicts there may be among accounts of events that occurred during the feudal ages, comparison of them brings out the incontestable truth that there was a Feudal System. By implication, chronicles and laws indicate the traits of this system; and on putting side by side narratives and documents written, not to tell us about the Feudal System but for quite other purposes, we get tolerably clear ideas of these traits in their essentials—ideas made clearer still on collating the evidence furnished by different contemporary societies. Similarly throughout. By making due use not so much of that which past and present witnesses intend to tell us, as of that which they tell us by implication, it is possible to collect data for inductions respecting social structures and functions in their origin and development: the obstacles which arise in the disentangling of such data in the case of any particular society being mostly surmountable by the help of the comparative method.

Nevertheless, the difficulties that have been enumerated must be ever present to us. Throughout, we hope to depend on testimony; and in every case we have to beware of the many modes in which evidence may be vitiated—have to estimate its worth when it has been discounted in various ways; and have to take care that our conclusions do not depend upon any particular class of facts gathered from any particular place or time.

EPIDEMIC DELUSIONS.

By Dr. CARPENTER, F.R.S., LL.D.

A LECTURE, DELIVERED IN THE HULME TOWN-HALL, MANCHESTER.

OUR subject to-night links itself in such a very decided manner to the subject in which we were engaged last week, and the illustrations which I shall give you are so satisfactorily explained on the scientific principle which I endeavored then to expound to you, that I would spend a very few minutes in just going over some of the points to which I then particularly directed your attention. My object was to show you that, between our Mental operations and our Will, there is something of that kind of relation which exists between a well-trained horse and his rider; that the Will—if rightly exercised in early infancy in directing and controlling the mental operations; in directing the attention to the objects to which the intellect should be applied; in controlling and repressing emotional disturbance; restraining the feelings when unduly excited, and putting a check upon the passions—that the will in that respect has the same kind of influence over the mind, or ought to have, as the rider has upon his horse; that the powers and activities of the mind are to a very great degree independent of the will; that the mind will go on of itself without any more than just the starting of the will, in the same manner as a horse will go on in the direction that it has been accustomed to go with merely the smallest impulse given by the voice, or the hand, or the heel of the rider, and every now and then a very slight check (if it is a well-trained horse) or guidance from the bridle, or from a touch of the spur, and will follow exactly the course that the rider desires, but by its own independent power. And, again, I showed you that as there are occasions on which a horse is best left to itself, so there are occasions when the mind is best left to itself, without the direction and control of the will; in fact, in which the operations of the mind are really disturbed by being continually checked and guided and pulled up by the action of the will, the result being really less satisfactory than when the mind, previously trained and disciplined in that particular course of activity, is left to itself. I gave you some curious illustrations of this from occurrences which have taken place in Dreaming, or in that form of dreaming which we call Somnambulism: where a legal opinion had been given, or a mathematical problem had been resolved, in the state of sleep-waking; that is to say, the mind being very much in the condition of that of the dreamer, its action being altogether automatic, going on of itself without any direction or control from the will—but the bodily activity obeying the direction of the mind. And then I went on to show you that this activity very often takes place, and works out most important results, even without our being conscious of any operations going on; and that some of these results are the best and most valuable to us in bringing at last to our consciousness, ideas which we have been vainly searching for—as in the case where we have endeavored to remember something that we have not at first been able to retrace, and which has flashed into our minds in a few hours, or it may be a day or two afterward; or, again, when we have been directing our minds to the solution of some problem which we have put aside in a sort of despair, and yet in the course of a little time that solution has presented itself while our minds have either been entirely inactive, as in sleep, or have been directed into some entirely different channel of action.

Now, like the well-trained horse which will go on of itself with the smallest possible guidance, yet still under the complete domination of the rider, and will even find its way home when the rider cannot direct it thither, we find that the human mind sometimes does that which even a well-trained horse will do—that it runs away from the guidance of its directing will. Something startles the horse, something gives it alarm; and it makes a sudden bound, and then, perhaps, sets off at a gallop, and the rider cannot pull it up. This alarm often spreads contagiously, as it were, from one horse to another, as we lately saw in the "stampede" at Aldershot. Or, again, a horse, even if well trained, when he gets a new rider, sometimes, as we say, "tries it on," to see whether the horse or the rider is really the master. I have heard many horsemen say that that is a very familiar experience. When you first go out with a new horse, it may be to a certain degree restive; but if the horse finds that you keep a tight hand upon him, and that his master knows well how to keep him under control, a little struggling may have to be gone through, and the horse from that time becomes perfectly docile and obedient. But, if, on the other hand, the horse finds that *he* is the master, even for a short time, no end of trouble is given afterward to the rider in acquiring that power which he desires to possess. Now, that is just the case with our minds; we may follow out the parallel very closely indeed. We find that if our minds once acquire habits—habits of thought, habits of feeling—which are independent of the will, which the will has not kept under adequate regulation, these habits get the better of us; and then we find that it is very difficult indeed to recover that power of self-direction which we have been aiming at, and which the well-trained and well-disciplined mind will make its highest object. So, again, we find that there are states in which, from some defect in the physical condition of the body, or it may be from some great shock which has affected the mind and weakened for a time the power of the will, very slight impulses—just like the slight things that will make a horse shy—will disturb us unduly; and we feel that our emotions are excited in a way that we cannot account for, and we wonder why such a little thing should worry and vex us in the way that it does. Even the best of us know, within our own personal experience, that when we are excessively fatigued in body, or overstrained in mind, our power of self-control is very much weakened; so that particular ideas will take possession of us, and for a time will guide our whole course of thought, in a manner which our sober judgment makes us feel to be very undesirable. What, for instance, is more common than for a person to take offence at something that has been said or done by his most intimate friend, or by some member of his family; merely because he has been jaded or overtasked, and has not the power of bringing to the fair judgment of his common-sense the question whether that offence was really intended, or whether it was a thing he ought not to take any notice of? He broods over this notion, and allows it to influence his judgment; and, if he does not in a day or two rouse himself and master his feelings by throwing it off, it may give rise to a permanent estrangement. We are all of us conscious of states of mind of that kind.

But there are states of mind which lead to very much more serious disorder, arising from the neglect of that primary discipline and culture on which I have laid so much stress. We find that ignorance, and that want of the habit of self-control which very commonly accompanies it, predispose very greatly indeed to the violent excitement of the feelings, and to the possession of the mind by ideas which we regard as essentially absurd; and under these states of excitement of feeling, and the tendency of these dominant ideas to acquire possession of the intellect, the strangest aberrations take place, not only in individuals but in communities; and it is of such that I have especially to speak to-night. We know perfectly well, in our individual experience, that these states tend to produce insanity if they are indulged in, and if the individual does not make an earnest effort to free himself from their influence. But, looking back at the history of the earlier ages, and carrying that survey down to the present time, we have experience in all ages of great masses of people being seized upon by these dominant ideas, accompanied with the excitement of some passion or strong impulse which leads to the most absurd results; and it is of these Epidemic Delusions I have to now speak. The word "epidemic" simply means something that falls upon, as it were, the great mass of the people—a delusion which affects the popular mind. And I believe that I can best introduce the subject to you by showing you how, in certain merely physical conditions, mere bodily states, there is a tendency to the propagation, by what is commonly called imitation, of very strange actions of the nervous system. I suppose there is no one of you who does not know what an hysteric fit means, a kind of fit to which young women are especially subject, but which affects the male sex also. One reason why young women are particularly subject to it is, that in the female the feelings are more easily excited, while the male generally has a less mobile nervous system, his feelings being less easily moved, while he is more influenced by the intellect. These hysteric fits are generally brought on by something that strongly affects the feelings. Now, it often happens that a case of this sort presents itself in a school or nunnery, sometimes in a factory where a number of young women are collected together; one being seized with a fit, others will go off in a fit of a very similar kind. There was an instance a good many years ago in a factory in a country town in Lancashire, in which a young girl was attacked with a violent convulsive fit, brought on by alarm, consequent upon one of her companions, a factory operative, putting a mouse down inside her dress. The girl had a particular antipathy to mice, and the sudden shock threw her into a violent fit. Some of the other girls who were near very soon passed off into a similar fit; and then there got to be a notion that these fits were produced by some emanations from a bale of cotton; and the consequence was that they spread, till scores of the young women were attacked day after day with these violent fits. The medical man who was called in saw at once what the state of things was; he assured them in the first place that this was all nonsense about the cotton; and he brought a remedy, in the second place, which was a very appropriate one under the circumstance—namely, an electrical machine; and he gave them some good violent shocks, which would do them no harm, assuring them that this would cure them. And cure them it did. There was not another attack afterward. I remember very well that when I was a student at Bristol, there was a ward in the hospital to which it was usual to send young servant-girls; for it was thought undesirable that these girls should be placed in the ward with women of a much lower class, especially the lower class of Irishwomen who inhabited one quarter of Bristol, as I believe there is an Irish quarter in Manchester. These girls were mostly respectable, well-conducted girls, and it was thought better that they should be kept together. Now, the result of this was that, if an hysteric fit took any one of them, the others would follow suit; and I remember perfectly well, when I happened to be a resident pupil, having to go and scold these girls well, threatening them with some very severe infliction. I forget what was threatened, perhaps it would be a shower-bath, for any one who went off into one of these fits. Now, here the cure is effected by a stronger emotion, the emotion of the dread of—we will not call it punishment—but of a curative measure; and this emotion overcame the tendency to what we commonly call imitation. It is the suggestion produced by the sight of one, that brings on the fit in another, where there is the predisposition to it. Now, I believe that in all these cases there is something wrong in the general health or in the nervous system; or the suggestion would not produce such results. Take the common teething-fits of children. We there see an exciting cause in the cutting of the teeth; the pressure of the tooth against the gum being the immediate cause of the production of convulsive action. But it will not do so in the healthy child. I feel sure that in every case where there is a teething-fit, of whatever kind, there is always some unhealthy condition of the nervous system—sometimes from bad food; more commonly from bad air. I have known many instances in which children had fits with every tooth that they cut, yet when sent into the country they had no recurrence of the fit. There must have been some predisposition, some unhealthy condition of the nervous system, to favor the exciting cause, which, acting upon this predisposition, brings out such very unpleasant results.

There are plenty of stories of this kind that I might relate to you. For instance, in nunneries it is not at all uncommon, from the secluded life, and the attention being fixed upon one subject, one particular set of ideas and feelings—the want of a healthy vent, so to speak, for the mental activity—that some particular odd propensity has developed itself. For instance, in one nunnery abroad, many years ago, one of the youngest nuns began to mew like a cat; and all the others, after a time, did the same. In another nunnery one began to bite, and the others were all affected with the propensity to bite. In one of these instances the mania was spreading like wild-fire through Germany, extending from one nunnery to another; and they were obliged to resort to some such severe measures as I have mentioned to drive it out. It was set down in some instances to demoniacal possession, but the devil was very easily exorcised by some pretty strong threat on the part of the medical man. The celebrated physician Boerhaave was called in to a case of that kind in an orphan asylum in Holland, and I think his remedy was a red-hot iron. He heated the poker in the fire, and said that the next girl who fell into one of these fits should be burnt in the arm; this was quite sufficient to stop it. In Scotland at one time there was a great tendency to breaking out into fits of this kind in the churches. This was particularly the case in Shetland; and a very wise minister there told them that the thing could not be permitted, and that the next person who gave way in this manner—as he was quite sure they could control themselves if they pleased—should be taken out and ducked in a pond near. There was no necessity at all to put his threat into execution. Here, you see, the stronger motive is substituted for the weaker one, and the stronger motive is sufficient to induce the individual to put a check upon herself. I have said that it usually happens with the female sex, though sometimes it occurs with young men who have more or less of the same constitutional tendency. What is necessary is to induce a stronger motive, which will call forth the power of self-control which has been previously abandoned.

Now, this tendency, which here shows itself in convulsive movements of the body, will also show itself in what we may call convulsive action of the Mind; that is, in the excitement of violent feelings and even passions, leading to the most extraordinary manifestations of different kinds. The early Christians, you know, practised self-mortification to a very great degree; and considered that these penances were so much scored up to the credit side of their account in heaven; that, in fact, they were earning a title to future salvation by self-mortification. Among other means of self-mortification, they scourged themselves. That was practised by individuals. But in the middle ages this disposition to self-mortification would attack whole communities, especially under the dominant idea that the world was coming to an end. In the middle of the thirteenth century, about 1250, there was this prevalent idea that the world was coming to an end; and whole communities gave themselves up to this self-mortification by whipping themselves. These Flagellants went about in bands with banners, and even music, carrying scourges; and then, at a given signal, every one would strip off the upper garment (men, women, and children joined these bands), and proceed to flog themselves very severely indeed, or to flog each other. This subsided for a time, but it broke out again during and immediately after that terrible plague which is known as the "black death," which devastated Europe in the reign of Edward III., about the year 1340. This black death seems to have been the Eastern plague in a very severe form, which we have not known in this country since the great plague of London in Charles II.'s time, and one or two smaller outbreaks since, but which has now entirely left us. The severity of this plague in Europe was so great that upon a very moderate calculation one in four of the entire population was carried off by it; and in some instances it is said that nine-tenths of the people died of it. You may imagine, therefore, what a terrible infliction it was. And you would have supposed that it would have called forth the better feelings of men and women generally; but it did not. One of the worst features, morally, of that terrible affliction, was the lamentable suspension of all natural feelings which it seemed to induce. When any member of a family was attacked by this plague, every one seemed to desert him, or desert her; the sick were left to die alone, or merely under the charge of any persons who thought that they would be paid for rendering this service; and the funerals were carried on merely by these paid hirelings in a manner most repulsive to the feelings: and yet the very people who so deserted their relatives would join the bands of flagellants, who paraded about from place to place, and even from country to country—mortifying their flesh in this manner for the purpose of saving their own souls, and, as they said, also making expiation for the great sins which had brought down this terrible visitation. This system of flagellation never gained the same head in this country that it did on the Continent. A band of about 100 came to London about the middle of the reign of Edward III., in the year 1350. They came in the usual style, with banners and even instruments of music, and they paraded the streets of London. At a given signal every one lay down and uncovered the shoulders, excepting the last person, who then flogged every one till he got to the front, where he lay down; and the person last in the rear stood up, and in his turn flogged every one in front of him. Then he went to the front and lay down; and so it went on until the whole number had thus been flogged, each by every one of his fellows. This discipline however, did not approve itself to the good citizens of London, and it is recorded that the band of flagellants returned without having made any converts. Whether the skins of the London citizens were too tender, or whether their good sense prevailed over this religious enthusiasm, we are not informed; at any rate, the flagellants went back very much as they came, and the system never took root in this country; yet for many years it was carried on elsewhere. One very curious instance is given of the manner in which it fastened on the mind—that mothers actually scourged their new-born infants before they were baptized, believing that in so doing they were making an offering acceptable to God. Now all this appears to us perfectly absurd. We can scarcely imagine the state of mind that should make any sober, rational persons suppose that this could be an offering acceptable to Almighty God; but it was in accordance with the religious ideas of the time; and for a good while even the Church sanctioned and encouraged it, until at last various moral irregularities grew up, of a kind that made the Pope think it a very undesirable thing, and it was then put down by ecclesiastical authority; yet it was still practised in secret for some time longer, so that it is said that even until the beginning of the last century there were small bands of flagellants in Italy, who used to meet for this self-mortification.

That was one form in which a dominant idea took possession of the mind and led to actions which might be called voluntary, for they were done under this impression, that such self-mortification was an acceptable offering. But there were other cases in which the action of the body seemed to be in a very great degree involuntary, just about as involuntary as an hysteric fit, and yet in which it was performed under a very distinct idea; such was what was called the "Dancing Mania," which followed upon this great plague. This dancing mania seemed in the first instance to seize upon persons who had a tendency to that complaint which we now know as St. Vitus's dance—St. Vitus was, in fact, the patron saint of these dancers. St. Vitus's dance, or chorea, in the moderate form in which we now know it, is simply this, that there is a tendency to jerking movements of the body, these movements sometimes going on independently of all voluntary action, and sometimes accompanying any attempt at voluntary movement; so that the body of a person may be entirely at rest until he desires to execute some ordinary movement, such as lifting his hand to his head to feed himself, or getting up to walk; then, when the impulse is given to execute a voluntary movement, instead of the muscles obeying the will, the movement is complicated (as it were) with violent jerking actions, which show that there is quite an independent activity. The fact is, that stammering is a sort of chorea. We give the name of chorea to this kind of disturbance of the nervous system, and the action of stammering is a limited chorea—chorea limited to the muscles concerned in speech, when the person cannot regulate the muscles so as to bring out the words desired; the very strongest effort of his will cannot make the muscles obey him, but there is a jerking, irregular action every time he attempts to pronounce particular syllables. And the discipline that the stammerer has to undergo in order to cure or alleviate his complaint is just the kind of discipline I have spoken of so frequently—the fixing the attention on the object to be gained, and regularly exercising the nerves and muscles in proceeding from that which they *can* do to that which they find a difficulty in doing. That is an illustration of the simpler form of this want of definite control over the muscular apparatus, connected with a certain mental excitement; because every one knows that a stammerer is very much affected by the condition of his feelings at the time. If, for example, he is at all excited, or if he apprehends that he shall stammer, that is enough to produce it. I have known persons who never stammered in ordinary conversation, yet when in company with stammerers they could scarcely avoid giving way to it; and even when the subject of stammering was talked about, when the idea was conveyed to their minds, they would begin to hesitate and stutter, unless they put a very strong control upon themselves. It is just in this way, then, only in the most exaggerated form, that these persons were afflicted with what was called the dancing mania. They would allow themselves to be possessed with the idea that they *must* dance; and this dancing went on, bands going from town to town, and taking in any who would join them. Instances are recorded in which they would go on for twenty-four or thirty-six hours, continually dancing and jumping and exerting themselves in the most violent manner, taking no food all this time, until at last they dropped on the ground almost lifeless; and in fact several persons, it is said, did die from pure exhaustion, and this just because they were possessed with the idea that they *must* dance. They were drawn in, as it were, by the contagion of example; and, when once they had given way to it, they did not seem to know when to stop. This was kept up by music and by the encouragement and excitement of the crowd around; and it spread among classes of persons who (it might be supposed) would have had more power of self-restraint, and would not have joined such unseemly exhibitions. The extraordinary capacity, as it were, for enduring physical pain, was one of the most curious parts of this condition. They would frequently ask to be struck violently; would sometimes lie down, and beg persons to come and thump and beat them with great force. They seemed to enjoy this.—In another case that I might mention this was shown still more. The case was of a similar type, but was connected more distinctly with the religious idea, and it occurred much more recently. The case was that known in medical history as the Convulsionnaires of St.-Médard. There was a cemetery in Paris in which a great saint had been interred, and some young women visiting his tomb had been thrown into a convulsive attack which propagated itself extensively; and these convulsionnaires spreading the contagion, as it were, into different classes of French society, one being seized after another till the number became very great in all grades. Here, again, one of the most curious things was the delight they seemed to take in what would induce in other persons the most violent physical suffering. There was an organized band of attendants, who went about with clubs, and violently beat them. This was called the *grand secours*, which was administered to those who were subject to these convulsive attacks. You would suppose that these violent blows with the clubs would do great mischief to the bodies of these people; but they only seemed to allay their suffering.

This, then, is another instance of the mode in which this tendency to strange actions under the dominance of a particular idea will spread through a community. Here you have the direct operation of the perverted mind upon the body. But there are a great many cases in which the perversion shows itself more in the mental state alone, leading to strange aberrations of Mind, and ultimately to very sad results in the condition of society where these things have spread, but not leading to any thing like these convulsive paroxysms. I particularly allude now to the epidemic belief in Witchcraft, which, more or less, formerly prevailed constantly among the mass of the population, but every now and then broke out with great vehemence. This belief in witchcraft comes down to us from very ancient periods; and at the present time it is entertained by the lowest and most ignorant of the population in all parts of the world. We have abundant instances of it still, I am sorry to say, in our own community. We have poor, ignorant servant-girls allowing themselves to be—if I may use such a word—"humbugged" by some designing old woman, who persuades them that she can predict the husbands they are to have, or tell where some article that they have lost is to be found, and who extracts money from them merely as a means of obtaining a living in this irregular way, and I believe at the bottom rather enjoying the cheat. Every now and then we hear of some brutal young farmer who has pretty nearly beaten to death a poor old woman, whom he suspected of causing a murrain among his cattle. This is what we know to exist among the least cultivated of the savage nations at the present time, and always to have existed. But we hope that the progress of rationalism in our own community will, in time, put an end to this, as it has in the middle and upper ranks of society during the last century or century and a half. It is not very long since almost every one believed in the possession of these occult powers by men and women, but especially by old women. This belief has prevailed generally in countries which have been overridden by a gloomy fanaticism in religious matters. I speak of it simply as a matter of history. There is no question at all that this prevailed where the Romish Church was most intolerant, especially in countries where the Inquisition was dominant, and its powers were exerted in such a manner as to repress free thought and the free exercise of feeling; and, again, where strong Calvinism has exercised an influence of exactly the same kind—as in Scotand, a century and a half ago, and in New England, where there was the same kind of religious fanaticism. It is in these communities that belief in witchcraft has been most rife, has extended itself most generally, and has taken possession of the public mind most strongly; and the most terrible results have happened. Now, I will only cite one particular instance, that of New England, in the early part of the last century and the end of the century before. Not very long after the settlement of New England, there was a terrible outbreak of this belief in witchcraft. It began in a family, the children of which were out of health; and certain persons whom they disliked were accused of having bewitched them. Against these persons a great deal of evidence that we should now consider most absurd was brought forward, and they were actually executed: and some of them under torture, or under moral torture—for it was not merely physical torture that was applied; in many cases it was the distress and moral torture of being so accused, the dread, even if found not guilty, of being considered outcasts all their lives, or of being a burden to their friends—made confessions which any sober persons would have considered perfectly ridiculous; but, under the dominant idea of the reality of this witchcraft, no one interfered to point out how utterly repugnant to common-sense these confessions were, as well as the testimony that was brought forward. And this spread to such a degree in New England, one person being accused after another, that, at last, even those who considered themselves God's chosen people began to feel, "Our turn may come next;" they then began to think better of it, and so put an end to these accusations, even some who were under sentence being allowed to go free; and to the great surprise of those who were entirely convinced of the truth of these accusations, this epidemic subsided, and witchcraft was not heard of for a long time afterward; so that the belief has never prevailed in New England from that time to the present, excepting among the lowest and most ignorant class. In Scotland, these witch-persecutions attained to a most fearful extent during the seventeenth century. They were introduced into England very much by James I., who came to England possessed by these ideas, and he communicated them to others, and there were a good many witch-persecutions during his reign. After the execution of Charles I., and during the time of the Commonwealth and the Puritans, there were a good many witch-persecutions; but I think, after that, very little more was heard of them. And yet the belief in witchcraft lingered for a considerable time longer. It is said that even Dr. Johnson was accustomed to remark that he did not see that there was any proof of the non-existence of witches; that, though their existence could not be proved, he was not at all satisfied that they did not exist. John Wesley was a most devout believer in witchcraft, and said on one occasion that, if witchcraft was not to be believed, we could not believe in the Bible. So you see that this belief had a very extraordinary hold over the public mind. It was only the most intelligent class, whose minds had been freed from prejudice by general culture, who were really free from it; and that cultivation happily permeated downward, as it were; so that now I should hope there are very few among our intelligent working-class in our great towns—where the general culture is much higher than it is in the agricultural districts—who retain any thing more than the lingering superstition which is to be found even in the very highest circles—as, for instance, not liking to be married on a Friday, or not liking to sit down thirteen at the dinner-table. These are things which even those who consider themselves the very aristocracy of intellect will sometimes confess to, laughing at it all the time, but saying, "It goes against the grain, and I would rather not do it." These, I believe, are only lingering superstitions that will probably pass away in another half century, and we shall hear nothing more of them; the fact being that the tendency to these delusions is being gradually grown out of.

Now, this is the point I would especially dwell upon. To the child-mind nothing is too strange to be believed. The young child knows nothing about the Laws of Nature; it knows no difference between what is conformable to principles, and what, on the other hand, is so strange that an educated man cannot believe it. To the child every new thing that it sees is equally strange; there is none of that power of discrimination that we acquire in the course of our education—the education given to us, and the education that we give ourselves. We gradually, in rising to adult years, grow out of this incapacity to distinguish what is strange from what is normal or ordinary. We gradually come to feel—"Well, I can readily believe that, because it fits in with my general habit of thought; I do not see any thing strange in this, although it is a little unusual." But, on the other hand, there are certain things we feel to be too strange and absurd to be believed; and that feeling we come to especially, when we have endeavored to cultivate our Common-Sense in the manner which I described to you in my last lecture. The higher our common-sense—that is, the general resultant of the whole character and discipline of our minds—the more valuable is the direct judgment that we form by the use of it. And it is the growth of that common-sense, which is the most remarkable feature in the progress of thought during the last century. The discoveries of science; the greater tendency to take rational and sober views of religion; the general habit of referring things to principles; and a number of influences which I cannot stop particularly to describe, have so operated on the public mind, that every generation is raised, I believe, not merely by its own culture, but by the acquired result of the experience of past ages; for I believe that every generation is born, I will not say wiser, but with a greater tendency to wisdom. I feel perfectly satisfied of this, that the child of an educated stock has a much greater power of acquiring knowledge than the child of an uneducated stock; that the child that is the descendant of a race in which high moral ideas have been always kept before the mind, has a much greater tendency to act uprightly than the child that has grown up from a breed that has been living in the gutter for generations past. I do not say that these activities are born with us, but the tendency to them—that is, the aptitude of mind for the acquirement of knowledge, the facility of learning, the disposition to act upon right principles—I believe is, to a very great degree, hereditary. Of course we have lamentable examples to the contrary, but I am speaking of the general average. I am old enough now to look back with some capacity of observation for forty years, and I can see in the progress of society a most marked evidence of the higher general intelligence, the greater aptitude for looking at things as they are, and for not allowing strange, absurd notions to take possession of the mind; while, again, I can trace, even within the last ten years, in a most remarkable manner, the prevalence of a desire to do right things for the right's sake, and not merely because they are politic. And I am quite sure that there is a gradual progress in this respect, which has a most important influence in checking aberrations of the class of which I have spoken.

Still we see these aberrations, and there is one just now which is exciting a good deal of attention—that which you have heard of under the name of "Spiritualism." Now, I look upon the root of this spiritualism to lie in that which is a very natural, and in some respects a wholesome disposition of the kind—a desire to connect ourselves in thought with those whom we have loved and who are gone from us. Nothing is more admirable, more beautiful, in our nature than this longing for the continuance of intercourse with those whom we have loved on earth. It has been felt in all nations and at all times, and we all of us experience it in regard to those to whom we have been most especially attached. But this manifestation of it is one which those who experience this feeling in its greatest purity and its greatest intensity feel to be absurd and contrary to common-sense—that the spirits of their departed friends should come and rap upon tables and make chairs dance in the air, and indicate their presence in grotesque methods of this kind. The most curious part of it is that the spirits should obey the directions of the persons with whom they profess to be in communication—that when they say, "Rap once if you mean yes, and rap twice if you mean no," and so on, they should just follow any orders they receive as to the mode in which they will telegraph replies to their questions. It seems to me repugnant to one's common-sense; but the higher manifestations of these spiritual agencies seem to me far more repugnant to common-sense; and that is when persons profess to be able to set all the laws of Nature at defiance; when it is said, for instance, that a human being is lifted bodily up into the air and carried, it may be, two or three miles, and descends through the ceiling of a room. One of the recent statements of this kind, you know, is that a certain very stout and heavy lady was carried a distance of about two miles from her own house, and dropped plump down upon the table round which eleven persons were sitting; she came down through the ceiling, they could not state how, because they were sitting in the dark, and that darkness has a good deal to do with most of these manifestations. Now, let us analyze them a little. I am speaking now of what I will call the genuine phenomena—those which happen to persons who really are honest in their belief. I exclude altogether, and put aside the cases, of which I have seen numbers, in which there is the most transparent trickery, and in which the only wonder is, that any rational persons should allow themselves to be deceived by it.

I have paid a great deal of attention during the last twenty years to this subject, and I can assure you that I have, in many instances, known things most absurd in themselves, and most inconsistent with the facts of the case as seen by myself and other sober-minded witnesses, believed in by persons of very great ability, and, upon all ordinary subjects, of great discrimination. But I account for it by the previous possession of their minds by this dominant idea—the expectation they have been led to form, either by their own earnest desire for this kind of communication, or by the sort of contagious influence to which some minds are especially subject. I say "the earnest desire," for it is a very curious thing that many of those who are the most devout spiritualists are persons who have been themselves previously rather skeptical upon religious matters; and many have said to me that this communication is really the only basis of their belief in the unseen world. Such being the case, I cannot wonder that they cling to it with very strong and earnest feeling. A lady, not undistinguished in the literary world, assured me several years ago that she had been converted by this spiritualism from a state of absolute unbelief in religion; and she assured me, also, that she regarded medical men and scientific men, who endeavored to explain these phenomena upon rational principles, and to expose deception, where deception did occur, as the emissaries of Satan, who so feared that the spread of spiritualism would destroy his power upon earth, that he put it into the minds of medical and scientific men to do all that they could to prevent it. Now that, I assure you, is a fact. That was said to me by a lady of considerable literary ability, and I believe it represents, though rather extravagantly, a state of mind which is very prevalent; the great spread of the intense materialism of our age tending to weaken, and in some instances to destroy, that healthful longing which we all have, I believe, in our innermost nature, for a higher future existence, and which is to my mind one of the most important foundations of our belief in it. We live too much in the present; we think too much of the things of the world as regards our material comfort and enjoyment, instead of thinking of them as they bear upon our own higher nature. I believe that this tendency, which I think is especially noticeable in America—or at least it was a few years ago—from all that I was able to learn, had a great deal to do with the spread of this belief in what is called Spiritualism. The spiritualists assert that in America they are numbered by millions, and that there are very few people of any kind of intellectual culture who have not either openly or secretly given in their adhesion to it. I believe that is a gross exaggeration; still, there can be no doubt, from the number of periodicals they maintain, and the advertisements in them of all kinds of strange things that are done—spirit-drawings made, drawings of deceased friends, and spiritual instruction given of various kinds—that there must be a very extended belief in this notion of communication with the unseen world through these "media."

I can only assure you for myself that, having, as I have said, devoted considerable attention to this subject, I have come to the conclusion most decidedly—with, I believe I may say, as little prepossession as most persons, and with every disposition to seek for truth simply—to allow for our knowledge, or I would rather say for our ignorance, a very large margin of many things that are beyond our philosophy—with every disposition to accept facts when I could once clearly satisfy myself that they were facts—I have had to come to the conclusion that whenever I have been permitted to employ such tests as I should employ in any scientific investigation, there was either intentional deception on the part of interested persons, or else self-deception on the part of persons who were very sober-minded and rational upon all ordinary affairs of life. Of that self-deception I could give you many very curious illustrations, but the limits of our time will prevent my giving you more than one or two. On one occasion I was assured that, on the evening before, a long dining-table had risen up and stood a foot high in the air, in the house in which I was, and to which I was then admitted for the purpose of seeing some of these manifestations by persons about whose good faith there could be no doubt whatever. I was assured by them—"It was a great pity you were not here last night, for, unfortunately, our principal medium is so exhausted by the efforts she put forth last night that she cannot repeat it." But I was assured, upon the word of three or four who were present, that this table had stood a foot high in the air, and remained suspended for some time, without any hands being near it, or at any rate with nothing supporting it; the hands might be over it. But I came to find, from experiments performed in my presence, that they considered it evidence of the table rising into the air, that it pressed upward against their hands; that they did not rest upon their sense of sight; for I was looking in this instance at the feet of the table, and I saw that the table upon which the hands of the performers were placed, and which was rocking about upon its spreading feet, really never rose into the air at all. It would tilt to one side or to the other side, but one foot was always resting on the ground. And when they declared to me that this table had risen in the air, I said, "I am very sorry to have to contradict you, but I was looking at the feet of the table all the time, and you were not; and I can assert most positively that one of the feet never left the ground. Will you allow me to ask what is *your* evidence that the table rose into the air?" "Because we felt it pressing upward against our hands." I assure you that was the answer I received; their conclusion that the table rose in the air being grounded on this, that their hands being placed upon the table, they felt, or they believed, that the table was pressing upward against their hands, though I saw all the time that one foot of the table had never left the ground. Now, that is what we call a "subjective sensation;" one of those sensations which arise in our own minds under the influence of an idea. Take, for instance, the very common case—when we sleep in a strange bed, it may be in an inn that is not very clean, and we begin to be a little suspicious of what other inhabitants there may be in that bed; and then we begin to feel a "creepy, crawly" sensation about us, which that idea will at once suggest. Now, those are subjective sensations; those sensations are produced by the mental idea. And so in this case I am perfectly satisfied that a very large number of these spiritual phenomena are simply subjective sensations; that is, that they are the result of expectation on the part of the individual. The sensations are real to them. You know that, when a man has suffered amputation of his leg, he will tell you at first that he feels his toes, that he feels his limb; and, perhaps to the end of his life, every now and then he will have this feeling of the limb moving, or of a pain in it; and yet we know perfectly well that this is simply the result of certain changes in the nerve, to which, of course, there is nothing answering in the limb that was removed. These subjective sensations, then, will be felt by the individuals as realities, and will be presented to others as realities, when, really, they are simply the creation of their own minds, that creation arising out of the expectation which they have themselves formed. These parties believed that the table would rise; and, when they felt the pressure against their hands, they fully believed that the table was rising.

Take the case of Table-turning, which occurred earlier. I dare say many of you remember that epidemic which preceded the spiritualism; in fact, the spiritualism, in some degree, arose out of table-turning. My friend the chairman (Dr. Noble) and I hunted in couples, a good many years ago, with a third friend, the late Sir John Forbes, and we went a great deal into these inquiries; and I very well remember sitting at a table with him, I suppose twenty-five years ago, waiting in solemn expectation for the turning of the table; and the table went round. This was simply the result of one of the party, who was not influenced by the philosophical skepticism that we had on the subject, having a strong belief that the phenomenon would occur; and when he had sat for some time with his hands pressed down upon the table, an involuntary muscular motion, of the kind I mentioned in my last lecture, took place, which sent the table turning. There was nothing to the Physiologist at all difficult in the understanding of this. Prof. Faraday was called upon to explain the table-turning, which many persons set down to electricity; but he was perfectly satisfied that this was a most untrue account of it, and that the explanation was (as, in fact, I had previously myself stated in a lecture at the Royal Institution) that the movements took place in obedience to ideas. Movements of this class are what I call "ideo-motor," or reflex actions of the brain; and the occurrence of these movements in obedience to the idea entertained is the explanation of all the phenomena of table-turning. Prof. Faraday constructed a very simple testing apparatus, merely two boards, one over the other, and confined by elastic bands, but the upper board rolling readily upon a couple of pencils or small rollers; and resting on the lower board was an index, so arranged that a very small motion of this upper board would manifest itself in the movement of the index through a large arc. He went about this investigation in a thoroughly scientific spirit. He first tied together the boards so that they could not move one upon the other, the object being to test whether the mere interposition of the instrument would prevent the action. He had three or four of these indicators prepared, and he put them down on the table so fixed that they would not move. He then put the hands of the table-turners on these; and it was found, as he fully expected, that the interposition of this indicator under their hands did not at all prevent the movement of the table. The hands were resting on the indicator; and when their involuntary pressure was exerted, the friction of the hands upon the indicators, and of the indicators upon the table, carried round the table just as it had done before. Now, if there had been any thing in the construction of the instrument to prevent it, that would not have happened. Then he loosened the upper board and put the index on, so that the smallest motion of the hands upon the board would manifest itself, before it would act on the table, in the movement of the index; and it was found that when the parties looked at the index, and watched its indications, they were pulled up as it were, at the very first involuntary action of their hands, by the knowledge that they were exerting this power, and the table then never went round. One of the strangest parts of this popular delusion was, that even after this complete exposure of it by Faraday, there were a great many persons, including many who were eminently sensible and rational in all the ordinary affairs of life, who said: "Oh, but this has nothing at all to do with it. It is all very well for Prof. Faraday to talk in this manner, but it has nothing at all to do with it. We *know* that we are not exerting any pressure. His explanation does not at all apply to *our* case." But then Prof. Faraday's table-turners were equally satisfied that *they* did not move the table, until the infallible index proved that they did. And if any one of these persons, who *know* that they did not move the table, were to sit down in the same manner with those indicators, it would have been at once shown that they did move the table. Nothing was more curious than the possession of the minds of sensible men and women by this idea that the tables went round by an action quite independent of their own hands; and not only that, but that really, like the people in the dancing mania, they *must* follow the table. I have seen sober and sensible people running round with a table, and with their hands placed on it, and asserting that they could not help themselves—that they were obliged to go with the table. Now, this is just simply the same kind of possession by a dominant idea, that possessed the dancing maniacs of the middle ages.

Then the Table-tilting came up. It was found that the table would tilt in obedience to the directions of some spirit, who was in the first instance (I speak now of about twenty years ago) always believed to be an evil spirit. The table-tilting first developed itself in Bath, under the guidance of some clergymen there, who were quite satisfied that the tiltings of the table were due to the presence of evil spirits. And one of these clergymen went further, and said that it was Satan himself. But it was very curious that the answers obtained by the rappings and tiltings of the tables always followed the notions of the persons who put the questions. These clergymen always got these answers as from evil spirits, or satisfied themselves that they were evil spirits by the answers they got. But, on the other hand, other persons got answers of a very different kind; an innocent girl, for instance, asked the table if it loved her, and the table jumped up and kissed her. A gentleman who put a question to one of these tables got an extremely curious answer, which affords a very remarkable illustration of the principle I was developing to you in the last lecture—the unconscious action of the brain. He had been studying the life of Edward Young, the poet, or at least had been thinking of writing it; and the spirit of Edward Young announced himself one evening, as he was sitting with his sister-in-law—the young lady who asked the table if it loved her. Edward Young announced himself by the raps, spelling out the words in accordance with the directions that the table received. He asked, "Are you Young, the poet?" "Yes." "The author of the 'Night Thoughts?'" "Yes." "If you are, repeat a line of his poetry." And the table spelled out, according to the system of telegraphy which had been agreed upon, this line:

"Man is not formed to question, but adore."

He said, "Is this in the 'Night Thoughts?'" "No." "Where is it?" "J O B." He could not tell what this meant. He went home, bought a copy of Young's works, and found that in the volume containing Young's poems there was a poetical commentary on Job which ended with that line. He was extremely puzzled at this; but two or three weeks afterward he found he had a copy of Young's works in his own library, and was satisfied from marks on it that he had read that poem before. I have no doubt whatever that that line had remained in his mind, that is, in the lower stratum of it; that it had been entirely forgotten by him, as even the possession of Young's poems had been forgotten; but that it had been treasured up as it were in some dark corner of his memory, and had come up in this manner, expressing itself in the action of the table, just as it might have come up in a dream.

These are curious illustrations, then, of the mode in which the minds of individuals act when there is no cheating at all—this action of what we call the subjective state of the individual dominating these movements; and I believe that that is really the clew to the interpretation of the genuine phenomena. On the other hand, there are a great many which we are assured of—for instance, this descent of a lady through the ceiling—which are self-delusions, pure mental delusions, resulting from the preconceived idea and the state of expectant attention in which these individuals are. Here are a dozen persons sitting round a table in the dark, with the anticipation of some extraordinary event happening. In another dark *séance* one young lady thought she would like to have a live lobster brought in, and presently she began to feel some uncomfortable sensations, which she attributed to the presence of this live lobster; and the fact is recorded that two live lobsters were brought in; that is, they appeared in this dark *séance*—making their presence known, I suppose, by crawling over the persons of the sitters. But that is all we know about it—that they felt something—they say they were two live lobsters, but what evidence is there of that?—the *séance* was a dark one. We are merely told that the young lady thought of a live lobster; she said they had received so many flowers and fruits that she was tired of them, and she thought of two live lobsters; and forthwith it was declared that the live lobsters were present. I certainly should be much more satisfied with the narration, if we were told that they had made a supper off these lobsters after the *séance* was ended.

Now, it has been my business lately to go rather carefully into the analysis of several of these cases, and to inquire into the mental condition of some of the individuals who have reported the most remarkable occurrences. I cannot—it would not be fair—say all I could say with regard to that mental condition; but I can only say this, that it all fits in perfectly well with the result of my previous studies upon the subject, viz., that there is nothing too strange to be believed by those who have once surrendered their judgment to the extent of accepting as credible things which common-sense tells us are entirely incredible. One gentleman says he glories in not having that scientific incredulity which should lead him to reject any thing incredible merely because it seems incredible. I can only say this, that we might as well go back to the state of childhood at once, the state in which we are utterly incapable of distinguishing the strange from the true. That is a low and imperfect condition of mental development; and all that we call education tends to produce the habit of mind that shall enable us to distinguish the true from the false—actual facts from the creations of our imagination. I do not say that we ought to reject every thing that to us, in the first instance, may seem strange. I could tell you of a number of such things in science within your own experience. How many things there are in the present day that we are perfectly familiar with—the electric telegraph, for instance—which fifty years ago would have been considered perfectly monstrous and incredible. But there we have the *rationale*. Any person who chooses to study the facts may at once obtain the definite scientific *rationale;* and these things can all be openly produced and experimented upon, expounded and explained. There is not a single thing we are asked to believe of this kind, that cannot be publicly exhibited. For instance, in this town, last week, I saw a stream of molten iron coming out from a foundery; I did not see on this occasion—but the thing has been done over and over again—that a man has gone and held his naked hand in such a stream of molten iron, and has done it without the least injury; all that is required being, to have his hand moist, and if his hand is dry he has merely to dip it in water, and he may hold his hand for a certain time in that stream of molten iron without receiving any injury whatever. This was exhibited publicly at a meeting of the British Association at Ipswich many years ago, at the foundery of Messrs. Ransome, the well-known agricultural implement makers. It is one of the miracles of science, so to speak; they are perfectly credible to scientific men, because they know the principle upon which it happens, and that principle is familiar to you all—that if you throw a drop of water upon hot iron, the water retains its spherical form, and does not spread upon it and wet it. Vapor is brought to that condition by intense heat, that it forms a sort of film, or atmosphere, between the hand and the hot iron, and for a time that atmosphere is not too hot to be perfectly bearable. There are a number of these miracles of science, then, which we believe, however incredible at first sight they may appear, because they can all be brought to the test of experience, and can be at any time reproduced under the necessary conditions. Houdin, the conjurer, in his very interesting autobiography—a little book I would really recommend to any of you who are interested in the study of the workings of the mind, and it may be had for two shillings—Houdin tells you that he himself tried this experiment after a good deal of persuasion; and he says that the sensation of immersing his hand in this molten metal was like handling liquid velvet. These things, I say, can be exhibited openly—above-board; but these Spiritual phenomena will only come just when certain favorable conditions are present—conditions of this kind, that there is to be no scrutiny—no careful examination by skeptics; that there is to be every disposition to believe, and no manifestation of any incredulity, but the most ready reception of what we are told. I was asked some years ago to go into an investigation of the Davenport Brothers; but then I was told that the whole thing was to be done in the dark, and that I was to join hands and form part of a circle; and I responded to the invitation by saying that in all scientific inquiries I considered the hands and the eyes essential instruments of investigation, and that I could not enter into any inquiry, and give whatever name I possess in science to the result of it, in which I was not allowed freely to use my hands and my eyes. And, wherever I have gone to any of these Spiritual manifestations, and have been bound over not to interfere, I have seen things which, I feel perfectly certain, I could have explained if I had only been allowed to look under the table, for instance, or to place my leg in contact with the leg of the medium. And it has been publicly stated within the last month, that the very medium whom I suspected strongly of cheating on an occasion of this kind, was detected in the very acts which I suspected, but which I was not allowed to examine. I cannot, then, go further into this inquiry at the present time, but I can only ask you to receive my assurance as that of a scientific man, who has for a long course of years been accustomed to investigate the curious class of actions to which I have alluded, and which disguise themselves under different names. A great number of the very things now done, by persons professing to call themselves Spiritualists, were done thirty years ago, or professed to be done, by those who call themselves "Mesmerists;" thus the lifting of the whole body in the air was a thing that was asserted as possible by mesmerists, as is now done by Mr. Home and his followers. These things, I say, crop up now and then, sometimes in one form, sometimes in another; and it is the same general tendency to credulity, to the abnegation of one's common-sense, that marks itself in every one of these epidemics.

Thus, then, we come back to the principle from which we started—that the great object of all education should be to give to the mind that rational direction which shall enable it to form an intelligent and definite judgment upon subjects of this kind, without having to go into any question of formal reasoning upon them. Thus, for example, is it more probable that Mr. Home floated out of one window and in at another, or that Lord Lindsay should have allowed himself to be deceived as to a matter which he admits only occurred *by moonlight?* That is the question for common-sense. I believe, as I stated just now, that the tendency to the higher culture of the present age will manifest itself in the improvement of the next generation, as well as of our own; and it is in that hope that I have been encouraged on this and other occasions to do what I could for the promotion of that desire for self-culture, of which I see so many hopeful manifestations at the present day. When once a good basis is laid by primary education, I do not see what limit there need be to—I will not say the *learning* of future generations—but to their *wisdom*, for wisdom and learning are two very different things. I have known some people of the greatest learning, who had the least amount of wisdom of any persons who have come in my way. Learning, and the use that is made of it, are two very different things. It is the effort to acquire a distinct and definite knowledge of any subject that is worth learning, which has its ultimate effect, as I have said, upon the race, as well as upon the individual.

But there are great differences, as to their effects upon the mind, among different subjects of study; and I have long been of opin ion that those studies afford the best discipline, in which the mind is brought into contact with outward realities—a view which has lately been put forth with new force by my friend Canon Kingsley. You know that Canon Kingsley has acquired great reputation as an historian. He held the Professorship of History at the University of Cambridge for many years, and, in fact, has only recently withdrawn from it. Canon Kingsley also early acquired a considerable amount of scientific culture, and he has always been particularly fond of Natural History. Now, he lately said to the working-men of Bristol that he strongly recommended them to cultivate Science, rather than study History; having himself almost withdrawn from the study of history, for this reason, that he found it more and more difficult to satisfy himself about the truth of any past event; while, on the other hand, in the study of science, he felt that we were always approaching nearer to the truth. A few days ago I was looking through a magazine article on the old and disputed question of Mary Queen of Scots, which crops up every now and then. She is once more put upon her trial. Was Mary Queen of Scots a vicious or a virtuous woman? The question will be variously answered by her enemies and by her advocates; and I believe it will crop up to the day of doom, without ever being settled. Now, on the other hand, as we study scientific truth, we gain a certain point, and may feel satisfied we are right up to that point, though there may be something beyond; while the elevation we have gained enables us to look higher still. It is like ascending a mountain; the nearer we get to the top, the clearer and more extensive is the view. I think this is a far better discipline to the mind than that of digging down into the dark depths of the past, in the search for that which we cannot hope ever thoroughly to bring to light. It so happened that only a fortnight ago I had the opportunity of asking another of our great historians, Mr. Froude, what he thought of Canon Kingsley's remark. He said, "I entirely agree with it;" and, in some further conversation I had with him on the subject, I was very much struck with finding how thoroughly his own mind had been led, by the very important and profound researches he has made into our history, to the same conclusion—the difficulty of arriving at absolute truth upon any historical subject. Now, we do hope and believe that there is absolute truth in Science, which, if not at present in our possession, is within our reach; and that, the nearer we are able to approach to it, the clearer will be our habitual perception of the difference between the real and the unreal, the firmer will be our grasp of all the questions that rise in the ordinary course of our lives, and the sounder will be the judgment we form as to great political events and great social changes. Especially will this gain be apparent in our power of resisting the contagious influence of "Mental Epidemics."

THE PRACTICAL MAN AS AN OBSTRUCTIVE.[1]

By F. J. BRAMWELL, C. E.

IN prosperous times those engaged in manufactures are too busy earning and saving money to attend to a reorganization of their plant; in bad times they are too dispirited and too little inclined to spend the money, that in better times they have saved, in replacing old and wasteful appliances by new and economical ones, and one feels that there is a very considerable amount of seeming justification for their conduct in both instances, and that it requires a really comprehensive and large intelligence and a belief in the future, possessed by only a few out of the bulk of mankind, to cause the manufacturer to pursue that which would be the true policy, as well for his own interests as for those of the community. But there is a further and a perpetual bugbear in the way of such improvements, and that bugbear is the so-called "practical man," and he was in my mind when, in previous parts of this address, I have hinted at the existence of an obstacle to the adoption of improvement.

I do not wish the section for one moment to suppose that I, brought up as an apprentice in a workshop, and who all my life have practised my profession, intend to say one word against the truly practical man. On the contrary, he is the man of all others that I admire, and by whom I would wish persons to be guided, because the truly practical man is one who knows the reason of that which he practises, who can give an account of the faith that is in him, and who, while he possesses the readiness of mind and the dexterity which arise from long-continued and daily intercourse with the subject of his profession, possesses also that necessary amount of theoretical and scientific knowledge which would justify him in pursuing any process he adopts, which in many cases enable him to devise new processes, or which, at all events, if he be not of an inventive quality of mind, will enable him to appreciate and value the new processes devised by others. This is the truly practical man, about whom I have nothing to say except that which is most laudatory. But the practical man as commonly understood means a man who knows the practice of his trade, and knows nothing else concerning it; the man whose wisdom consists in standing by, seeing but not investigating the new discoveries which are taking place around him; in decrying those discoveries; in applying to those who invent improvements, even the very greatest, the epithet of "schemes;" and then, when he finds that beyond all dispute some new matter is good and has come into general practice, taking to it grumblingly, but still taking to it, because if he do not he could not compete with his

[1] Extract from the opening address of the chairman of the Mechanical Section of the British Association, at Brighton.

co-manufacturers, the aim and object of such a man being to insure that he should never make a mistake by embarking his capital or his time in that which has not been proved by men of large hearts and large intelligence. It is such a practical man as this who delays all improvement. For years he delayed the development in England of the utilization of the waste gases of blast-furnaces, and he has done it so successfully that, as I have already had occasion to remark, this utilization is by no means universal in this kingdom. It was such men as these who kept back surface condensation for twenty years. It is such a man as this who, when semaphores were invented, would have said, "Don't suggest such a mode to me of transmitting messages; I am a practical man, sir, and I believe that the way to transmit a message is to write it on paper, deliver it to a messenger, and put him on horseback." In the next generation his successor would be a believer in semaphores, and when the electrical telegraphist came to him and said, "Do you know that I can transmit movement by invisible electrical power through a wire, however long, and it seems to me that if one were to make a code out of this movement I could speak to you at Portsmouth at one end of the wire while I was in London at the other," what would have been the answer of the practical man? "Sir, I don't believe in transmitting messages by an invisible agency; I am a practical man, and I believe in semaphores, which I can see working." In like manner when the Siemens' regenerative gas-furnace was introduced, what said the practical man? "Turn your coals into gas and burn the gas, and then talk of regeneration! I don't know what you mean by regeneration, except in a spiritual sense. I am a practical man, and if I want heat out of coals I put coals on to a fire and burn them;" and for fifteen years the practical man has been the bar to this most enormous improvement in metallurgical operations. The practical man is beginning slowly to yield with respect to these furnaces, because he finds, as I have already said, that men of greater intelligence have now in sufficiently large numbers adopted the invention to make a formidable competition with persons who stolidly refuse to be improved. The same practical man for years stood in the way of the development of Bessemer steel. Now he has been compelled to become a convert.

I will not weary you by citing more instances; but one knows, and one's experience teaches one that this is the conduct of the so-called practical man; and his conduct arises not only from the cause which I have given (his ignorance of the principles of his profession), but from another one which I have had occasion to allude to when speaking upon a different subject, and that is, you offend his pride when you come to him and say, "Adopt such a plan; it is an improvement on the process you carry on." His instinct revolts at the notion that you, a stranger, very likely his junior, and very probably, if the improvement be an original and radical one, a person not even connected with the trade to which that improvement relates, should dare to assert that you can inform him of something connected with his business that he did not know. It may be said that employers and the heads of manufactories are, as a rule, in these days, educated gentlemen, and that therefore it is wrong to impute to them the narrow-mindedness of the practical man. I agree that in numerous instances this would be wrong; but the fact is that, in many cases—I think I may say in most cases—the head of the establishment, the moneyed man, the man who, by his commercial ability (that most necessary element in all establishments), keeps the concern going by finding lucrative orders, is not intimately acquainted with the practice of the business carried on by his firm; he relies upon some manager or foreman, who, too commonly, is not the real, but the so-called practical man. It is such men as those who simply practise that which they have seen, without knowing why they practise it. To them the title of practical man has most improperly been attributed, and it is on the advice of such men that the true heads of the firm too commonly regulate their conduct as to the management of their business, and as to the necessary changes to be made in the way of improvement.

As I have said, the practical man derides those who bring forward new inventions, and calls them schemers. No doubt, whatever they do scheme—and well it is for the country that there are men who do so—it also may be true that the majority of schemes prove abortive; but it must be recollected that the whole progress of art and manufacture has depended and will depend upon successful discoveries which, in their inception, were and will be schemes just as much as were those discoveries that have been and will be unfruitful; but the successful discoveries, because they are successful, are taken out of the category of schemes when years of untiring application on the part of the inventors have, so to speak, thrust them down the throat of the unwilling practical man. Take the instance of Mr. Bessemer, who was beset for years by difficulties of detail in his great scheme of improvement in the manufacture of steel. As long as he was so beset the practical men chorused, "He is a schemer; he is one of the schemers; it is a scheme." Supposing that these practical difficulties had beaten Mr. Bessemer, and that they had not been overcome to this day? The practical man would have derided him still as a schemer, although the theory and groundwork of his invention would have been as true under these circumstances as it now is. Fortunately for the world, and happily for him, he was able to overcome these most vexatious hindrances and make his invention that which it is. No one now dares apply the term "schemer" to Mr. Bessemer, or "scheme" to his invention, but it is as true now that he is a "schemer" and his invention a "scheme" as it would have been had he failed up to the present to conquer the minor difficulties. It is a species of profanation to suggest, but I must suggest it, for it is true, that Watt, Stephenson, Faraday, and almost every other name among the honored dead to whose inventive genius we owe the development that has taken place within the last century in all the luxuries, the comforts, even the bare necessities of our daily existence, would, in their day, and while struggling for success, have been spoken of as schemers, even in respect of those very inventions of which we are now enjoying the fruits. But I feel I need not labor this point further at a meeting of the Mechanical Section of the British Association, an association established for the advancement of science. I know I shall be accused of decrying the practical man and of upholding the "schemers." I say most emphatically that I do not decry the practical man; I plead guilty to the charge of decrying the miscalled practical man, and I glory in my guilt, while I readily accept that which I consider the praise of upholding "schemers," and I do so for this simple reason, that, if there were no schemers, there would be no improvement. I think it becomes a scientific body like the British Association to laud the generous effort of the unsuccessful inventor, rather than to encourage the cold selfishness of the man who stands by and sees others endeavor to raise the structure of improvement without lending a hand to help, and even sneers at the builders, but, when the structure is fully raised and solidly established, claims to come in to inhabit, and, being in, probably essays, cuckoo-like, to oust the builders and to take possession for his own benefit.

DEVELOPMENT IN DRESS.

By GEORGE H. DARWIN.

THE development of dress presents a strong analogy to that of organisms, as explained by the modern theories of evolution; and in this article I propose to illustrate some of the features which they have in common. We shall see that the truth expressed by the proverb, "Natura non facit saltum," is applicable in the one case as in the other; the law of progress holds good in dress, and forms blend into one another with almost complete continuity. In both cases a form yields to a succeeding form, which is better adapted to the then surrounding conditions; thus, when it ceased to be requisite that men in active life should be ready to ride at any moment, and when riding had for some time ceased to be the ordinary method of travelling, knee-breeches and boots yielded to trousers. The "Ulster coat," now so much in vogue, is evidently largely fostered by railway-travelling, and could hardly have flourished in the last century, when men either rode or travelled in coaches, where there was no spare room for any very bulky garment.

A new invention bears a kind of analogy to a new variation in animals; there are many such inventions, and many such variations; those that are not really beneficial die away, and those that are really good become incorporated by "natural selection," as a new item in our system. I may illustrate this by pointing out how macintosh-coats and crush-hats have become somewhat important items in our dress.

Then, again, the degree of advancement in the scale of dress may be pretty accurately estimated by the extent to which various "organs" are specialized. For example, about sixty years ago, our present evening-dress was the ordinary dress for gentlemen; top-boots, always worn by old-fashioned "John Bull" in *Punch's* cartoons, are now reserved for the hunting-field; and that the red coat was formerly only a best coat, appears from the following observations of a "Lawyer of the Middle Temple," in No. 129 of the *Spectator:* "Here (in Cornwall) we fancied ourselves in Charles II.'s reign—the people having made little variations in their dress since that time. The smartest of the country squires appear still in the Monmouth cock; and when they go a-wooing (whether they have any post in the militia or not) they put on a red coat."[1]

But besides the general adaptation of dress above referred to, there is another influence which has perhaps a still more important bearing on the development of dress, and that is fashion. The love of novelty, and the extraordinary tendency which men have to exaggerate any peculiarity, for the time being considered a mark of good station in life, or handsome in itself, give rise, I suppose, to fashion. This influence bears no distant analogy to the "sexual selection," on which so much stress has recently been laid in the "Descent of Man." Both in animals and dress, remnants of former stages of development survive to a later age, and thus preserve a tattered record of the history of their evolution.

These remnants may be observed in two different stages or forms: 1. Some parts of the dress have been fostered and exaggerated by the selection of fashion, and are then retained and crystallized, as it were, as part of our dress, notwithstanding that their use is entirely gone (e. g., the embroidered pocket-flaps in a court uniform, now sewn fast to the coat). 2. Parts originally useful have ceased to be of any service, and have been handed down in an atrophied condition.

The first class of cases have their analogue in the peacock's tail, as explained by sexual selection; and the second in the wing of the apteryx, as explained by the effects of disuse.

Of the second kind of remnant Mr. Tylor gives very good instances when he says:[2] "The ridiculous little tails of the German postilion's coat show of themselves how they came to dwindle to such absurd rudiments; but the English clergyman's bands no longer convey their

[1] *See* p. 356 of Fairholt's "Costume in England," London, 1846.

[2] "Primitive Culture," vol. i., p. 16, London, 1871.

history to the eye, and look unaccountable enough till one has seen the intermediate stages through which they came down from the more serviceable wide collars, such as Milton wears in his portraits, and which gave their name to the 'band-box' they used to be kept in." These collars are, curiously enough, worn to this day by the choristers of Jesus College, Cambridge.

According to such ideas as these, it becomes interesting to try to discover the marks of descent in our dresses, and in making this attempt many things apparently meaningless may be shown to be full of meaning.

Women's dress retains a general similarity from age to age, together with a great instability in details, and therefore does not afford so much subject for remark as does men's dress. I propose, therefore, to confine myself almost entirely to the latter, and to begin at the top of the body, and to work downward through the principal articles of clothing.

Hats.—Hats were originally made of some soft material, probably of cloth or leather, and, in order to make them fit the head, a cord was fastened round them, so as to form a sort of contraction. This is illustrated on p. 524 of Fairholt's "Costume in England," in the figure of the head of an Anglo-Saxon woman, wearing a hood bound on with a head-band; and on p. 530 are figures of several hats worn during the fourteenth century, which were bound to the head by rolls of cloth; and all the early hats seem provided with some sort of band. We may trace the remnants of this cord or band in the present hat-band. A similar survival may be observed in the strings of the Scotch-cap, and even in the mitre of the bishop.[1]

It is probable that the hat-band would long ago have disappeared had it not been made use of for the purpose of hiding the seam joining the crown to the brim. If this explanation of the retention of the hat-band is the true one, we have here a part originally of use for one purpose applied to a new one, and so changing its function; a case which has an analogy to that of the development of the swimming-bladders of fishes, used to give them lightness in the water, into the lungs of mammals and birds, used as the furnace for supporting animal heat.

The duties of the hat-band have been taken in modern hats by two running strings fastened to the lining, and these again have in their turn become obsolete, for they are now generally represented by a small piece of string, by means of which it is no longer possible to make the hat fit the head more closely.

The ancestor from which our present chimney-pot hat takes most of its characteristics is the broad-brimmed, low-crowned hat, with an immense plume falling down on to the shoulder, which was worn during the reign of Charles II.[2] At the end of the seventeenth, and during

[1] For the origin of this curious head-dress, *see* Fairholt, p. 564. [2] Ibid., p. 540.

the eighteenth century, this hat was varied by the omission of the plume, and by giving of the brim various "cocks." That these "cocks" were formerly merely temporary is shown by Hogarth's picture of Hudibras beating Sidrophel and his man Whacum, where there is a hat, the brim of which is buttoned up in front to the crown with three buttons. This would be a hat of the seventeenth century. Afterward, during the eighteenth century, the brim was bent up in two or three places, and, notwithstanding that these "cocks" became permanent, yet the hats still retained the marks of their origin in the button and strap on the right side. The cockade, I imagine, took its name from its being a badge worn on one of the "cocks."

The modern cocked-hat, apparently of such an anomalous shape, proves, on examination, to be merely a hat of the shape above referred to; it appears further that the right side was bent up at an earlier date than the left, for the hat is not symmetrical, and the "cock" on the right side forms a straight crease in the (quondam) brim, and that on the left is bent rather over the crown, thus making the right side of the hat rather straighter than the left. The hat-band here remains in the shape of two gold tassels, which are just visible within the two points of the cocked-hat.

A bishop's hat shows the transition from the three-cocked hat to our present chimney-pot; and because sixty years ago beaver-fur was the fashionable material for hats, we must now needs wear a silken imitation, which could deceive no one into thinking it fur, and which is bad to resist the effects of weather. Even in a lady's bonnet the elements of brim, crown, and hat-band, may be traced.

The "busby" of our hussars affords a curious instance of survival. It would now appear to be merely a fancy head-dress, but on inspection it proves not to be so. The hussar was originally a Hungarian soldier, and he brought his hat with him to our country. I found the clew to the meaning of the hat in a picture of a Hungarian peasant. He wore a red nightcap, something like that worn by our brewers' men, or by a Sicilian peasant, but the cap was edged with so broad a band of fur that it made in fact a low "busby." And now in our hussars the fur has grown enormously, and the bag has dwindled into a flapping ornament, which may be detached at pleasure. Lastly, in the new "busby" of the Royal Engineers the bag has vanished, although the top of the cap (which is made of cloth and not of fur) is still blue, as was the bag formerly; the top cannot, however, be seen, except from a bird's-eye point of view.

It appears that all cockades and plumes are worn on the left side of the hat, and this may, I think, be explained by the fact that a large plume, such as that worn in the time of Charles II., or that of the modern Italian Bersaglieri, would impede the free use of the sword; and this same explanation would also serve to show how it was that the right side of the hat was the first to receive a "cock." A London servant would be little inclined to think that he wears his cockade on the left side to give his sword-arm full liberty.

Coats.—Every one must have noticed the nick in the folded collar of the coat and of the waistcoat; this is of course made to allow for the buttoning round the neck, but it is in the condition of a rudimentary organ, for the nick would probably not come into the right place, and in the waistcoat at least there are usually neither the requisite buttons nor button-holes.

"The modern gentleman's coat may be said to take its origin from the *vest*, or long outer garment, worn toward the end of the reign of Charles II."[1] This vest seems to have had no gathering at the waist, and to have been buttoned all down the front, and in shape rather like a loose bag; to facilitate riding it was furnished with a slit behind, which could be buttoned up at pleasure; the button-holes were embroidered, and, in order to secure similarity of embroidery on each side of the slit, the buttons were sewn on to a strip of lace matching the corresponding button-hole on the other side. These buttons and button-holes left their marks in the coats of a century later in the form of gold lacing on either side of the slit of the tails.

In about the year 1700, it began to be the fashion to gather in the vest or coat at the waist, and it seems that this was first done by two buttons near the hips being buttoned to loops rather nearer to the edge of the coat, and situated at about the level of the waist. Our soldiers much in the same manner now make a waist in their loose overcoats, by buttoning a short strap to two buttons, placed a considerable distance apart on the back.

This old fashion is illustrated in a figure dressed in the costume of 1696, in an old illustration of the "Tale of the Tub," and also in the figure of a dandy smelling a nosegay, in Hogarth's picture, entitled "Here Justice triumphs in his Easy-Chair," etc., as well as elsewhere. Engravings of this transition period of dress are, however, somewhat rare, and it is naturally not common to be able to get a good view of the part of the coat under the arms. This habit of gathering in the waist will, I think, explain how it was that, although the buttons and button-holes were retained down the front edges, the coat came to be worn somewhat open in front.

The coat naturally fell in a number of plaits or folds below these hip-buttons; but in most of Hogarth's pictures, although the buttons and plaits remain, yet the creases above the buttons disappear, and seams appear to run from the buttons up under the arms. It may be worth mentioning that in all such matters of detail Hogarth's accuracy is notorious, and that therefore his engravings are most valuable for the study of the dress of the period. At the end of the seventeenth, and at the beginning of the eighteenth centuries, coats seem very commonly to have been furnished with slits running from the edge of the

[1] Fairholt, p. 479.

skirt, up under the arms, and these were made to button up, in a manner similar in all respects to the slit of the tails. The sword was usually worn under the coat, and the sword-hilt came through the slit on the left side. Later on these slits appear to have been sewed up, and the buttons and button-holes died away, with the exception of two or three buttons just at the tops of the slits; thus in coats of about the year 1705, it is not uncommon to see several buttons clustered about the tops of all three slits. The buttons at the top of the centre slit entirely disappeared, but the two buttons now on the backs of our coats trace their pedigree up to those on the hips. Thus it is not improbable that, although our present buttons represent those used for making the waist, as above explained, yet that they in part represent the buttons for fastening up these side-slits.

The folds which we now wear below the buttons on the back are the descendants of the falling plaits, notwithstanding that they appear as though they were made for, and that they are in fact commonly used as, the recesses for the tail-pockets; but that this was not their original object is proved by the fact that during the last century the pockets were either vertical or horizontal, placed a little in front of the two hip-buttons (which have since moved round toward the back), and had highly-embroidered flaps, buttons, and button-holes. The horizontal pockets may now be traced in the pocket-flaps of court-dress before alluded to; and the vertical pocket is represented by some curious braiding and a row of buttons, which may be observed on the tails of the tunics of the Foot-Guards. The details of the manner in which this last rudiment became reduced to its present shape may be traced in books of uniforms, and one of the stages may now be frequently seen in the livery of servants, in the form of a row of three or four buttons running down near the edge of the tail, *sewn* on to a scalloped patch of cloth (the pocket-flap), which is itself sewed to the coat.

In the last century, when the coats had large flapping skirts, it became the custom (as may be seen in Hogarth's pictures) to button back the two corners of the coat, and also to button forward the inner corners, so as to separate the tails for convenience in riding.[1] This custom left its traces in the uniform of our soldiers down to the introduction of the modern tunic, and such traces may still be seen in some uniforms, for example, those of a lord-lieutenant and of the French gensdarmerie. In the uniforms of which I speak, the coats have swallow-tails, and these are broadly edged with a light-colored border, tapering upward and getting broader downward; at the bottom of the tail, below where the borders join (at which joining there is usually a button), there is a small triangle of the same color as the coat with its apex at this button. This curious appearance is explained thus: the two corners, one of which is buttoned forward and the

[1] It seems to have been in actual use in 1760, although not in 1794. *See* Cannon's "Hist. Rec. of British Army" (London, 1837), the Second Dragoon Guards

other backward, could not be buttoned actually to the edge of the coat, but had to be fastened a little inland as it were; and thus part of the coat was visible at the bottom of the tail: the light-colored border, although sewn to the coat, evidently now represents the lining, which was shown by the corners being turned back.

It was not until the reign of George III. that coats were cut back at the waist, as are our present evening-coats; but since, before that fashion was introduced, the coats had become swallow-tailed in the manner explained, it seems likely that this form of coat was suggested by the previous fashion. And, indeed, stages of development of a somewhat intermediate character may be observed in old engravings. In the uniforms of the last century the coats were double-breasted, but were generally worn open, with the flaps thrown back and buttoned to rows of buttons on the coat. These flaps, of course, showed the lining of the coat, and were of the same color as the tails; the button-holes were usually embroidered, and thus the whole of the front of the coat became richly laced. Toward the end of the century the coats were made tight, and were fastened together in front by hooks, but the vestiges of the flaps remained in a double line of buttons, and in the front of the coat being of a different color from that of the rest, and being richly laced. A uniform of this nature is still retained in some foreign armies. This seems also to explain the use of the term "facings" as applied to the collar and cuffs of a uniform, since, as we shall see hereafter, they would be of the same color as these flaps. It may also explain the habit of braiding the front of a coat, as is done in our hussar and other regiments.

In a "History of Male Fashions," published in the *London Chronicle* in 1762, we find that "surtouts have now four laps on each side, which are called 'dog's ears;' when these pieces are unbuttoned, they flap backward and forward, like so many supernumerary patches just tacked on at one end, and the wearer seems to have been playing at backswords till his coat was cut to pieces. . . . Very spruce *smarts* have no buttons nor holes upon the breast of these their surtouts, save what are upon the ears, and their garments only wrap over their bodies like a morning-gown." These dog's ears may now be seen in a very meaningless state on the breasts of the patrol-jackets of our officers, and this is confirmed by the fact that their jackets are not buttoned, but fastened by hooks.

In early times, when coats were of silk or velvet, and enormously expensive, it was no doubt customary to turn up the cuffs, so as not to soil the coat, and thus the custom of having the cuffs turned back came in. During the latter part of the seventeenth and during the eighteenth century, the cuffs were very widely turned back, and the sleeves consequently very short, and this led to dandies wearing large lace cuffs to their shirts.

The pictures of Hogarth and of others show that the coat-cuffs were buttoned back to a row of buttons running round the wrist. These buttons still exist in the sleeves of a Queen's Counsel, although the cuffs are sewed back and the button-holes only exist in the form of pieces of braid. This habit explains why our soldiers now have their cuffs of different colors from that of their coats; the color of the linings was probably determined for each regiment by the colonel for the time being, since he formerly supplied the clothing; and we know that the color of the facings was by no means fixed until recently. The shape of the cuff has been recently altered in the line regiments, so that all the original meaning is gone.

In order to allow of turning back with ease, the sleeve was generally split on the outer side, and this split could be fastened together with a line of buttons and embroidered holes. In Hogarth's pictures some two or three of these buttons may be commonly seen above the reversed cuff; and notwithstanding that at first the buttons were out of sight (as they ought to be) in the reversed part of the cuff, yet after the turning back had become quite a fixed habit, and when sleeves were made tight again, it seems to have been usual to have the button for the cuff sewed on to the proper inside, that is to say, the real outside of the sleeve.

The early stage may be seen in Hogarth's picture of the "Guards marching to Finchley," and the present rudiment is excellently illustrated in the cuffs of the same regiments now. The curious buttons and gold lace on the cuffs and collars of the tunics of the Life-Guards have the like explanation, but this is hardly intelligible without reference to a book of uniforms, as for example Cannon's "History of the Second Dragoon Guards."

The collar of a coat would in ordinary weather be turned down and the lining shown; hence the collar has commonly a different color from that of the coat, and in uniforms the same color as have the cuffs, which form, with the collars, the so-called "facings." A picture of Lucien Bonaparte in Lacroix's work on Costume shows a collar so immense that were it turned up it would be as high as the top of his head. This drawing indicates that even the very broad stand-up collars worn in uniforms in the early part of this century, and of a different color from that of the coat, were merely survivals of an older form of turn-down collar. In these days, notwithstanding that the same difference in color indicates that the collar was originally turned down, yet in all uniforms it is made to stand up.

The pieces of braid or seams which run round the wrist in ordinary coats are clearly the last remains of the inversion of the cuffs.

Trousers.—I will merely observe that we find an intermediate stage between trousers and breeches in the pantaloon, in which the knee-buttons of the breeches have walked down to the ankle. I have seen also a German servant who wore a row of buttons running from the knee to the ankle of his trousers.

Boots.—One of the most perfect rudiments is presented by top-boots. These boots were originally meant to come above the knee; and, as may be observed in old pictures, it became customary to turn the upper part down, so that the lining was visible all round the top. The lining being of unblacked leather, formed the brown top which is now worn. The original boot-tag may be observed in the form of a mere wisp of leather sewn fast to the top, while the real acting tag is sewn to the inside of the boot. The back of the top is also fastened up, so that it could not by any ingenuity be turned up again into its original position.

Again, why do we black and polish our boots? The key is found in the French *cirage*, or blacking. We black our boots because brown leather would, with wet and use, naturally get discolored with dark patches, and thus boots to look well should be colored black. Now, shooting-boots are usually greased, and that it was formerly customary to treat ordinary boots in the same manner is shown by the following verse in the ballad of "Argentile and Curan:"

"He borrowed on the working daies
His holy russets oft,
And of the bacon's fat to make
His startops black and soft."

Startops were a kind of rustic high shoes. Fairholt in his work states that "the oldest kind of blacking for boots and shoes appears to have been a thick, viscid, oily substance." But for neat boots a cleaner substance than grease would be required, and thus wax would be thought of; and that this was the case is shown by the French word *cirer*, which means indifferently to "wax" or to "polish boots." Boots are of course polished because wax takes so good a polish. Lastly, patent-leather is an imitation of common blacking.

I have now gone through the principal articles of men's clothing, and have shown how numerous and curious are the rudiments or "survivals," as Mr. Tylor calls them; a more thorough search proves the existence of many more. For instance, the various gowns worn at the universities and elsewhere, afford examples. These gowns were, as late as the reign of Queen Elizabeth, simply upper garments,[1] but have survived into this age as mere badges. Their chief peculiarities consist in the sleeves, and it is curious that nearly all of such peculiarities point to various devices by which the wearing of the sleeves has been eluded or rendered less burdensome. Thus the plaits and buttons in a barrister's gown, and the slit in front of the sleeve of the B. A.'s gown, are for this purpose. In an M. A.'s gown the sleeves extend below the knees, but there is a hole in the side through which the arm is passed; the end of the sleeve is sewed up, but there is a kind of scallop at the lower part, which represents the narrowing for the

[1] *See* figures, pp. 254, 311, Fairholt.

wrist. A barrister's gown has a small hood sewed to the left shoulder, which would hardly go on to the head of an infant, even if it could be opened out into a hood-shape.

It is not, however, in our dress alone that these survivals exist; they are to be found in all the things of our every-day life. For instance, any one who has experienced a drive on a road so bad that leaning back in the carriage is impossible, will understand the full benefit to be derived from arm-slings such as are placed in first-class railway-carriages, and will agree that in such carriages they are mere survivals. The rounded tracery on the outsides of railway-carriages shows the remnants of the idea that a coach was the proper pattern on which to build them; and the word "guard" is derived from the man who sat behind the coach and defended the passengers and mails with his blunderbuss.

In the early trains (1838–'39) of the Birmingham Railway there were special "mail" carriages, which were made very narrow, and to hold only four in each compartment (two and two), so as to be like the coach they had just superseded.

The words *dele*, *stet*, used in correcting proof-sheets, the words *sed vide* or *s. v.*, *ubi sup.*, *ibid.*, *loc. cit.*, used in foot-notes, the sign "&," which is merely a corruption of the word *et*, the word *finis*, until recently placed at the ends of books, are all doubtless survivals from the day when all books were in Latin. The mark ∧ used in writing for interpolations appears to be the remains of an arrow pointing to the sentence to be included. The royal "broad-arrow" mark is a survival of the head of "a barbed javelin, carried by sergeants-at-arms in the king's presence as early as Richard the First's time."[1] Then, again, we probably mount horses from the left side lest our swords should impede us. The small saddle on the surcingle of a horse, the seams in the backs of cloth-bound books, and those at the backs of gloves, are rudiments—but to give a catalogue of such things would be almost endless. I have said enough, however, to show that by remembering that there is *nihil sine causa*, the observation of even common things of every-day life may be made less trivial than it might at first sight appear.

It seems a general rule that on solemn or ceremonial occasions men retain archaic forms; thus it is that court-dress is a survival of the every-day dress of the last century; that uniforms in general are richer in rudiments than common dress; that a carriage with a postilion is *de rigueur* at a wedding; and that (as mentioned by Sir John Lubbock) the priests of a savage nation, acquainted with the use of metals, still use a stone knife for their sacrifices—just as Anglican priests still prefer candles to gas.

The details given in this article, although merely curious, and perhaps insignificant in themselves, show that the study of dress from an

[1] Fairholt, p. 580.

evolutional stand-point serves as yet one further illustration of the almost infinite ramifications to which natural selection and its associated doctrines of development may be applied.—*Macmillan's Magazine.*

SUNLIGHT, SEA, AND SKY.

By WILLIAM SPOTTISWOODE, F. R. S.

THERE are many ways in which men have looked at life, the higher kind of life, that ideal which each of us forms in his own mind, to which we each hope that we are always tending. But all these various ideas may for the most part be grouped under two heads: the Ideal of Rest and the Ideal of Work. "Rest, rest!" said a brave old German worker, "shall I not have Eternity to rest in?" That represents one view. "Work, work!" said another; "must I not work now, that I may the better work in Eternal Life?" That represents the other. But, without entering upon the somewhat transcendental question of a future life, these ideas and aspirations have a meaning and reality even in the life which we now live. How do we hope to spend the leisure which old age may some day bring? Or, nearer still, when the day's work is done, and the day itself is not quite spent; or when such holiday as may befall each of us comes round, how do we hope to spend the time? Do we long for mere rest, for that

"land
In which it seemed always afternoon?"

Do we desire to sit us

"down upon the yellow sand
Between the sun and moon upon the shore,"

and sing with the lotus-eaters:

"All things have rest; why should we toil alone,
Nor steep our brows in slumber's holy balm,
Nor hearken what the inner spirit sings.
There is no joy but calm?"

Or do we rather with Ulysses say:

"How dull to pause, to make an end,
To rust unburnished, not to shine in use!
As though to breathe were life. Life piled on life
Were all too little, and of one to me
Too little remains; but every hour is saved
From that eternal silence, something more,
A bringer of new things; and vile it were
For some [few] suns to store and hoard myself,
And this gray spirit yearning in desire
To follow knowledge like a sinking star
Beyond the utmost bounds of human thought."

To which of these two ideals I myself lean has perhaps already betrayed itself; and that being so, I shall venture to consider your presence here a proof that, for this evening at least, you side with me, and that you are willing to spend an hour of your leisure in an intellectual effort to see a little deeper into those phenomena which Nature in this place and at this season displays with such profusion and splendor.

But at the outset I must warn you that we are met by a difficulty, for the surmounting of which you must rely upon yourselves rather than upon me. It is this: the phenomena to which I propose to draw your attention, although taking place nearly every day, and all day long, and in almost every direction, are veiled from our eyes; and it is only by the use of special appliances to aid our eyes that they can be made visible. It will be my business to supply these appliances, and, reproducing on such scale as may be possible within these four walls the optical processes which are going on in the sea and sky outside, to exhibit the hidden phenomena of which I am speaking. But it must be your part to transport yourselves mentally from the mechanism of the lecture-room to the operations of Nature, and by a "scientific use of the imagination" (to adopt what has now become a household word at these meetings) to connect the one with the other.

Now the main point in question is this: that light, when subjected to the very ordinary processes of reflection from smooth surfaces, such as a window, a mahogany table, or the sea itself, or when scattered to us from the deep clear sky, undergoes in many cases some very peculiar changes, the character and causes of which we have come here to investigate. The principal appliance which will be used to detect the existence of such changes, as well as to examine their nature, consists of this piece of Iceland spar, called—from the man who first constructed a compound block of the kind—a Nicol's prism, and this plate of quartz or rock crystal; both of which, as you will observe when the light passes through them, are clear, transparent, and colorless, and both of which transmit the direct light from the electric lamp with equal facility, however they may be turned round about the beam of light as an axis.

If, however, instead of allowing the beam to fall directly upon the Nicol, we first cause it to be reflected from this plate of glass, we shall find that the process of reflection has put the light into a new condition. The light is no longer indifferent to the rotation of the Nicol; in one position of the Nicol the light passes as before, but as the instrument is turned round the light gradually fades, and when it is turned through a right angle the light is extinguished. Beyond this position the light reappears, and the same changes of fading and revival are observed in the light for every right angle through which the instrument is turned.

But these phenomena are susceptible of a very beautiful modification by the interposition of this plate of quartz between the reflecting surface and the Nicol. The changes in the light are no longer mere alterations of brightness, but exhibit a succession of colors resembling in their main features those of the rainbow or spectrum.

The peculiar condition to which light must be brought in order that these phenomena may be produced is called polarization; and, although an explanation of its nature must be reserved until later, I beg you to notice that it is effected in this instance by reflection from a plate of glass. A similar effect is produced if light be reflected from many other substances, such as the leaves of trees, particularly ivy, mahogany furniture, windows, shutters, and often roofs of houses, oil-paintings, etc., and last, but not least, the surface of water. In each of these cases the alternations of light and darkness are most strongly marked, and the colors (if a quartz plate be used) are most vivid, or, in technical language, the polarization is most complete, when the light is reflected from each substance at a particular angle. In proportion as the inclination of the light deviates from this angle the colors become fainter, until, when it deviates very greatly, all trace of polarization at last disappears. Without occupying the time necessary to shift our apparatus so as to exhibit this with the glass plate, we may alter the reflecting surface from glass to water, and, by projecting on the screen the beautiful phenomena of liquid waves, make visible the different degrees of polarization produced at the variously-inclined portions of the surfaces of those waves. A tea-tray will serve as well as any thing else to form our little sea, and a periodic tap at one corner will cause ripple enough for our present purpose. The waves now appear bright on the screen, and, although brighter in some parts than in others, they are nowhere entirely dark. But on turning round the Nicol the contrast of light and darkness becomes much stronger than before. Here and there the light is absolutely extinguished; in these parts the polarization is complete, in others incomplete in various degrees. And if the quartz plate be again introduced we have the beautiful phenomena of iris-colored rings playing over the surface of our miniature sea.

Now, that which you see here produced by our lamp and tea-tray, you may see any day under the bright sky of this southern coast. By using an apparatus such as we have here, or a simpler one which I will immediately describe, you may bring out for yourselves these phenomena of color, and thereby detect the profusion of polarization which Nature sheds around us. But, before describing it, there is one peculiar feature of all these experiments which must be noticed—namely, that the same results would be produced if we changed the positions of the lamp and the screen. The light which is now polarized by the glass or the water, and examined by the Nicol, might equally well be polarized by the Nicol and examined by the glass or the water. And, therefore, if we find that any contrivance will serve for the one purpose, we may conclude that it will serve equally well for the other.

And now a word about that simpler apparatus. When light falls upon a transparent substance, part is reflected, part transmitted. If, therefore, the reflected part is polarized (and you have already seen that this is sometimes the case), it is not surprising that the transmitted part should be so also. And further, if the polarization by a single reflection or transmission is incomplete, it will become more and more complete by a repetition of the processes. This being so, if we take a pile of glass plates—say half a dozen, more or less, the thinner the better—and hold them obliquely before our eye at an angle of about 30° (say one-third of a right angle) to the direction in which we are looking, we shall have all that is necessary to detect the presence of polarization; and if, further, we hold a piece of talc or mica, such as is commonly used as a cover to the globes of gas-burners, beyond the pile of plates, color will be produced in the same general manner as with the quartz, although with some essential difference in detail.

Suppose that we now turn our attention from the sea to the sky, and that on a clear, bright day we sweep the heavens with our apparatus, or polariscope, as it is called, we shall find traces of polarization colors brought out in a great many directions. But if we observe more closely we shall find that the most marked effects are produced in directions at right angles to that of the sun, when, in fact, we are looking across the direction of the solar beams. Thus, if the sun were just rising in the east or setting in the west, the line of most vivid effect would lie on a circle traced over the heavens from north to south. If the sun were in the zenith, or immediately overhead, the most vivid effects would be found round the horizon; while at intermediate hours the circle would shift round at the same rate as the clock, so as always to retain its direction at right angles to that of the sun.

Now, what is it that can produce this effect—or what even produces the light from all parts of a clear sky? The firmament is not a solid sphere or canopy, as was once supposed; it is clear, pure space, with no contents, save a few miles of the atmosphere of our earth, and beyond that the impalpable fluid or ether, as it is called, which is supposed to pervade all space, and to transmit light from the further limits of the stellar universe. But, apart from this ether, which is certainly inoperative to produce the sky appearance as we see it, a very simple experiment will suffice to show that a diffusion, or, as it has been better called, a scattering of light, is due to the presence of small particles in the air. If a beam from the electric lamp, or from the sun if we had it, be allowed to pass the room, its track becomes visible, as is well known by its reflection from the motes or floating bodies, in fact by the dust in the air. But if we clear the air of dust, as I now do by burning it with a spirit-lamp placed underneath, the beam disappears from the parts so cleared, and the space becomes dark. If, therefore, the air were absolutely pure and devoid of matter foreign to it, the azure of the sky would be no longer seen, and the heavens would appear black; the illumination of objects would be strong and glaring on the one side, and on the other their shadows would be deep, and unrelieved by the diffused light to which we are accustomed.

Now, setting aside the dust, of which we may hope that there is but little on the downs behind your town, or out to sea in front, there are always minute particles of water floating in the atmosphere. These vary in size from the great rain-drops which fall to earth on a sultry day, through the intermediate forms of mist and of fine, fleecy cloud, to the absolutely invisible minuteness of pure aqueous vapor which is present in the brightest of skies. It is these particles which scatter the solar rays, and suffuse the heavens with light. And it is a curious fact, established by Prof. Tyndall while operating with minute traces of gaseous vapors (which I can only notice in passing, because it belongs only in part to our present subject), that while coarse particles scatter rays of every color equally—in other words, scatter white light—finer particles scatter fewer rays from the red end of the spectrum, while the finest scatter only those from the blue end. And, in accordance with this law, clouds are white, clear sky is blue.

But besides this fact, viz., that light scattered laterally from fine particles is blue, the same philosopher perceived that light so scattered is polarized; and by that observation he again connected the celestial phenomena described above with laboratory experiments.

By a slight modification of his experiment, due to Prof. Stokes, I hope to make this visible to the audience. It will probably be in your recollection that when polarized light passed through a Nicol, its intensity is unaltered when the Nicol is in one position, but it is destroyed when it is in another at right angles to the first. I now pass the beam from the electric lamp through a tube of water containing a few drops of mastic dissolved in alcohol. The mixture so formed holds fine particles of mastic in a state of suspension; these scatter the light laterally, so as to be visible, I hope, to the entire audience. And if we were to examine with a Nicol this scattered light, we should find the phenomena of polarization. But, better still, we can cause the light to pass through the Nicol before being scattered, and produce the same effect, not only upon the particular part to which our eye is directed, but upon the whole body of scattered light. As the Nicol is turned, the light seen laterally begins to fade; and when the instrument has been turned through a right angle, the only parts remaining visible are those which are reflected from the larger impurities floating in the water independently of the mastic. An effect still more beautiful, and at the same time more instructive, can be produced by interposing, as was done in the case of reflection, a plate of quartz between the Nicol and the medium which causes polarization. The whole beam is now suffused with color, the tint of which changes, as did the tints on the waves, while the Nicol is turned round. And not only so, but while the Nicol remains at rest, the tints are to be seen scattered in a regular and definite order in different directions about the sides of the beam. This may be shown by reflecting from a looking-glass a side of the beam not visible directly, and by comparing the tint seen by reflection with that seen direct. But this radial distribution of colors may also be shown in a more striking manner, by putting together two half-plates of quartz of the kinds which have the property of distributing the colors in opposite orders, and by observing the result along the line of junction. The compound plate here used is known by the name of a biquartz, and affords one of the most delicate tests of the presence of polarized light. In this case, when the Nicol is turned round, the colors of the two halves follow one another in opposite orders; and as each series is completed twice in a revolution of the Nicol, the halves of the quartz will be of the same color four times in a revolution—twice of one color and twice of its complementary.

The colors which we have here seen are those which would be observed, as before remarked, upon examining a clear sky in a position at right angles to that of the sun; and the exact tint visible will depend upon the position in which we hold the Nicol, as well as upon that of the sun. Suppose, therefore, we direct our apparatus to that part of the sky which is all day long at right angles to the sun, that is, to the region about the north-pole of the heavens (accurately to the north-pole at the vernal and autumnal equinox); then, if on the one hand we turn the Nicol round, say in a direction opposite to that of the sun's motion, the colors will change in a definite order; if, on the other, we hold it fixed, and allow the sun to move round, the colors will change in a similar manner. And thus, in the latter case, we might conclude the position of the sun, or, in other words, the time of day, by the colors so shown. This is the principle of Sir Charles Wheatstone's polar clock; one of the few practical applications which this branch of polarization has yet found. The action of such a clock may be thus roughly shown: There is now projected upon the screen a dial-plate, in which the hours are arranged in their usual order, but are crowded together into half their usual space, viz., twelve hours occupy half instead of the entire circle. The inner part of the disk is covered with a plate of selenite (mica would serve the purpose equally well), which is capable of revolving about its centre, and which, as you see, in a particular position shows color more strongly than in any other. An hour-hand is roughly drawn upon the plate. The apparatus here used is furnished with two Nicol's prisms, the hinder one of which imitates the polarizing effect of the sun, while that in front is the instrument with which we should examine the north-pole of the sky. The whole is now so arranged that when the plate shows brightest color the hand points to XII., say noon. As the back Nicol is turned round, say as the sun begins to sink, the color fades; and when the plate is turned so as to restore the color, the hand points to I. Similarly, as the back Nicol is turned gradually farther, representing the passage of the sun westward during the afternoon, the position of the plate giving the strongest color, as indicated by the hand, corresponds to the successive hours of the dial; and when the Nicol has been turned through 90°, that is, when the sun has reached the horizon, the hand has moved from XII. to VI. In this way, as its inventor has remarked, a dial may be constructed which will work equally well in sunshine or in shade, or even when the sun itself is overcast, provided only that there be a patch of clear sky to the north.

Up to this point we have reproduced in an experimental fashion the general every-day phenomena, both celestial and terrestrial, which give rise to polarization; and we have given such general account of them as will serve to connect them together, and to show that they all belong to one system of laws affecting the nature of light. I should, however, regret, and I feel confident that you would share in that regret, if we were to leave the subject with its surface as it were merely scratched, and without any attempt to penetrate deeper into its substance. With your permission, therefore, we will devote such time as you may be still willing to grant me to a few elementary experiments in polarization, which, while certainly not less beautiful than those which you have already seen, will, perhaps, better illustrate the nature of the processes which we are now trying to investigate.

Polarized light, as indicated at the outset, is distinguished from common light by the presence of certain peculiarities not ordinarily found, and these peculiarities are to be detected only by means of special instruments. Light which has been reflected or transmitted at particular angles from various substances, light which has been scattered by small particles, is found to be in this peculiar condition. So likewise is light which has passed through this transparent piece of Iceland spar, or Nicol's prism, as it is called. Yet the light which has so passed through, and which is now projected on the screen, is to the unaided eye in no way different from the same light before its passage. Nevertheless, if we examine or analyze it by means of a second Nicol, we shall find the peculiarity of its condition revealed. For if either of the Nicols be turned gradually round (and remember that they are both transparent, colorless blocks of crystal) the light gradually fades until, when it has been turned through a right angle, the light is absolutely extinguished. On turning the Nicol farther the light revives, and afterward again fades, in such a manner that in a complete revolution the light is twice at its brightest, and twice is extinguished. Now, light is due to extremely small and rapid vibrations of a very subtle medium, which is supposed to pervade all space. The fact that vibrations (i. e., motions to and fro) in one direction can produce waves advancing in another will be familiar to all of you who have watched the movement of a cork floating on the sea. You will have noticed that the cork has simply moved up and down, or nearly so, while the waves have passed, as it were, under it, along the surface of the water.

Now, in order to make clearer to our minds how this wave-motion is produced, I will throw the electric light upon a machine devised for the purpose. You now see a horizontal row of knobs. As the slider is pushed in, the knobs at one end begin to rise in succession until each has in turn attained its greatest elevation. Immediately after reaching its highest position it begins to descend; so that the knobs first rise and then fall in regular succession, and continue to rise and fall in the same manner so long as the motion is continued. Each of the knobs, beginning from number one, is thus successively at the highest position, while at the same moment those immediately before and behind it are at lower positions. And as the knob which is at the highest position represents what we call the crest of the wave, the crest will pass successively along all the knobs, beginning from the first. Thus the waves are transmitted along the line, while the vibrations take place across it. If the line of knobs represent the direction of a ray, their motions will represent the vibrations and waves to which the light is supposed to be due. In ordinary light these vibrations may take place in any directions perpendicular to the ray; and the effect of the crystal of which the Nicol is made, is to restrict these vibrations to a particular direction. In the arrangement now before you the first Nicol causes the vibrations to be altogether horizontal. When the second Nicol is placed similarly to the first, it will obviously have no further effect upon the light; but if it be turned through an angle, it will transmit only vibrations inclined to the horizontal at that angle; that is, only such part of the original horizontal vibrations as can be brought into the inclined direction; in other words, it will transmit only part of the light. And as the inclination is increased the part of the light transmitted will diminish, until, when the second Nicol is in a position to transmit only vertical vibrations (i. e., when it has turned through a right angle), the light will vanish. Such is an explanation of this fundamental experiment in polarization on the principle of what is called the Wave Theory of Light; and I have ventured to give it in some detail, because it is the key to all others, and forms a starting-point for any who may desire to go further in the subject; and it is a remarkable feature in this Wave Theory of Light that the results of many other experimental combinations, to some of which we will now proceed, might be predicted upon the principles already laid down.

If a plate of crystal, such as selenite, be placed between the two Nicols, and turned round in its own plane, it will be found that in certain positions at right angles to one another no effect is produced. These may be called neutral positions. In all other positions the field is tinted with color, which is most brilliant when the plate has been turned through half a right angle from a neutral position. If one of the Nicols be turned, the selenite remaining still, the color will fade and entirely vanish when the Nicol has turned through half a right angle. After this position the complementary color will begin to appear, and will be brightest when the Nicol has completed a right angle.

The colors so produced depend upon the thickness of the plate; thus, if we take a plate of selenite merely split and not ground to a uniform thickness, we shall have a variety of tints indicating the thickness of each particular part; or we may, by a careful arrangement of suitable thicknesses, produce a colored pattern of delicacy and variety dependent only upon the skill with which the pieces have been worked.

A plate of the same crystal worked into a concave form is interesting as showing not only that the colors are dependent upon the thickness, but also that when, with an increasing or diminishing thickness of crystal, they have run through their cycle, they begin again; in other words, that the phenomenon is periodic. The field is then covered with a series of concentric rings, each of which is tinted with colors in a regular order.

In all these instances it is clear, from the experiments themselves, as well as from other experiments which form no part of our present subject, that the modifications which light undergoes are due to the internal structure of the crystals used. And it becomes a question of interest whether it be not possible, by some mechanical process, performed upon a non-cystalline substance, such as glass, so far to imitate a crystalline structure as to reproduce some of the optical results already shown. For this purpose let us take a bar of glass. On interposing it in its natural state between the Nicols when crossed, we find that no effect is produced in the dark field upon the screen. If, however, I merely press it as though with the intention of bending or breaking it, there will be at once brought about a condition of strain capable of affecting the vibrations of the ray falling upon it, to such a degree that some of them will find their way through the screen. And this result may be explained on precisely the same mechanical principles as in the case of the crystal. The effect may be heightened by placing the piece of glass in a vice, and screwing it up so as to bend or compress it to a greater degree than was possible by the hand alone. When this is done the direction and even the relative amount of torsion or compression of the different parts will be noted down as it were by the forms and hues of the figures thrown upon the screen.

The same kind of effect is shown by a piece of glass unevenly heated; but better still by glass which has been rapidly and unevenly cooled—unannealed glass, as it is called. In the pieces now before you, the outside, having become first cooled and solidified, has formed a rigid framework, to which all the interior has been obliged to conform. The interior parts have consequently undergone strains and pressures in different directions and in different degrees, in accordance with which each part has become the subject of a definite internal molecular arrangement; and these, by each in its own way, modifying the light which they transmit, give rise to the figures now before you.

I will conclude this series of experiments by one which, although not so beautiful or striking as those which you have already seen, is still interesting as bringing the subject home to us, and as the only application of polarization to commercial life which has yet been made. You will recollect the brilliant sequence of color shown by a quartz plate when submitted to polarized light. Well, the effects produced by that quartz plate are also produced by not only some other crystals, but, what is very remarkable, also by many of their solutions, e. g., by that of sugar. Into this tube I have put a solution of sugar; when it is placed before the lamp, polarization colors are shown on the screen, while the liquid itself remains colorless. If the solution be strengthened by the addition of more sugar, the tints vary; and, by accurate observation of the colors for different positions of the Nicol, the strength of the solution may be determined. An instrument constructed with proper means of registering these phenomena with accuracy is called a saccharometer.

These experiments may be multiplied almost indefinitely, and many a long winter evening might be spent in following polarization into other branches of science upon which it has something to say. For example, on examining a variety of vegetable and animal tissues, slices of wood, fronds of fern, scales of fish, hair, horn, mother-of-pearl, etc., with a suitable polariscope, we should find that they exhibit, internally, definite structural characters, capable of affecting the light, which they transmit in the same general way as do crystals. Or again, if we were to apply the principles established in an early part of this lecture to the conditions of sky, aspect, and time of day under which the photographer notices that he can obtain the most perfect image in his picture, we should find that they correspond with those which will furnish him with daylight in the most perfectly polarized condition.

Once more, among the many and curious phenomena which are visible during a solar eclipse, there is one which has longer than any other refused to lift its veil to the solicitations of science. I mean that halo of light, or corona as it is called, which extends beyond the dark disk of the moon, beyond those red flames of burning gas which the researches of Lockyer, of Janssen, and of others, have brought almost home to us, far away for millions of miles into distant regions of space. It was preëminently to investigate this phenomenon that the last Eclipse Expedition, furnished with funds by her Majesty's Government at the instance of this British Association, was sent out. And upon this investigation all the powers of the twin instruments of modern times, the spectroscope and the polariscope, were turned. The spectroscope could tell us the nature of the substances to the combustion of which the light is due, and even the conditions of temperature and of pressure under which the combustion is taking place; but it could not disentangle those parts of the phenomenon which are due to direct, from those which are due to reflected or to scattered light. It was for the polariscope to tell us whether the corona is a terrestrial effect—a mere glare, in fact, from our own atmosphere—or a true solar phenomenon; and in the latter issue, whether any of it is due to direct rays from incandescent matter, or all of it to rays originating in such incandescent matter below, but scattered laterally from gases which have cooled in the upper regions surrounding the sun. This question has not even yet received a definitive answer. But the brief account given within the last few days by Mr. Lockyer, in anticipation of his more complete digest of the voluminous reports from the various branches of the Expedition, seems to justify us in the conclusion that the corona is substantially a solar phenomenon due not to direct but to reflected or scattered rays.

The principle upon which the polariscope enables us to make these refined distinctions in such far-off phenomena is, after all, very simple. If the corona were due wholly to the effect of our atmosphere on such light as reaches us during a total eclipse of the sun, the whole of that light would be similarly affected, because it comes very nearly from the same part of the heavens. In other words, its polarization would be uniform, and the corona, when examined by a Nicol and quartz, would appear of a uniform color. But if the phenomenon were wholly due to the sun and its surroundings, the light would be affected, if at all, differently in different directions drawn outward (like spokes or radii of a wheel) from the sun as a centre. In other words, its polarization would be arranged spokewise, or, to use the technical term, radially; and the corona, when examined as before, would vary in color on different sides of the sun.

I have already drawn largely, perhaps too largely, upon your patience. But it will not have been without purpose that, besides witnessing the exhibition of a few experiments, you should have seen, at least in outline, what manner of thing a scientific investigation is. Well, whatever it is (and I will not weary you with a dry statement of its processes), the foundation of it must always be laid in careful, accurate, and intelligent observation of facts. And it is a consideration which may well stir the hearts of us outsiders of science, especially on an occasion when we come face to face with some of the greatest philosophers of our time, that any one of us, by practising his eye and riveting his attention, may contribute some natural fact, some fragment of knowledge, to the common stock. And surely has not this a particular significance and importance to us, at a period when, by shortening the hours of labor, more leisure, as we may hope, will be at the command of many? It will, I take it, be our own fault if we spend that leisure in walking through dry places seeking rest; for, to those who have the eyes to see and the spirit to discern, the world is neither dry nor barren; but rather, it is like the mountain as it appeared to the servant of the prophet when his eyes were opened, full of beauty and wonder, of mystery and power—full of hosts from all nations, striving manfully onward to promised lands of knowledge and of truth, and waging ceaseless warfare against ignorance and prejudice, and the long train of evils which are consequent upon them. And if, as the eventide of life draws on, our eye wax dim, and our step grow weary, so that we can no longer follow, we may still lay us down to rest in some unknown spot, in the full confidence that others will not be wanting to fill our places and gain fresh ground, though we may not live to see it.—*Nature.*

SMOKELESS GUNPOWDER.

IT is very often the case that one bird falls to the right barrel, and "the rest unhurt" go on their way, rejoicing no doubt at having escaped a deadly volley from the left barrel. There is, however, a reason for their having got off scot-free, well known to all sportsmen; i. e., the smoke from the first barrel obscured the birds from the sportsman's second aim, until they were out of range. Science, however, has discovered a panacea for this oft-recurring disappointment, in Schultze's wood-powder, a smokeless explosive which we wish to introduce to those of our readers who are not already conversant with its merits. Of course, every one knows our "dear, dirty old friend," Black Gunpowder; the acquaintance of which we made in early youth, turning it into a "devil" to frighten our grandmother; but we have cut our "dear, dirty old friend," and our gun is now loaded with Schultze's wood-powder instead. "How is this?" you inquire. "Why abandon an explosive with which Colonel Hawker, and the never-to-be-forgotten Maxwell of 'Wild Sports of the West' celebrity, killed so many head of game?" To this we reply, Schultze's wood-powder was not invented in *their* day, or they *would* have used it, and for these reasons:

For seven hundred years and more, even granting the invention to have been Roger Bacon's, the dull-black mixture of sulphur, nitre, and charcoal—it is only a mixture, not a chemical compound—has had the monopoly of guns, large and small. It has answered every purpose moderately well, perhaps more than moderately. Nevertheless, from time to time the desire has arisen to evolve out of chemical stores some new compound, mechanical or chemical, that should do better duty. Somewhat extraordinary, indeed, the case seems that, amid all the improvements of guns and gunnery, all the advancement of chemistry and mechanism, the gaseous motor for gun-projectiles should be composed as at first. The explanation is difficult. Gunpowder occupies a sort of half-way ground between things innocent and things dangerous; a medium quality favoring its many applications. Exploding readily enough for all convenient needs, it never *spontaneously* explodes—a great point in its favor. Then its power of water-absorption not being very great, it stores tolerably well. But, more than any thing else, gunpowder has held its long and almost exclusive sway over guns and gunners owing to the two following circumstances: it can be made of any desired percentage composition, and it may be corned or grained to any degree of coarseness or fineness. As employed for different purposes, it is necessary that gunpowder should have various strengths. To a considerable extent the strength of gunpowder, by varying the relative amount of its components, can be modified; but the great adjustive resource consists in increasing or lessening the dimension of its grains.

Having taken account of certain special good qualities of gunpowder, we now come to certain of its bad qualities. Safe it indeed is in the sense of not igniting spontaneously; but it deteriorates by keeping, the more especially if in a moist atmosphere. If gunpowder be thoroughly wetted, then may it be considered wholly spoilt. In burning, gunpowder evolves much heat, much smoke; it also deposits much foulness. On the debtor side of gunpowder must be reckoned, also, the danger attendant on manufacture. It would be a great advantage if possible to devise a gunpowder that should acquire its usefully-dangerous qualities with the very last manufacturing touch, whereby in every incipient stage it might be stored without possibility of risk.

It will have been gathered, then, that gunpowder, ordinary black gunpowder, though it has seen some service and done some hard duty in its time, is not so perfect as to fulfil all requisitions desired; wherefore from time to time experiments have been directed to the manufacture of a substitute.

The only substitute yet invented which has met with favorable notice from practical sportsmen is Schultze's wood-powder, which, from its being granulated, and consequently permeated by air, can never generate fire of itself. This explosive, invented by Captain Schultze, a Prussian officer, was originally manufactured at Potsdam, near Berlin, and the factory catching fire in 1868, instead of *exploding*—ruining the neighborhood, and leaving many widows and orphans, like the recent gun-cotton explosion at Stowmarket—*burned quietly to the ground.* A company of English gentlemen, fond of field-sports, foreseeing the advantages to be derived from its introduction into England, purchased a site for its production in the New Forest, and thither we must carry our readers on "a visit to the Schultze Gunpowder manufactory," at Redbridge near Southampton.

Here and there, at intervals wide apart, are various buildings of light structure, from one of which rises a tall chimney, instrumental in raising steam to drive a 10-horse-power sawing-machine, which rapidly creates the "wood-powder" to be turned into use for the gun by the following process:

The grains, being collected in a mass, are subjected to a treatment of chemical washing, whereby calcareous and various other impurities are separated, leaving hardly any thing behind save pure woody matter, cellulose or lignine. The next operation has for its end the conversion of these cellulose grains into a sort of incipient xyloidine, or gun-cotton material, by digestion with a mixture of sulphuric and nitric acids. Practically it is found that absolutely perfected xyloidine (of which ordinary gun-cotton is the purest type) not only decomposes spontaneously by time, the chief products of combustion being gum and oxalic acid, but it is, moreover, liable to combustion of a sort that may be practically called spontaneous, so slight and so uncontrollable are the causes sufficing to bring it about. Cellulose or woody matter, otherwise termed lignine, partially converted to xyloidine is, the inventor affirms, subject to neither of those contingencies. Our readers will understand that, inasmuch as the wood used as a constituent of the Schultze gunpowder is not charred, its original hydrogen is left, and by-and-by, at the time of firing, will be necessarily utilized toward the gaseous propulsive resultant. Next, washed with carbonate-of-soda solution and dried, an important circumstance is now recognizable.

The grains, brought to the condition just described, are stored away in bulk, not necessarily to be endowed with final explosive energy until the time of package, transport, and consignment. Only one treatment has to be carried out, and it is very simple. The ligneous grains have to be charged with a certain definite percentage of some nitrate, which is done by steeping them in the nitrate solution and drying. Ordinarily a solution of nitrate of potash (common saltpetre) is employed; but, in elaborating certain varieties of white powder, nitrate of baryta is preferred.

Having traced the new powder to its final stage, we may contemplate it under the light of two distinct scrutinies—theoretical and practical. Review of the chemical agencies involved, or that may be evolved, suggests the reaction, especially under prolonged moisture, of the sulphur and nitre of ordinary powder, whereby sulphide of potassium should result. Practice is confirmatory: under the condition indicated sulphide of potassium, more or less, does result, and proportionate to the extent of decomposition is the powder deteriorated. Inasmuch as the Schultze gunpowder is wholly devoid of sulphur, so is the particular decomposition adverted to impossible; and theory, at least, fails to suggest any other decomposition as probable or even possible.

All the buildings requisite for manufacturing this explosive are cheap and flimsy, so that if it did catch fire no loss would ensue. The "plant of machinery" is of small cost in comparison with that used for making black gunpowder, and Schultze's wood-powder is sold at a price commensurate with its cheap production. An explosive is often "better known than liked," such as gun-cotton; but Schultze's wood-powder requires only "to be known to be liked," as a trial of it, lately made for the satisfaction of its readers by the conductors of the *Land and Water* journal, recently showed. Indeed, it was proved to give more penetration than gunpowder, and it costs less. There is also no smoke, and consequently the second barrel can always be used at once, instead of waiting for the smoke to clear away, as when using black powder.—*Belgravia.*

ON THE FUNCTIONS OF THE BRAIN.

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TRANSLATED FROM THE REVUE DES DEUX MONDES, BY A. R. MACDONOUGH, ESQ.

I.

THE first task of physiology was to localize the functions of life in the various organs of the body which serve as their instruments. Thus digestion was assigned to the stomach, circulation to the heart, respiration to the lungs; thus, too, the seat of intelligence and thought was placed in the brain. Still, with regard to the latter organ, a reservation was thought proper, excluding the idea that the metaphysical expression of the intellectual and moral powers was the manifestation, simply and merely, of the cerebral function. Descartes, who is to be classed among the promoters of modern physiology, because he thoroughly understood that the explanation of vital phenomena must depend on the general laws of physics and of mechanism, expressed himself very plainly on this matter. Adopting Galen's ideas on the formation of "animal spirits" in the brain, he assigns them the task of distribution by means of the nerves throughout the animated machine, so as to carry to each of the parts the impulse needed for its special activity. Yet, above and apart from this physiological function of the brain, Descartes admits the soul, which gives man the faculty of thinking: it was supposed to have its seat in the pineal gland, and to direct those "animal spirits" which issue from and are subject to it.

Descartes's opinions as to the function of the brain would not bear the slightest examination by modern physiology; his explanations, founded on imperfect anatomical knowledge, produced nothing but hypotheses marked by the coarsest mechanical conceptions. Yet they have an historic value for us, in the proof that this great philosopher recognized two things in the brain: first, a physiological mechanism; and then, above and beyond that, the thinking faculty of the soul. These ideas are nearly the same with those that afterward prevailed among many philosophers and some naturalists; the brain, in which the most important functions of the nervous system are performed, was for them not the real organ of thought, but simply the substratum of intelligence. Indeed, the objection was often enough expressed, that the brain forms a physiological exception to all the other organs of the body, in that it is the seat of metaphysical manifestations, which the physiologist has no concern with. It was perceived how digestion, respiration, movement, etc., could be referred to the phenomena of mechanism, of physics, and chemistry; but it was not allowed that thought, intelligence, and will, could be subjected to like explanation. There is, it was said, a chasm between the organ and the function, because the question is about metaphysical phenomena, and not at all about physico-chemical mechanism. De Blainville, in his lectures on zoology, laid great stress on the distinction between the *organ* and the *substratum*. "In the organ," he said, "there is a visible and necessary connection between anatomical structure and function; in the heart, the organ of circulation, the form and arrangement of valves and orifices account perfectly for the circulation of the blood. In the substratum, nothing like this is observable; the brain is the substratum of thought; thought has its seat in the brain, but it cannot be inferred from the brain's anatomy." Such considerations served as a foundation for the belief that, in cases of insanity, the reason might be affected essentially, as it was termed; that is, without the existence of any lesion in the substance of the brain. Even the converse was asserted, and cases are cited in physiological treatises of the unimpaired manifestation of intelligence in persons with softened or indurated brains. The progress of modern science has destroyed all such doctrines; yet it must be admitted that those physiologists who have drawn from the most delicate recent researches into the structure of the brain the conclusion that thought must be localized in a particular substance, or in nerve-cells of a determinate form and order, have equally failed to solve the problem, since they have done nothing more, in reality, than to oppose materialistic theories to other spiritualistic theories.

From what has been said, I shall draw the only conclusion which legitimately results; namely, that the mechanism of thought is unknown to us—a conclusion with which every one will probably agree. None the less the fundamental question I have suggested exists; for what concerns us is to know whether our present ignorance on this subject is a relative ignorance which will vanish with the progress of science, or an absolute ignorance in the sense of its relating to a vital problem which must forever remain beyond the ken of physiology. For myself, I reject the latter opinion, because I deny that scientific truth can thus be divided into fractions. How, indeed, can one understand that it is permitted to the physiologist to succeed in explaining the phenomena that occur in all the organs of the body, except a part of those that occur in the brain? Such distinctions cannot exist among vital phenomena. Unquestionably they present very different degrees of complexity, but they are all alike in being either soluble or insoluble by our examination; and the brain, marvellous as those metaphysical manifestations that take place in it appear to us, cannot form an exception among the other bodily organs.

II.

From a physiological point of view, those metaphysical phenomena of thought, consciousness, and intelligence, which serve for the various manifestations of the human soul, are nothing but ordinary vital phenomena, and can result from nothing but the action of the organ that expresses them. We shall show that, in fact, the physiology of the brain, like that of all the other bodily organs, is deduced from anatomical observations, from experiments conducted physiologically, and from the teachings of pathological anatomy.

In its anatomical development the brain follows the general law; that is, it increases in volume whenever the functions which it controls increase in energy. In the graduated orders of animals we find the brain gain in development in proportion to the greater manifestation of intelligence; and in man, with whom the phenomena of mind have reached their highest expression, the cerebral organ presents the largest volume. The intelligence of the various animals can be readily inferred from the shape of the brain, and the number of creases or folds that extend its surface. But not only does the outward appearance of the brain change with the modification of its functions; it presents in its inner structure also a complexity that increases with the variety and intensity of the mental manifestations. As regards the texture of the brain, we are long past the days of Buffon, who considered the brains, as he contemptuously called them, a mucous substance of no importance. The advance of general anatomy and of histology has taught us that the cerebral organ possesses a texture more delicate as well as more complex than that of any other nerve-arrangement. The anatomical elements that make it up are nerve-elements in the shape of tubes and of cells variously joined and interlaced. These elements are alike in all animals as to their physiological properties and histologic character; they differ as to their number, net-work, and connection, in a word their arrangement, which in the brain of various species presents a disposition peculiar to each. In this the brain again follows a general law, for in all organs the anatomical element has fixed characteristics by which it may be known; the completeness of the organ consists chiefly in the arrangement of these elements, which presents in every animal species its own peculiar form. Every organ is in fact, then, an instrument whose constituent elements remain identical, while their grouping grows more and more involved in the same degree as the function itself displays more variety and complexity.

Reflecting, now, on the organic and physico-chemical conditions required for the support of life and the discharge of its functions, we find that they are the same in the brain as in all the other organs. The blood acts on the anatomical elements of all the tissues by supplying their indispensable conditions of nutrition, temperature, and humidity. When a diminished supply of blood flows to any organ, its activity of function declines, and the organ rests; but if the blood is quite cut off, the elementary properties of the tissue slowly change, while at the same time its function perishes. It is precisely the same as to the brain's anatomical elements: as soon as the blood ceases to flow to it, its nerve-properties are affected, as well as its function, which gradually disappears, if the blood remains wholly withheld. A simple modification of the temperature of the blood, in its pressure, is enough to produce grave disturbances in the sensibility, the power of motion, or the will.

All the bodily organs present alternate states of rest and of activity in which the phenomena of circulation differ essentially. Numerous observations, made upon the most different structures, place these facts beyond doubt. When, for instance, we examine the alimentary canal of a fasting animal, we find the mucous membrane that lines the inner face of the stomach and intestines, pale and but little supplied with blood; during digestion, on the contrary, we learn that the same membrane is highly colored, and swollen with the blood which flows energetically into it. These two phases of circulation, in a state of rest and a state of activity, have been brought under direct investigation in the stomach of a living man. All physiologists recollect the story of a young Canadian accidentally wounded by a leaden musket-ball which struck him almost point-blank on the left side. The abdominal cavity was laid open by an immense contused wound, and the stomach, extensively perforated, allowed the food which he had last taken, to escape. The patient was attended by Dr. Beaumont, a surgeon of the United States Army; he recovered, but retained a fistulous wound, opening with a circumference of about an inch and a half through which different substances could be introduced, and the action of the stomach easily examined. Dr. Beaumont, anxious to study this remarkable case, employed the young man as a servant, after the complete restoration of his health and particularly of his digestive powers. He was able to keep him in his service for seven years, during which he made a great number of observations of the highest interest to physiology. On looking into the interior of the stomach while empty of food, the lining membrane could be plainly seen, lying in uneven folds, with its surface of a pale rose-color, motionless, and lubricated by nothing whatever but mucus. As soon as articles of food made their way into the stomach, and touched the mucous membrane, its circulation grew rapid and its color lively, while peristaltic movements became evident. The mucous papillæ then poured out their gastric juice, a clear and transparent fluid, designed to dissolve the food. On wiping away the mucus that covered the villous membrane, with a sponge or fine cloth, the gastric juice was soon seen reappearing and gathering in little drops that ran along the walls of the stomach like perspiration on the face. What we have just seen as to the mucous membrane is known to occur alike throughout the intestine, and in all the glandular organs connected with the digestive apparatus. The salivary glands and the pancreas, in the intervals of the act of digestion, present a pale and bloodless tissue, the secretions of which are wholly suspended. During the period of digestion, on the contrary, these same glands are swollen with blood, as if inflamed and erectile, while their vessels pour out the secreted fluids abundantly.

Two orders of circulation, then, must be recognized in the organs: one, the general circulation, known since Harvey's day; and the other, local circulation, only discovered and studied in recent times. In the phenomena of general circulation the blood may be said to do nothing more than traverse the parts, to pass from the arteries into the veins; in the phenomena of local, which is the true functional circulation, the blood penetrates all the folds of the organ, and gathers closely about its anatomical elements, to arouse and excite their special mode of activity. The nervous system, sensitive in its action through the vessels, governs all those phenomena of local circulation which attend organic activity; thus, the saliva flows copiously when a sapid substance makes an impression on the nerves of the mucous membrane of the mouth, and the gastric juice forms under the influence of contract between food and the sensitive surface of the stomach. But, for this mechanical excitement of the peripheral nerves of sensation, influencing the organ by reflex action, a purely psychic or cerebral excitement can be substituted. A simple experiment proves this: If a horse is taken while fasting, and the excretory duct of the parotid gland upon the side of the jaw is exposed and divided, nothing flows from it; the gland is at rest. If, now, oats are shown to the animal, or, still better, if, without any thing being shown, a movement is made which leads him to think he is about to have food given him, immediately a continuous flow of saliva issues from the duct of the parotid, and at the same time the tissue of the gland is injected, and becomes the seat of a more active circulation. Dr. Beaumont remarked similar phenomena in his Canadian. The idea of savory food not only solicited a secretion from the salivary glands, but provoked, besides, an immediate flow of blood to the mucous membrane of the stomach.

What we have just said as to the local or functional circulations, applies not only to those secreting organs in which there takes place the separation of a liquid, to the formation of which the blood must more or less give its aid; it rather expresses a phenomenon generally remarked in all the organs, whatever the nature of their function may be. The muscular system, which produces nothing but mechanical work, is in this regard like the glands, which act chemically. At the instant of muscular action the blood circulates with greater activity, which relaxes when the organ begins to rest. The peripheral nervous system, the spinal marrow, and the brain, which serve to manifest the phenomena of innervation and intelligence, are equally subject to this law, as we are about to see.

The relations existing between the phenomena of circulation in the brain and the functional activity of that organ have long remained obscure, owing to mistaken ideas of the conditions of sleep, which is rightly considered the state of rest of the cerebral organ. The ancients supposed that sleep resulted from compression exerted on the brain by the blood when its circulation declined. They imagined that this pressure was chiefly exerted at the back part of the head, at the point where the veined folds of the dura mater unite in a common confluent, which is still called the *torcular or compress of Herophilus*, from the name of the anatomist who first described it. These conjectural explanations have been handed down to us; and it is only of late years that experiment has succeeded in proving their falsity. In fact, it has been shown by direct experiment that, during sleep, the brain, instead of being congested, is on the contrary pale and bloodless; while in a state of wakefulness the circulation, becoming more active, provokes a flow of blood proportioned to the intensity of cerebral activity. In this respect natural sleep and the anæsthetic sleep of chloroform are alike; in both cases, the brain, sunk into rest or inactivity, presents the same paleness and relative bloodlessness.

The experiment is made in this manner: A part of the bony covering of an animal's skull is carefully removed, and the brain laid bare so as to study the circulation at the surface of this organ. Then chloroform is administered to produce insensibility. In the first exciting stage of the action of the chloroform, the brain is observed to grow congested and to lap over at the edges; but as soon as the stage of anæsthetic sleep is reached, the substance of the brain sinks in and grows paler, presenting a languid movement of capillary circulation, which lasts as long as the state of sleep or cerebral rest continues. For the study of the brain in natural sleep a circular trepan is made on a dog's head, and the piece of bone removed is replaced by a watch-glass carefully adjusted to the exact opening, so as to prevent the irritating action of the air. The animals subjected to the operation survive it; and observations on their brain through this sort of window, while awake and when asleep, prove that when the dog is asleep the brain is always paler, and that a fresh afflux of blood is regularly noticed on his awaking, when the functions of the brain resume their activity.

Facts analogous to those observed in animals have been studied directly in the human brain. Upon a person injured by a frightful railroad accident the effect of a considerable loss of brain-substance was examined. The brain was visible over a surface of three by six inches. The patient suffered frequent and severe attacks of epilepsy and coma, during which the brain invariably expanded. Sleep succeeded these attacks, and the cerebral hernia gradually subsided. When the patient awoke, the brain again projected and rose to the level of the surface of the external, bony table. In the case of another person injured in consequence of a fracture of the skull, the cerebral circulation was studied during the administration of anæsthetics. With the first inhalations, the surface of the brain became branchy and filled with blood; the flow of blood and throbbing of the brain increased, and then, at the instant of sleep, its surface subsided by degrees below the opening, while at the same time growing relatively pale and bloodless.

Briefly, then, the brain is governed by the common law that controls blood-circulation in all the organs. By virtue of this law, when the organs are at rest and their action suspended, the circulation in them grows languid; and it increases, on the contrary, as soon as activity is resumed. The brain, I repeat, is no exception to this general law, as had been supposed, for it is now demonstrated that the state of sleep coincides not with congestion, but, on the contrary, with bloodlessness of the brain.

If we seek now to understand the relations that may exist between great activity of blood-circulation and the functional condition of the organs, we shall readily see that this increased flow of the sanguineous fluid corresponds with greater intensity in the chemical alterations going on within the tissues, as also with an exaltation in the phenomena connected with heat which are their necessary and immediate consequence. The production of heat in living beings is a fact established from remote antiquity; but the ancients had erroneous ideas as to the origin of heat: they attributed it to an innate organic power that had its seat in the heart, that ardent centre of ebullition for the blood and the passions. At a later date the lungs were regarded as a sort of furnace to which the mass of the blood repaired successively to gain the heat which circulation was bidden to distribute throughout the body. The advance of modern physiology has proved that all these absolute consignments of vital conditions to special points are chimeras. The sources of animal warmth exist everywhere, and in no region exclusively. It is only through the harmonious functional play of the various organs that the temperature is kept nearly constant in man and the warm-blooded animals. There are, in truth, as many heat-producing centres as there are special organs and tissues, and we are obliged always to connect evolving heat with functional labor of the organs. When a muscle contracts, when a mucous surface or a gland secretes, production of heat invariably takes place at the same time with increased activity in the phenomena of local circulation.

Is the case the same with the nervous system and the brain? Modern experiments forbid us to doubt it. Whenever the spinal marrow and the nerves exhibit sensibility or movement, whenever an intellectual effort takes place in the brain, a corresponding quantity of heat is evolved in it. We must, then, regard heat in the animal economy as a resultant of the organic labor of all the parts of the body; but at the same time it becomes also the principle of activity for each of these parts. This correlation is, above all, indispensable for the brain and the nervous system, which hold all the other vital actions under their control. Experiments have demonstrated that the tissue of the brain exhibits a higher temperature than any other organ of the body. In man and the warm-blooded animals the brain itself produces the heat required for the manifestation of the peculiarities of its tissue. If this were not so, it would infallibly grow cooler, and we should at once see all the functions of the brain become torpid, and intelligence and will perish. This does, in fact, occur in cold-blooded animals, in which the function of heat-production is not energetic enough to sustain the organism in resistance to external causes of refrigeration.

III.

With respect to the organic or physico-chemical conditions of its activity, the brain, then, presents nothing exceptional. If we turn to experiments made upon it by physiologists, we shall find that they have succeeded in analyzing cerebral phenomena in the same way as those of all the other organs. The experimental process usually employed to determine the functions of organs consists in removing them or in destroying them either gradually or suddenly, so as to determine the uses of the organ according to the special disturbances thus caused in vital phenomena. This method of the removal or destruction of organs, which forms a sort of brutal vivisection, has been applied on a great scale to the study of the whole nervous system. Thus, after a nerve is cut, when the parts to which it had been distributed lose their sensibility, we conclude from this that it is one of the nerves of sensation; if it is motion that ceases, we infer thence that we are dealing with one of the nerves of motion. The same method has been applied in examining the functions of the different parts of the encephalic organ, and, though the complexity of the parts has occasioned novel difficulties of execution, the method has yielded results that are not to be contested. Every one has long known that, without the brain, intelligence is not possible, but experiment has discovered exactly the part that is played by each portion of the organ. It teaches us that consciousness, or intelligence properly so called, resides in the cerebral lobes, while the lower portions of the brain contain nervous centres destined for organic functions of a lower kind. This is not the place to describe the special functions of these different sorts of nervous centres which are superposed and in a manner ranged along quite into the spinal marrow; it is enough to say that we owe the knowledge of them to that method of vivisection by organic removal which is adopted in a general way in all physiological inquiries. Here the brain behaves in exactly the same way as all the other bodily organs, in this sense, that every lesion of its substance produces characteristic disturbances in its functions, which always correspond with the mutilation effected.

By means of the cerebral lesions he produces, the physiologist does not stop at the creation of local paralysis, which suspends the action of the will on certain organic instruments; he is able also, by merely disturbing the equilibrium of cerebral action, to produce a suspension of freedom in voluntary motion. Thus, by injuring the peduncles of the cerebellum, and different points of the brain, the experimenter can make an animal move as he chooses, to right or left, forward or backward, or can make it turn, sometimes by leaps, sometimes by rotary movement on the axis of its body. The will of the animal persists, but power to guide its motions is gone. In spite of its efforts of will, it moves necessarily in the direction determined by the organic lesion. Pathologists have remarked numerous similar instances in man. Lesions of the peduncles of the cerebellum create rotary movements in men as in animals. Some patients could walk only straight onward. In one case, cruel in its irony, a brave veteran general could only move backward. Therefore the will, which proceeds from the brain, does not take effect on our organs of locomotion themselves; it impresses itself on secondary nervous centres, which need to be kept harmoniously balanced by a perfect physiological equilibrium.

There is another and more delicate experimental method, which consists in introducing into the blood various poisonous substances intended to exert their action upon the anatomical elements of the organs, while these are left undisturbed and kept uninjured. Aided by this method, we can extinguish separately the properties of certain nervous and cerebral elements, in the same way that we can also sever the other organic elements, whether muscular or sanguine. Anæsthetics, for instance, destroy consciousness and depress sensibility, while they leave the power of movement untouched. Curare, on the other hand, destroys the power of movement, and leaves sensibility and will unimpaired; poisons affecting the heart, suspend muscular contractility, and the oxide of carbon destroys the oxidizing properties of the blood-globules, without at all affecting the properties of the nerve-elements. As we see, by this method of investigation or elementary analysis of organic properties, the brain and those phenomena that have their seat in it may also be affected in the same manner as all the other functional instruments of the body.

There is yet a third method of experimenting, which may be called that of experiment by reproduction. This method, to some extent, combines physiological analysis and synthesis, and enables us to establish by evidence and counter-evidence those relations which unite the organ with the function in cerebral manifestations. When the brain of the inferior animals is removed, the function of the organ is necessarily suppressed; but the persistence of life in these beings allows the brain to grow again, and, in proportion as the organ reproduces itself, we observe its functions reappear. The like experiment succeeds in the same way with superior animals, such as birds, in whom intelligence is much more developed. For instance, when the cerebral lobes of a pigeon have been removed, the animal at once loses its senses, and the power of seeking its food. Yet if the animal is artificially fed, it can survive, because its functions of nutrition continue unimpaired so long as their special nervous centres are left unharmed. Little by little the brain renews itself with its particular anatomical elements, and in the degree in which this restoration takes place we observe the animal's use of its senses, and its instincts and intelligence return. Here, I repeat with emphasis, the experiment is complete: there has been as it were both analysis and synthesis of the vital function, because the successive destruction of the different parts of the brain has successively extinguished its different functional manifestations, and because the successive reproduction of the same parts has caused the same manifestations to reappear. It is hardly necessary to add that the same thing happens as to all the other parts of the body which are susceptible of reproduction.

Diseases, which are at bottom nothing but vital perturbations caused by Nature instead of being produced by the hand of the physiologist, affect the brain according to the usual laws of pathology; that is to say, by occasioning functional troubles which always correspond to the nature and seat of the injury. In a word, the brain has its pathological anatomy exactly as all the organs of the economy have, and the pathology of the brain has its special series of symptoms, just as the other organs have theirs. In mental alienation we observe the most remarkable disturbances of the reason, furnishing in their study a rich mine for the researches of the physiologist and the philosopher; but the various forms of lunacy or madness are nothing more than disturbances of the normal function of the brain, and these alterations of function in the cerebral organ, as in all the rest, are combined with invariable anatomical alterations. If, under many circumstances, these are not yet understood, the blame must be laid wholly on the imperfection of our means of investigation. Besides, do we not find that certain poisons, such as opium and curare, paralyze the nerves and the brain, without being able to discover any visible alteration in the nerve-substance? Yet we are sure that such alterations exist; for, to admit the contrary, would be to admit an effect without a cause. When the poison has ceased to act, we find the mental disturbances disappear, and the normal condition return. It is the same when pathological injuries are healed; the trouble in the intelligence ceases, and reason comes back. Pathology here, too, furnishes us with a kind of functional analysis and synthesis, just as may be observed in experiments of reproduction. Disease, in a word, suppresses the function more or less entirely, by changing more or less completely the texture of the organ, and the cure restores the function by reëstablishing the normal organic condition.

If the manifestations of the brain's functions were the earliest to attract the attention of philosophers, they will assuredly be the last to receive explanation from physiologists. We believe that the progress of modern science allows us now to approach the subject of the physiology of the brain; but, before beginning the study of the cerebral functions, we must clearly understand our point of departure. In this essay, we have attempted to state only one term of the problem, and to show how untenable is the opinion that the brain forms an exception in the organism, and is the *substratum* of intelligence instead of being its instrument. This idea is not merely an obsolete conception, but an unscientific one, injurious to the progress of physiology and psychology. Indeed, what sense is there in the notion that any apparatus of Nature, whether in its lifeless or its living domain, can be the seat of a phenomenon without being its instrument? Preconceived ideas clearly have a great influence in discussing the functions of the brain, and a solution is combated by arguments used for the sake of their tendency. Some refuse to allow that the brain can be the organ of intelligence, from fear of being involved by that admission in materialistic doctrines; while others eagerly and arbitrarily lodge intelligence in a round or fusiform nerve-cell, for fear of being charged with spiritualism. For ourselves, we are not concerned about such fears. Physiology tells us that, except in the difference and the greater complexity of the phenomena, the brain is the organ of intelligence in exactly the same way that the heart is the organ of circulation, and the larynx that of the voice. We discover everywhere a necessary bond between the organs and their functions; it is a general principle, from which no organ of the body can escape. Physiology should copy the example of more advanced sciences, and free itself from the fetters of philosophy that would impede its progress; its mission is to seek truth calmly and confidently, its object to establish it beyond doubt or change, without any alarm as to the form under which it may make its appearance.

ON METEORIC STONES.[1]

By PROFESSOR N. S. MASKELYNE, M. A., F. R. S.

THE substantial unity of the celestial objects distinguished in common language by the names shooting or falling stars, fire-balls, and meteorites, and further, the coincidence in many important respects of these with comets, and possibly with the zodiacal light, were suggestions made by Humboldt in the "Cosmos," which have received much confirmation from the subsequent advance of science.

The greater apparent velocity with which the ordinary meteors traverse the atmosphere as compared with that with which the less frequent larger bodies are seen to move, the marked periodicity that attends the recurrence of the former in several, and especially in two, notable cases of meteor-showers, offer an apparent contrast between these classes of meteors; it is not, however, in all probability, a real contrast, for the one class passes into the other by every gradation in the magnitude of the mass or masses of which the meteor consists, and consequently in the grandeur of the phenomena which accompany its advent. If of the material composing the ordinary falling star we have never yet been able to recognize any vestiges as reaching the earth, of the meteorite, on the other hand, the mineral collections of Europe contain numerous carefully-collected specimens, which are the fragments that have escaped the fiery ordeal of the transit through our earth's atmosphere, and in these we recognize masses composed either of iron (siderites), or of stones (aërolites), or of a mixture of the two (siderolites). The phenomena associated with such falls of meteoric matter have been described in very similar language by those who have witnessed them in various parts of the world, and these accounts, whether coming from European observers or from Hindoo herdsmen (of which some were read by the lecturer), concur generally in the approach of the meteorite as a fiery mass, emanating from a cloud when seen by day and exploding often with successive detonations that are heard over a great extent of country, even in certain cases at points more than 60 miles distant, but finally reaching the earth with a velocity little higher than what might be due to the motion of a falling body. Externally these meteoric masses are generally hot when they fall; sometimes, however, they are not so; the discrepancies in the accounts being explained by one authenticated case in which the mass was internally intensely cold, though at first hot externally. The fallen meteorite is invariably coated with an incrustation, sometimes shining as an enamel, generally black, but occasionally colorless where the aërolite is free from ferrous silicates; and this incrustation is seen to have been formed in the atmosphere,

[1] Read before the Royal Institution of Great Britain.

since it is found coating surfaces of fragments that have been severed by the explosions in the air.

Aërolites frequently fall simultaneously in large numbers, many thousands of them being in such cases spread over a surface of the country some miles in extent; and such showers of stones seem to have entered the atmosphere as a group, though their numbers must subsequently have been greatly increased by the division accompanying their detonation.

The explanation of the incrustation and of the cloud left by the meteorite, or out of which it seems to emerge, is found in the transformation into heat of the energy actuating a body that enters our atmosphere with a motion of 12 to 40 miles a second. The velocity of the body is almost instantaneously arrested by the atmospheric resistance, and in a very few seconds the mass becomes, comparatively speaking, stationary. Its surface must, as a consequence, be immediately fused, and the melted matter would be flung off from it into the surrounding air, fresh surfaces continually affording new fused material to form the cloud of, so to say, siliceous spray that lingers along and around the path of the meteorite.

When the mass is small—and in the case of meteoric showers and ordinary falling stars it cannot exceed a few ounces, and may often be but a few grains—the whole material is thus consumed, and must ultimately fall as an unperceived, because widely-scattered, dust. The meteorite is the residue that survives this wasting action where the magnitude of the mass is more considerable. The cause of the violent and often successive explosions is probably to be sought in the expansion of the outer portions of the mass, while the interior retains the contracted volume due to the intense cold of space with which the meteorite enters the atmosphere.

From time to time these contending conditions of volume may, as in a Prince Rupert's drop, produce explosion, the heated shell in the case of the meteorite flying off in fragments from the internally cold inner core, which if sufficient velocity remain to the mass will undergo a recurrence of the same conditions of surface fusion and explosion. The loudness of the detonation is also probably enhanced by the simultaneous collapse of the air on the vacuum that would follow the rapidly-moving mass.

The pitted surface characteristic of meteorites probably bears witness to a similar effect of unequal dilatation operating more especially in the freshly-broken surfaces of the mass, small fragments splintering off in this way from the cold and brittle stone under the sudden influence of intense heat.

A remark made by Humboldt, that light and meteorites are the only sources of our knowledge regarding the universe external to our world, points to the true ground for our interest in the waifs and strays of extra-telluric matter that thus fall upon our globe.

In physical as well as in chemical characters aërolites resemble at the first aspect some terrestrial volcanic rocks.

The minerals of which they are composed are nearly entirely crystalline, as is evinced by the colors in polarized light of such as are transparent. These minerals are usually aggregated with slight cohesion, and they present in by far the greatest number of cases a peculiar spherular or "*chondritic*" structure.

In these the spherules are composed of similar minerals to those which enclose them, and even contain metallic iron sometimes in microscopically fine grains disseminated through them.

A section of an aërolite was exhibited by the microscope in which some of the spherules had been broken before being cemented by the surrounding mass, and in another fissures were seen which had been filled with a fused material after one side of the fissure had slidden along the other; facts pointing to events in the history of the meteorite subsequent to its first formation.

The chemical composition and the mineral constitution of aërolites were illustrated by tables showing the elements met with in these bodies, and the minerals in which they were distributed. The former comprised about one-third of the known elements; among them magnesium, iron, silicon, oxygen, and sulphur, were conspicuous; calcium, aluminium, nickel, carbon, and phosphorus, coming next in importance, the basic elements of most importance by their amount being the same as those which are found by spectroscopic analysis to be present in the sun—and in those stars which have been the best examined.

The minerals most frequent in aërolites besides nickeliferous iron or troilite (iron monosulphide) and graphite, are bronzite (a ferriferous enstatite) and olivine, both of the latter being essentially magnesium silicates. Augite and anorthite also occur (more particularly in the eukritic aërolites of Rose) and some minerals unknown in terrestrial mineralogy have also been met with; such are the different varieties of Schreibersite (phosphides of iron and nickel); calcium sulphide, asmanite (a form of silica crystallizing in the orthorhombic system and having the specific gravity of fused quartz), and a cubic mineral with the composition of labradorite. The crystalline form of bronzite was first determined from the crystals in a meteorite, and was found to confirm the conclusion Descloizeaux had arrived at as regards its system from observations on the distribution of the optic axes in the terrestrial bronzite and enstatite.

The question as to whence the meteorites come is one that we are not yet in a position to answer with certainty. The various hypotheses which suppose for them an origin in lunar volcanoes, or in our atmosphere, or again in a destroyed telluric satellite, or that would treat them as fragments of an original planet of which the asteroids are parts, or as masses ejected from the sun; all these hypotheses seem to be more or less precluded by the known velocities, the retrograde motion so frequently characterizing meteors and meteorites, or else by the chemical conditions that, for instance, are involved in the passage of the meteorite through the sun's chromosphere. Whether meteorites move or do not move in circumsolar orbits is at present impossible to say; because, while with our incomplete knowledge we cannot to-day attach the character of periodicity to any known class of meteorites, we are not justified in founding any conclusion on a negative result with so limited a foundation.

But even if all or some of them may have been, on their encountering the earth, members temporarily or permanently of the solar system, we may with considerable probability consider them as having originally entered our system from the interstellar spaces beyond it. Such at least must be our conclusion if we are to admit the unity of the whole class of phenomena of meteorites and falling stars. For, since the orbits of the two best-known meteoric streams, those namely of August and November, have been identified with the orbits of two comets, and since in regard to one of these (that of November) Leverrier has shown, with great probability, that as a meteoric cloud it entered and became a member of our system only some 1,700 years ago in consequence of the attraction of Uranus, while the August meteoric ring only differs in this respect from it, that it had at a much more remote period found an elliptic orbit round the sun: we are constrained on the assumption with which we started to recognize also in a meteorite a visitor from the regions of remote space. And so far as it goes, the observation by Secchi that the November falling stars exhibit the magnesium lines is in harmony with this view.

It may, however, further be said that the tendency of scientific conviction is in the direction of recognizing the collection toward and concentration in definite centres, of the matter of the universe, as a cosmical law, rather than the opposite supposition of such centres being the sources whence matter is dispersed into space. In the meteorites that fall on our earth (certainly in considerable numbers) we have to acknowledge the evidence of a vast and perpetual movement of space, about which we can only reason as part of a great feature in the universe which we have every ground for not supposing to be confined within the limits of the solar system.

That this matter, whether intercepted or not by the planets and the sun, should to an ever-increasing amount become entangled in the web of solar and planetary attraction, and that the same operation should be collecting round other stars and in distant systems such moving "clouds" of star-dust as have been treated by Schiaparelli, Leverrier, and other astronomers, or individual masses of wandering stone or iron, is a necessary deduction from the view that we have assumed regarding the tendency of cosmical matter to collect toward centres. But in order to trace the previous stages of the history of any meteorite, and, in particular, to determine the conditions under which its present constitution as a rock took its origin, we have only for our guide the actual record written on the meteoric mass itself; and it is in this direction that the mineralogist is now working.

But the progress is necessarily a gradual one. We may indeed assert that the meteorites we know have, probably all of them, been originally formed under conditions from which the presence of water or of free oxygen to the amount requisite to oxidize entirely the elements present were excluded; for this is proved by the nature of the minerals constituting the meteorites, and by the way in which the metallic iron is distributed through them.

And one suggestive and significant fact remains to be alluded to; the presence, namely, in some few meteorites of combinations of hydrogen and carbon, which if met with in a terrestrial mineral would with little hesitation be assigned to an organic origin. A few grains were exhibited to the audience of such a body, crystallized from ether, which solvent had extracted it to the amount of about 0.25 per cent. from six ounces of the Cold Bokkveldt meteorite.

Similar substances have been extracted by Wöhler, Roscoe, and other chemists, from this and other meteorites. It was, however, observed, as pointing to the probability of the comparatively porous meteoric stone having in this case taken up the hydrocarbon as a substance extraneous to it (possibly when in the state of a vapor), that ether extracted it entirely from the solid lumps of the meteorite; pulverization not in any way adding to the amount obtained, or facilitating in any appreciable degree the separation of the substance.

SCIENCE AND RELIGION.

BY PROFESSOR TYNDALL, LL. D., F. R. S.

THE editor of the *Contemporary Review* is liberal enough to grant me space for a few brief reflections on a subject, a former reference to which in these pages has, I believe, brought down upon him and me a considerable amount of animadversion.

It may be interesting to some if I glance at a few cases illustrative of the history of the human mind in relation to this and kindred subjects. In the fourth century the belief in Antipodes was deemed unscriptural and heretical. The pious Lactantius was as angry with the people who held this notion as my censors are with me, and quite as unsparing in his denunciations of their "Monstrosities." Lactantius was irritated because, in his mind, by education and habit, cosmogony and religion were indissolubly associated, and therefore simultaneously disturbed. In the early part of the seventeenth century the notion that the earth was fixed, and that the sun and stars revolved round it daily, was interwoven in a similar manner with religious feeling, the separation then attempted by Galileo arousing animosity and kindling persecution. Men still living can remember the indignation excited by the first revelations of geology, regarding the age of the earth, the association between chronology and religion being for the time indissoluble. In our day, however, the best-informed clergymen are prepared to admit that our views of the Universe, and its Author, are not impaired, but improved, by the abandonment of the Mosaic account of the Creation. Look, finally, at the excitement caused by the publication of the "Origin of Species," and compare it with the calm attendant on the appearance of the far more outspoken, and, from the old point of view, more impious "Descent of Man."

Thus religion survives after the removal of what had been long considered essential to it. In our day the Antipodes are accepted, the fixity of the earth is given up, the period of Creation and the reputed age of the world are alike dissipated, Evolution is looked upon without terror, and other changes have occurred in the same direction too numerous to be dwelt upon here. In fact, from the earliest times to the present, religion has been undergoing a process of purification, freeing itself slowly and painfully from the physical errors which the busy and uninformed intellect mingled with the aspiration of the soul, and which ignorance sought to perpetuate. Some of us think a final act of purification remains to be performed, while others oppose this notion with the confidence and the warmth of ancient times. The bone of contention at present is *the physical value of prayer*. It is not my wish to excite surprise, much less to draw forth protest by the employment of this phrase. I would simply ask any intelligent person to look the problem honestly and steadily in the face, and then to say whether, in the estimation of the great body of those who sincerely resort to it, prayer does not, at all events upon special occasions, invoke a Power which checks and augments the descent of rain, which changes the force and direction of winds, which affects the growth of corn, and the health of men and cattle—a Power, in short, which, when appealed to under pressing circumstances, produces the precise effects caused by physical energy in the ordinary course of things. To any person who deals sincerely with the subject, and refuses to blur his moral vision by intellectual subtleties, this, I think, will appear a true statement of the case.

It is under this aspect alone that the scientific student, so far as I represent him, has any wish to meddle with prayer. Forced upon his attention as a form of physical energy, or as the equivalent of such energy, he claims the right of subjecting it to those methods of examination from which all our present knowledge of the physical universe is derived. And, if his researches lead him to a conclusion adverse to its claims—if his inquiries rivet him still closer to the philosophy enfolded in the words, "He maketh his sun to shine on the evil and on the good, and sendeth rain upon the just and upon the unjust"—he contends only for the displacement of prayer, not for its extinction. He simply says, physical Nature is not its legitimate domain.

This conclusion, moreover, must be based on pure physical evidence, and not on any inherent unreasonableness in the act of prayer. The theory that the system of Nature is under the control of a Being who changes phenomena in compliance with the prayers of men, is, in my opinion, a perfectly legitimate one. It may of course be rendered futile by being associated with conceptions which contradict it, but such conceptions form no necessary part of the theory. It is a matter of experience that an earthly father, who is at the same time both wise and tender, listens to the requests of his children, and, if they do not ask amiss, takes pleasure in granting their requests. We know also that this compliance extends to the alteration, within certain limits, of the current of events on earth. With this suggestion offered by our experience, it is no departure from scientific method to place behind natural phenomena a universal Father, who, in answer to the prayers of His children, alters the currents of those phenomena. Thus far Theology and Science go hand in hand. The conception of an ether, for example, trembling with the waves of light, is suggested by the ordinary phenomena of wave-motion in water and in air; and in like manner the conception of personal volition in Nature is suggested by the ordinary action of man upon earth. I therefore urge no *impossibilities*, though you constantly charge me with doing so. I do not even urge inconsistency, but, on the contrary, frankly admit that you have as good a right to place your conception at the root of phenomena as I have to place mine.

But, without *verification*, a theoretic conception is a mere figment of the intellect, and I am sorry to find us parting company at this point. The region of theory, both in science and theology, lies behind the world of the senses, but the verification of theory occurs in the sensible world. To check the theory we have simply to compare the deductions from it with the facts of observation. If the deductions be in accordance with the facts, we accept the theory: if in opposition, the theory is given up. A single experiment is frequently devised by which the theory must stand or fall. Of this character was the determination of the velocity of light in liquids as a crucial test of the Emission Theory. According to Newton, light travelled faster in water than in air; according to an experiment suggested by Arago, and executed by Fizeau and Foucault, it travelled faster in air than in water. The experiment was conclusive against Newton's theory.

But while science cheerfully submits to this ordeal, it seems impossible to devise a mode of verification of their theory which does not arouse resentment in theological minds. Is it that, while the pleasure of the scientific man culminates in the demonstrated harmony between theory and fact, the highest pleasure of the religious man has been already tasted in the very act of praying, prior to verification, any further effort in this direction being a mere disturbance of his peace? Or is it that we have before us a residue of that mysticism of the middle ages which has been so admirably described by Whewell —that "practice of referring things and events not to clear and distinct notions, not to general rules capable of direct verification, but to notions vague, distant, and vast, which we cannot bring into contact with facts; as when we connect natural events with moral and historic causes. . . . Thus," he continues, "the character of mysticism is that it refers particulars, not to generalizations, homogeneous and immediate, but to such as are heterogeneous and remote; to which we must add that the process of this reference is not a calm act of the intellect, but is accompanied with a glow of enthusiastic feeling."

Every feature here depicted, and some more questionable ones, have shown themselves of late; most conspicuously, I regret to say, in the "leaders" of a weekly journal of considerable influence, and one, on many grounds, entitled to the respect of thoughtful men. In the correspondence, however, published by the same journal, are to be found two or three letters well calculated to correct the temporary flightiness of the journal itself.

It is not my habit of mind to think otherwise than solemnly of the feeling which prompts prayer. It is a potency which I should like to see guided, not extinguished, devoted to practicable objects instead of wasted upon air. In some form or other, not yet evident, it may, as alleged, be necessary to man's highest culture. Certain it is that, while I rank many persons who employ it low in the scale of being, natural foolishness, bigotry, and intolerance, being in their case intensified by the notion that they have access to the ear of God, I regard others who employ it as forming part of the very cream of the earth. The faith that simply adds to the folly and ferocity of the one, is turned to enduring sweetness, holiness, abounding charity, and self-sacrifice, by the other. Christianity, in fact, varies with the nature upon which it falls. Often unreasonable, if not contemptible, in its purer forms prayer hints at disciplines which few of us can neglect without moral loss. But no good can come of giving it a delusive value by claiming for it a power in physical Nature. It may strengthen the heart to meet life's losses, and thus indirectly promote physical well-being, as the digging of Æsop's orchard brought a treasure of fertility greater than the treasure sought. Such indirect issues we all admit; but it would be simply dishonest to affirm that it is such issues that are always in view. Here, for the present, I must end. I ask no space to reply to those railers who make such free use of the terms insolence, outrage, profanity, and blasphemy. They obviously lack the sobriety of mind necessary to give accuracy to their statements, or to render their charges worthy of serious refutation.—*Advance Sheets.*

SPONTANEOUS GENERATION.

THE appearance of the long-promised work of Dr. Bastian on the "Beginnings of Life"[1] will be welcomed by the students of natural history as an important step forward in the progress of an old and interesting controversy. Whether all the life of the earth came from some primordial spark in the dim beginning, that has spread in multitudinous diversity through earth, sea, and air; or whether all forms of living things sprang into perfect existence after their distinctive kinds by a supernatural fiat; or whether the origination of living things is still within the compass of natural operations, are questions equally fascinating to pursue and difficult to determine. But the radical problem of the origin of life is now accepted as legitimate in the field of science, and much of the world's ablest talent is profoundly occupied with its investigation. We propose to give a brief account of Dr. Bastian's contribution to the inquiry, or rather to point out his line of research, referring those who are interested in the subject to his able work, which is now accessible to American readers.

The doctrine that certain forms of living things originate directly in the operations of Nature, without the agency of parentage, is an ancient speculation. Three centuries before the Christian era, Aristotle believed in the spontaneous origination of eels and other fish out of the slimy mud of rivers and marshes; also, that certain insects took origin from the vernal dew on plants; and that lice were spontaneously engendered in the flesh of animals. He believed also that animals might proceed from vegetables—that the caterpillars of certain butterflies, for instance, were actually the products of the plants upon which they fed. To the authority of Aristotle, which was despotic in the schools for nearly two thousand years, was added in this case the influence of poetry by which the Aristotlean science was popularized. Ovid, who is reputed to have been forty-three years old at the Christian era, sung of spontaneous generation as follows—Dryden being responsible for the English:

"The rest of animals from teeming earth
Produced, in various forms received their birth.
The native moisture, in its close retreat
Digested by the sun's ethereal heat
As in a kindly womb, began to breed,
Then swelled and quickened by the vital seed;
And some in less, and some in longer space,
Were ripened into form and took a several face.

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[1] "The Beginnings of Life; being some Account of the Nature, Modes of Origin, and Transformations of Lower Organisms." By H. Charlton Bastian, M. A., M. D., F. R. S. In two volumes, pp. 1200; with numerous Illustrations.

Thus when the Nile from Pharian fields is fled,
And seeks, with ebbing tide, his ancient bed,
The fat manure with heavenly fire is warmed,
And crusted creatures, as in wombs, are formed;
These, when they turn the glebe, the peasants find;
Some rude, and yet unfinished in their kind.
Short of their limbs, a lame, imperfect birth;
One half alive, and one of lifeless earth."

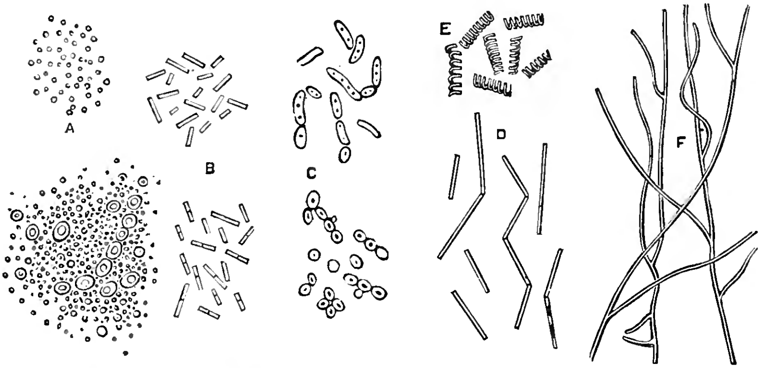
Crude ideas of this kind prevailed universally until the seventeenth century. The celebrated physiologist, Dr. William Harvey, the discoverer of the circulation of the blood, has the credit of first propounding the modern view expressed in the maxim "Omne vivum ex vivo," which being interpreted signifies, "No life without antecedent life." He maintained that all living beings proceed from eggs; but exactly what he meant by "eggs," that is, whether they were always derived from parental organisms, or might originate in some other way, is considered uncertain.

The first distinct announcement of the doctrine that all living matter has sprung from preëxisting living matter, was made by Francesco Redi, an Italian physician, who published his views just two hundred and four years ago. His position is thus stated by Prof. Huxley: "Here are dead animals, or pieces of meat; I expose them to the air in hot weather, and in a few days they swarm with maggots. You tell me that these are generated in the dead flesh; but, if I put similar bodies, while quite fresh, into a jar, and tie some fine gauze over the top of the jar, not a maggot makes its appearance, while the dead substances, nevertheless, putrefy just in the same way as before. It is obvious, therefore, that the maggots are not generated by the corruption of the meat, and that the cause of their formation must be a something which is kept away by gauze. But gauze will not keep away aëriform bodies or fluids. This something must, therefore, exist in the form of solid particles too big to get through the gauze. Nor is one left long in doubt what these solid particles are; for the blow-flies, attracted by the odor of the meat, swarm round the vessel, and urged by a powerful but in this case misleading instinct, lay eggs out of which maggots are immediately hatched upon the gauze. The conclusion, therefore, is unavoidable: the maggots are not generated by the meat, but the eggs which give rise to them are brought through the air by the flies."

These experiments were unanswerable; but the doctrine of spontaneous generation had been too long and firmly believed, to be surrendered merely because of the demonstrated falsity of its grounds. It was held to have the sanction of the Bible, which affirmed that bees were generated from the carcass of a dead lion: Dr. Redi was therefore called upon to defend himself against the charge of impugning Scripture authority.

The views of Redi prevailed for a century, and the hypothesis of spontaneous generation had become completely discredited. But meantime the microscope had been improved, and a new world of life revealed. When animal or vegetable substances are infused for a time in water, swarms of creatures are produced in it, called infusorial animalculæ, and which are so small that they can only be seen with a powerful magnifier. This was a new aspect of the production of life, and favored the view of its spontaneous origin. In the middle of the eighteenth century, an Englishman named Needham took the ground that, although putrefying meat may not engender *insects*, it may yet give rise to *animalculæ*. "If," said Needham, "these animalculæ come

FIG. 1.



SOME OF THE MOST COMMON PRIMORDIAL FORMS OF LIFE. (× 800.)
A. Plastide-particles; B. Bacteria; C. Torula; D. Vibriones; E. Spirilla; F. Leptothrix.

from germs, these germs must exist, either in the infused substance, the water, or the adjacent air. All germs are killed by heat; if, therefore, I boil the infusion, seal it up, and then heat the whole vessel, I shall destroy the germs." He did this; but, after waiting for a time, the animalculæ still appeared in the closed vessel. The experiment seemed conclusive in favor of spontaneous generation, or life without germs; but, again, a learned Italian appeared and attacked the hypothesis. Spallanzani repeated Needham's experiments with more vigilant precautions. He closed the tubes more effectually, and exposed them to a greater heat, after which the animalculæ failed to appear. The real issue in the case was thus fairly reached, and the question became one of the existence of atmospheric germs, and of their power of resisting heat. The results of Spallanzani were generally held conclusive against the hypothesis of spontaneous generation; but, toward the middle of the present century, the question was again opened, and it has been assiduously investigated and hotly discussed by men of science for the last forty years. We cannot even mention the numerous contributions to it that have been made by eminent scientists, but must refer the reader to Dr. Bastian's work, where the history of recent investigations upon the subject is given in detail.

The growth of new distinctions and more precise ideas in science requires the use of new terms to mark them, while, at the same time, old terms have to be discarded, as conveying erroneous ideas. The term "spontaneous generation," although so long applied to the subject, that it will be apt to continue in popular use, has lost its place in biological science, as it is too indefinite, and conveys a false idea. Those who hold that life originates directly from non-living matter do not consider that its production in this way is any more truly "spontaneous" than its usual production from parental germs. Several words have been introduced by different writers to define their ideas, which it is desirable here to explain.

Biogenesis is the term applied by Prof. Huxley to the derivation of life from previously-existing life; and *Abiogenesis* to the production of life from non-living matter. The latter term, therefore, corresponds to what is commonly meant by "spontaneous generation."

Homogenesis, or *Homogeny*, are terms that have been long applied to the production of like from like; that is, the common case in which the living parent gives rise to offspring which pass through the same changes as itself.

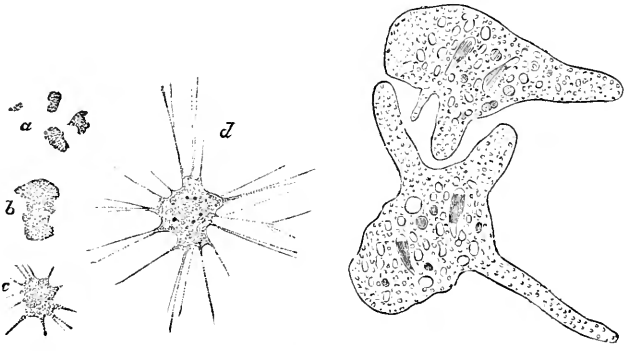
Heterogenesis, or *Heterogeny*, is the name applied to processes by which living things arise from the matter of preëxisting organisms, belonging to a totally different species. It has, however, had different meanings, and its use has created some obscurity, but it is customary to apply it to the so-called cases of "spontaneous generation;" and those who hold this doctrine are therefore known as *Heterogenists.*

Panspermy is the name given to the doctrine of diffused atmospheric germs, as the sources of infusorial life, and those who hold to this view are called *Panspermists.* "Spontaneous generation," so called, or the production of living creatures without parentage, may take place in two ways: either from preëxisting living matter (heterogenesis), or from not-living matter. This production of living forms from inorganic materials is termed by Dr. Bastian *Archebiosis*, which literally means "beginning to live."

It was in the course of some investigations upon the microscopical characters of the blood of persons suffering from acute diseases that Dr. Bastian's attention was first drawn to the question of the origin of life. He soon became interested in it as an independent scientific problem, and pursued the inquiry experimentally for three years, the results being recorded in the present work. In Part I. he aims to show that the now commonly-accepted doctrine of the Correlation of Forces favors the independent origin of living matter. In this part, also, he has an elaborate chapter showing that the cell cannot be regarded as the ultimate organic unit. In Part II., under the head of Archebiosis, he takes up the real issue of the spontaneous generation of new matter endowed with living properties. The question is thus stated: "It must be considered to turn almost wholly upon the possibility of the *de novo* origin of *bacteria;* since, if such a mode of origin can be proved for them, it must also be conceded for other allied fungoid and algoid units. Evidence, which is of the most convincing character when looked at from all sides, now shows that bacteria are killed by a temperature of 140° Fahr. Yet similar organisms will constantly appear and rapidly multiply within closed flasks containing organic fluids, although the flasks and their contents have been previously exposed for some time to a temperature of 212° Fahr."

As it will be impossible in this article to give the details of Dr. Bastian's experiments, we will try to convey to our readers some notion of these living organisms, which it is now claimed can be produced when all germs are destroyed. When a fluid containing an organic substance in solution is left to itself for a time, which may be variable in different circumstances, the infusion gradually becomes turbid, and there forms upon its surface a thin, semi-translucent scum,

FIG. 2.



REPRESENTATION OF HAECKEL'S GROUP MONERA. (× 800.) THE COMMON AMŒBA.
a. Minute Specks of Protoplasm from Fine Surface Mud of Fresh-water Ponds; *b.* Protomœba Primitiva, two Individuals resulting from a Recent Fission; *c.* Vampyrella Pendula; *d.* Amœba Porreta, a Form of Protomœba.

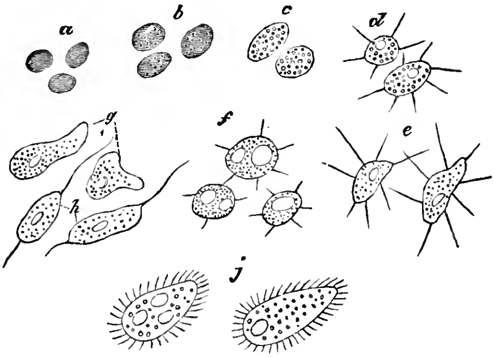
or pellicle, that soon thickens into a membrane. If the fluid be observed by a microscope of the highest power, when it first begins to grow clouded, it will be found swarming with multitudes of moving specks or spherical particles (Fig. 1, A), varying from $\frac{1}{20000}$ to $\frac{1}{100000}$ of an inch in diameter. These specks have been variously named. They have been called "monads," or "mycrozimes," or "micrococci," and are termed by Dr. Bastian *plastide-particles.* They are regarded by him as the primordial particles of living matter, and as giving origin to organisms of a higher grade.

Among these are the infusorial objects known as *bacteria* (Fig. 1, B). These are minute, rod-like, jointed bodies, varying in size according to circumstances, but pretty uniform in the same solution. They are in length from $\frac{1}{15000}$ to $\frac{1}{2000}$ of an inch, and in thickness from $\frac{1}{30000}$ to $\frac{1}{40000}$ of an inch. The rods are formed of a series of granules placed end to end, and their appearance has been likened to a number of fine needles embedded in a thin film of glue. They often present a joint or line in the middle, dividing them into two equal parts. "Their movements are frequently of a more or less rapid, oscillating, or irregularly rotating character; though at other times they may be seen darting from place to place, either directly or in curves of various descriptions. All gradations exist, in fact, between movements which suffice at once to stamp them as living things, and mere slow oscillations, the presence of which alone may make us doubtful as to whether we have to do with living or dead organisms."

Along with the plastide-particles and the bacteria, there appears one of the lowest and simplest of organic bodies—the *Torula*, or yeast-plant (Fig. 1, C). The torula is a simple cell, possessing a cell-wall formed of a thin, homogeneous membrane, and containing a soft formative layer composed of protoplasm. These cells are about $\frac{1}{6000}$ of an inch and smaller, and multiply by budding or gemmation, being usually seen in chains, or clustered groups. *Vibriones* (Fig. 1, D) are described as jointed bodies, composed of long, rod-like segments, bent at various angles, which exhibit certain slow movements—either as mere bending of the body, or else an actual undulating progression. In size they may vary from that of the largest bacteria, up to a body $\frac{1}{300}$ of an inch in length, by $\frac{1}{17000}$ in breadth, though there is no definite limit to their dimensions. The *Spirilla* (Fig. 1, E) are less common organic forms, characterized by the most active movements, and in which the body is thread-like, though twisted into the form of a helix, or spiral. *Leptothrix* (Fig. 1 F) is a name applied to certain filamentous objects that are generally motionless, and often not much thicker than vibriones. They may be either straight or undulating in outline, and perfectly plain, or marked by minute segmentations, after the fashion of the larger fungous filaments, into which it is said they sometimes develop.

Within a few years past, attention has been called by Prof. Haeckel to certain of the lowest forms of organic life, which he considers intermediate between the animal and vegetable kingdoms, and by which they are connected. These he calls the PROTISTA, meaning, first of all, primordial. This primordial organic kingdom, Haeckel divides into ten groups, the lowest of which he names the *Monera*, which includes certain minute jelly-specks termed *protomœba* and *protogenes*. Prof. Haeckel says: "I have called these forms of life standing at the lowest grade of organization *monera*. Their whole body, in a fully-developed and freely-moving condition, consists of an entirely homogeneous and structureless substance, a living particle of albumen capable of nourishment and reproduction. These simplest and most imperfect of all organisms are, in many respects, of the highest interest. For the albumen-like, organic matter meets us here as the material substratum of all life-phenomena, apparently not only under the simplest form as yet actually observed, but also under the simplest form which can well be imagined. Simpler and more incomplete organisms than the monera cannot be conceived. . . . Indeed, the whole body of the monera, however strange this may sound, represents nothing more than a single, thoroughly homogeneous particle of albumen, in a firmly adhesive condition. The external form is quite irregular, continually changing, globularly contracted when at rest. Our sharpest discrimination can detect no trace of an internal structure, or of a formation from dissimilar parts. As the homogeneous, albuminous mass of the body of the moner does not even exhibit a differentiation into an inner nucleus and an outer plasma, and as, moreover, the whole body consists of a homogeneous plasma or protoplasma, the organic matter here does not even reach the importance of the simplest cell. It remains in the lowest imaginable grade of organic individuality." Prof. Haeckel afterward says: "The monera are indeed protista. They are neither animals nor plants. They are organisms of the most primitive kind; among which the distinction between animals and plants does not exist."

FIG. 3.



TRANSFORMATIONS OF CHLOROPHYLL CORPUSCLES. (× 600.)

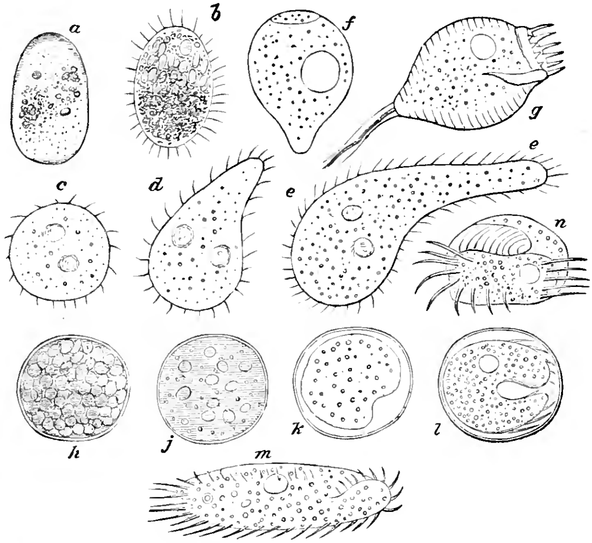
a, Pale, unaltered Chlorophyll Corpuscles of Nitella; *b*, Others lying side by side with former, but larger, of a darker green, and slightly granular; *c*, Decolorization advancing—a few granules still green; *d*, Similar corpuscles after the protrusion of motionless rays, and formation of a vacuole; *e*, Similar corpuscles completely decolorized and converted into sluggish specimens of Actinophrys; *f*, First stage in transformation of Actinophrys, some of which are converted into Amœbæ (*g*), and others into Monads (*h*) with two flagella; *j*, Enchelys-like organisms, probably derived from further development of some Monads and Amœbæ.

The common amœba is described as a microscopic animal at the very bottom of the scale of living things. It is a minute, shapeless, structureless mass of semi-fluid jelly or protoplasm, without organs of any kind, but it has the marvellous power of extemporizing organs as it requires them. Thus, if it wishes to move, it shoots out a part of its body as a temporary foot, and retracts it when no longer wanted.

If it desires to seize any thing, it protrudes an arm for the purpose; and, when it has in this way got possession of the needed nutriment, becoming all stomach, it wraps itself round its food, and absorbs or digests it.

Dr. Carpenter describes it as "changing itself into a greater variety of forms than the fabled Proteus, laying hold of its food without members, swallowing it without a mouth, digesting it without a stomach, appropriating its nutritious material without absorbent vessels or a circulating system, moving from place to place without muscles, feeling (if it has any power to do so) without nerves, multiplying itself without eggs, and not only this, but, in many instances, forming shelly coverings of a symmetry and complexity not surpassed by those of any testaceous animal."

Fig. 4.

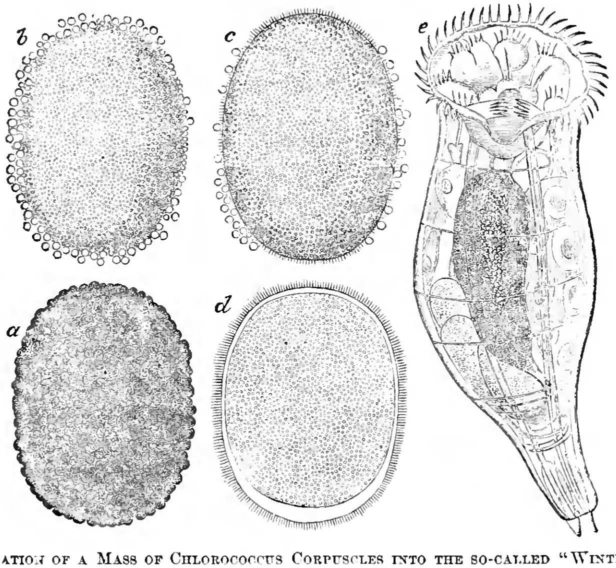


Modes of Origin and Development of Ciliated Infusoria. (× 600.)

a, Transforming Euglena, with red "eye-speck" still visible; *b*, A similar body, having many of its chlorophyll corpuscles still green, fringed with almost motionless cilia; *c*, A completely decolorized sphere derived from a transformed Euglena, provided with a few partly-motionless cilia; *d* and *e*, More advanced forms of a similar embryo developing into a Dileptus (?); *f*, Vorticella, soon after its emergence from a cyst of Euglena origin, which subsequently develops into a striated variety (*g*); *h*, A large Chlorococcus-vesicle, whose contents gradually undergo decolorization (*j*), and at last becomes converted into an animalized mass (*k*), which gradually shapes itself into the form of an Oxytricha (*l*). This after a time ruptures its cyst and soon takes on the characteristics shown at *m*; *n*, A form of Plœsconia derived from an embryo produced within other, apparently similar, Chlorococcus-vesicles.

The experiments of Dr. Bastian force upon him the conclusion that the several organisms here considered, bacteria, torula, vibriones, fungus-filaments, protomœba, and monads, are products of the direct development of new-born specks of living matter. His experiments seem to have been conducted with extreme precautions. He hermetically closed the narrow necks of his flasks during violent ebullition, thus producing an almost perfect vacuum above the infusion. After this he subjected the flasks to a heat of from 212° Fahr. to over 400° Fahr. After being left a few days under favorable situations, and then examined, they were found to contain the living creatures we have described. The only remaining question is, Could these organisms or their germs survive this degree of heat? The alternative to which the opponents of spontaneous generation seem to be driven, by these investigations, is thus pointedly stated by Mr. Alfred Russell Wallace, in a late review of Dr. Bastian's book, in *Nature*. He says: "The only way of escaping from the results of such a series of experiments as that here recorded is by asserting that, although the *organisms* which are produced in the flasks are killed by a temperature much below that

FIG. 5.



TRANSFORMATION OF A MASS OF CHLOROCOCCUS CORPUSCLES INTO THE SO-CALLED "WINTER-EGG" OF *Hydatina senta.* (× 250.)

a, Ovoid mass of bright-green Chlorococcus Corpuscles, about $\frac{1}{200}$ in long diameter; *b*. Such a mass after its transformation into a brown granular body, without distinct bounding wall (should have been intermediate in tint between *a* and *c*); *c*, A similar body at a later stage, when a limiting envelop has made its appearance, upon which villous outgrowths had been produced; *d*, Later stage, constituting the so-called "winter-egg" of *Hydatina*; *e*, *Hydatina senta* which is produced from such a body—almost adult.

to which the flasks have been subjected, the *germs* from which they have been produced are not so killed. We are asked, therefore, to accept as facts three pure suppositions: first, that such excessively minute and simple organisms as bacteria, whose only mode of multiplication is by fission or gemmation, have germs which possess different physical properties from themselves; secondly, that these germs, as well as many others, are omnipresent in the atmosphere; and, thirdly, that they are not injured by an exposure for four hours to vapor heated to over 300° Fahr.; and, finally, we are to accept all these suppositions as facts in order to avoid admitting that specks of living protoplasm are originated *de novo* in some fluids just as specks of crystalline matter originate in other fluids, and although some organisms can be seen to make their appearance in fluids independently of all preëxisting visible germs, just as crystals do."

In Part III., Dr. Bastian takes up the processes of heterogenesis, whereby the matter of already existing living units gives birth to other living things, wholly different from themselves, and having no tendency to revert to the parental type. The transformations and developments represented in Figs. 3, 4, and 5, will mainly interest those familiar with the objects delineated, but they are of a very remarkable character. It is alleged that the cells of confervæ give rise to euglena, a beautiful green organism which abounds in stagnant water, while this undergoes still further transformation into amœba, and ciliated infusoria. And still more surprising, if possible, is the transformation of the minute algoid chlorococcus into the large, complex, and well-known rotifer, *Hydatina senta* (Fig. 5).

As Dr. Bastian remarks: "The fact that animals with such distinct and specific organs should arise in this definite manner, from the reproductive products of the plant, will doubtless seem to many to flavor more of fable than of fact." This is undoubtedly true. Dr. Bastian's views contravene general experience. The derivation of organisms from preëxisting germs is the actual method which we know that Nature employs in all grades from the top to the bottom of the scale of life. We know, moreover, that infusorial germs do exist, and float about, in the atmosphere. Besides, all our past knowledge of life implies the slow operation of the forces of evolution. As for the appearance of infusorial organisms in liquids, which a few hours before did not contain them, they must be explained in accordance with known modes of action, until some other method is demonstrated. To this, Dr. Bastian replies—1. That science now admits that, at some period in the earth's history, the lower forms of life have arisen by the operation of natural causes. 2. That all the considerations bearing upon the case favor the view that such organisms may be produced now, and that it is little else than absurd to suppose that "the simplest and most structureless amœba of the present day can boast a line of ancestors stretching back to such far-remote periods that in comparison with them the primeval men were but as things of yesterday;" and 3. That the *de novo* origin of living matter, and the transformation of low vegetable organisms into infusoria and animalcula are facts that must now be considered as experimentally established. The whole question will therefore turn on the future testing of these remarkable processes. The subject cannot be allowed to rest here; and, if Dr. Bastian's experiments shall be verified, the publication of his work will constitute an epoch in the progress of biological science. It may be remarked that the "Beginnings of Life" is written in a popular and intelligible style, but, as it was composed while the doctor was absorbed in his investigations, it is somewhat defective in classification and condensation. This is to be regretted, yet it is quite a secondary matter. Mr. Wallace deprecates its literary defects, but cordially concedes its scientific importance. He says: "It is so full of curious and novel facts and experiments, it contains so much excellent reasoning and acute criticism, and it opens up such new and astounding views of the nature and origin of life, that one feels it ought to and might have ranked with such standard works as the 'Origin of Species' and the 'Principles of Biology,' if equal care had been bestowed upon it as a literary composition."

AIMS AND INSTRUMENTS OF SCIENTIFIC THOUGHT.[1]

By Professor W. KINGDON CLIFFORD,

OF UNIVERSITY COLLEGE, LONDON.

I.

IT may have occurred (and very naturally, too, to such as have had the curiostity to read the title of this lecture) that it must necessarily be a very dry and difficult subject; interesting to very few, intelligible to still fewer, and, above all, utterly incapable of adequate treatment within the limits of a discourse like this. It is quite true that a complete setting forth of my subject would require a comprehensive treatise on logic, with incidental discussion of the main questions of metaphysics; that it would deal with ideas demanding close study for their apprehension, and investigations requiring a peculiar taste to relish them. It is not my intention now to present you with such a treatise.

The British Association, like the world in general, contains three classes of persons. In the first place, it contains scientific thinkers; that is to say, persons whose thoughts have very frequently the characters which I shall presently describe. Secondly, it contains persons who are engaged in work upon what are called scientific subjects, but who in general do not, and are not expected to, think about these subjects in a scientific manner. Lastly, it contains persons who suppose that their work and their thoughts are unscientific, but who would like to know something about the business of the other two classes aforesaid. Now, to any one who, belonging to one of these classes, considers either of the other two, it will be apparent that there is a certain gulf between him and them; that he does not quite understand them, nor they him; and that an opportunity for sympathy and com-

[1] A Lecture delivered before the members of the British Association, at Brighton, August 19, 1872.

radeship is lost through this want of understanding. It is this gulf that I desire to bridge over, to the best of my power. That the scientific thinker may consider his business in relation to the great life of mankind; that the noble army of practical workers may recognize their fellowship with the outer world, and the spirit which must guide both; that this so-called outer world may see in the work of science only the putting in evidence of all that is excellent in its own work; may feel that the kingdom of science is within it: these are the objects of the present discourse. And they compel me to choose such portions of my vast subject as shall be intelligible to all, while they ought at least to command an interest universal, personal, and profound.

In the first place, then, what is meant by scientific thought? You may have heard some of it expressed in the various sections this morning. You have probably also heard expressed in the same places a great deal of unscientific thought; notwithstanding that it was about mechanical energy, or about hydrocarbons, or about eocene deposits, or about malacopterygii. For scientific thought does not mean thought about scientific subjects with long names. There are no scientific subjects. The subject of science is the human universe; that is to say, every thing that is, or has been, or may be, related to man. Let us, then, taking several topics in succession, endeavor to make out in what cases thought about them is scientific, and in what cases not.

Ancient astronomers observed that the relative motions of the sun and moon recurred all over again in the same order about every nineteen years. They were thus enabled to predict the time at which eclipses would take place. A calculator at one of our observatories can do a great deal more this. Like them, he makes use of past experience to predict the future; but he knows of a great number of other cycles besides that one of the nineteen years, and takes account of all of them; and he can tell about the solar eclipse of six years hence—exactly where it will be visible, and how much of the sun's surface will be covered at each place, and, to a second, at what time of day it will begin and finish there. This prediction involves technical skill of the highest order; but it does not involve scientific thought, as any astronomer will tell you.

By such calculations the places of the planet Uranus at different times of the year have been predicted and set down. The predictions were not fulfilled. Then arose Adams, and from these errors in the prediction he calculated the place of an entirely new planet, that had never yet been suspected; and you all know how the new planet was actually found in that place. Now, this prediction does involve scientific thought, as any one who has studied it will tell you.

Here, then, are two cases of thought about the same subject, both predicting events by the application of previous experience, yet we say one is *technical* and the other *scientific.*

Now, let us take an example from the building of bridges and roofs. When an opening is to be spanned over by a material construction, which must bear a certain weight without bending enough to injure itself, there are two forms in which this construction can be made, the arch and the chain. Every part of an arch is compressed or pushed by the other parts; every part of a chain is in a state of tension, or is pulled by the other parts. In many cases these forms are united. A girder consists of two main pieces or booms, of which the upper one acts as an arch and is compressed, while the lower one acts as a chain and is pulled; and this is true even when both the pieces are quite straight. They are enabled to act in this way by being tied together, or braced, as it is called, by cross-pieces, which you must often have seen. Now, suppose that any good, practical engineer makes a bridge or roof upon some approved pattern which has been made before. He designs the size and shape of it to suit the opening which has to be spanned; selects his material according to the locality; assigns the strength which must be given to the several parts of the structure according to the load which it will have to bear. There is a great deal of thought in the making of this design, whose success is predicted by the application of previous experience; it requires technical skill of a very high order; but it is not scientific thought. On the other hand, Mr. Fleeming Jenkin[1] designs a roof consisting of two arches braced together, instead of an arch and a chain braced together; and, although this form is quite different from any known structure, yet before it is built he assigns with accuracy the amount of material that must be put into every part of the structure in order to make it bear the required load, and this prediction may be trusted with perfect security. What is the natural comment on this? Why, that Mr. Fleeming Jenkin is a scientific engineer.

Now, it seems to me that the difference between scientific and merely technical thought, not only in these, but in all other instances which I have considered, is just this: Both of them make use of experience to direct human action; but while technical thought or skill enables a man to deal with the same circumstances that he has met with before, scientific thought enables him to deal with different circumstances that he has never met with before. But how can experience of one thing enable us to deal with another quite different thing? To answer this question we shall have to consider more closely the nature of scientific thought.

Let us take another example. You know that if you make a dot on a piece of paper, and then hold a piece of Iceland spar over it, you will see not one dot but two. A mineralogist, by measuring the angles of a crystal, can tell you whether or no it possesses this property without looking through it. He requires no scientific thought to do that. But Sir William Rowan Hamilton, the late Astronomer-Royal

[1] "On Braced Arches and Suspension Bridges." Edinburgh, Neill, 1870.

of Ireland, knowing these facts and also the explanation of them which Fresnel had given, thought about the subject, and he predicted that, by looking through certain crystals in a particular direction, we should see not two dots, but a continuous circle. Mr. Lloyd made the experiment, and saw the circle a result which had never been even suspected. This has always been considered one of most signal instances of scientific thought in the domain of physics. It is most distinctly an application of experience, gained under certain circumstances, to entirely different circumstances.

Now, suppose that, the night before coming down to Brighton, you had dreamed of a railway accident, caused by the engine getting frightened at a flock of sheep, and jumping suddenly back over all the carriages; the result of which was that your head was unfortunately cut off, so that you had to put it in your hat-box, and take it back home to be mended. There are, I fear, many persons, even at this day, who would tell you that, after such a dream, it was unwise to travel by railway to Brighton. This is a proposal that you should take experience gained while you are asleep, when you have no common-sense—experience about a phantom-railway—and apply it to guide you when you are awake, and have common-sense, in your dealings with a real railway. And yet this proposal is not dictated by scientific thought.

Now, let us take the great example of biology. I pass over the process of classification, which itself requires a great deal of scientific thought, in particular when a naturalist, who has studied and monographed a fauna or a flora rather than a family, is able at once to pick out the distinguishing characters required for the subdivision of an order quite new to him. Suppose that we possess all this minute and comprehensive knowledge of plants and animals and intermediate organisms, their affinities and differences, their structures and functions—a vast body of experience, collected by incalculable labor and devotion. Then comes Mr. Herbert Spencer; he takes that experience of life which is not human, which is apparently stationary, going on in exactly the same way from year to year, and he applies that to tell us how to deal with the changing characters of human nature and human society. How is it that experience of this sort, vast as it is, can guide us in a matter so different from itself? How does scientific thought, applied to the development of a kangaroo-fœtus, or the movement of the sap in exogens, make prediction possible for the first time in that most important of all sciences, the relations of man with man?

In the dark or unscientific ages men had another way of applying experience to altered circumstances. They believed, for example, that the plant called jew's-ear, which does bear a certain resemblance to the human ear, was a useful cure for diseases of that organ. This doctrine of "signatures," as it was called, exercised an enormous influence on the medicine of the time. I need hardly tell you that it is hopelessly unscientific; yet it agrees with those other examples that we have been considering in this particular: that it applies experience about the shape of a plant—which is one circumstance connected with it—to dealings with its medicinal properties, which are other and different circumstances. Again, suppose that you had been frightened by a thunder-storm on land, or your heart had failed you in a storm at sea; if any one then told you that, in consequence of this, you should always cultivate an unpleasant sensation in the pit of your stomach, till you took delight in it—that you should regulate your sane and sober life by the sensations of a moment of unreasoning terror; this advice would not be an example of scientific thought. Yet it would be an application of past experience to new and different circumstances.

But you will already have observed what is the additional clause that we must add to our definition in order to describe scientific thought, and that only. The step between experience about animals and dealings with changing humanity is the law of evolution. The step from errors in the calculated places of Uranus to the existence of Neptune is the law of gravitation. The step from the observed behavior of crystals to conical refraction is made up of laws of light and geometry. The step from old bridges to new ones is the laws of elasticity and the strength of materials.

The step, then, from past experience to new circumstances must be made in accordance with an observed uniformity in the order of events. This uniformity has held good in the past in certain places; if it should also hold good in the future, and in other places, then, being combined with our experience of the past, it enables us to predict the future, and to know what is going on elsewhere, so that we are able to regulate our conduct in accordance with this knowledge.

The aim of scientific thought, then, is to apply past experience to new circumstances: the instrument is an observed uniformity in the course of events. By the use of this instrument it gives us information transcending our experience, it enables us to infer things that we have not seen from things that we have seen; and the evidence for the truth of that information depends on our supposing that the uniformity holds good beyond our experience. I now want to consider this uniformity a little more closely, to show how the character of scientific thought and the force of its inferences depend upon the character of the uniformity of Nature. I cannot, of course, tell you all that is known of this character without writing an encyclopædia, but I shall confine myself to two points of it, about which, it seems to me, that just now there is something to be said. I want to find out what we mean when we say that the uniformity of Nature is *exact;* and what we mean when we say that it is *reasonable.*

When a student is first introduced to those sciences which have come under the dominion of mathematics, a new and wonderful aspect of Nature bursts upon his view. He has been accustomed to regard things as essentially more or less vague. All the facts that he has hitherto known have been expressed qualitatively, with a little allowance for error on either side. Things which are let go fall to the ground. A very observant man may know also that they fall faster as they go along. But our student is shown that, after falling for one second in a vacuum, a body is going at the rate of thirty-two feet per second; that after falling for two seconds it is going twice as fast; after going two and a half seconds, two and a half times as fast. If he makes the experiment, and finds a single inch per second too much or too little in the rate, one of two things must have happened: either the law of falling bodies has been wrongly stated, or the experiment is not accurate—there is some mistake. He finds reason to think that the latter is always the case: the more carefully he goes to work, the more of the error turns out to belong to the experiment. Again, he may know that water consists of two gases, oxygen and hydrogen, combined; but he now learns that two pints of steam at a temperature of 150° centigrade will always make two pints of hydrogen and one pint of oxygen at the same temperature, all of them being pressed as much as the atmosphere is pressed. If he makes the experiment and gets rather more or less than a pint of oxygen, is the law disproved? No; the steam was impure, or there was some mistake. Myriads of analyses attest the law of combining volumes; the more carefully they are made, the more nearly they coincide with it. The aspects of the faces of a crystal are connected together by a geometrical law, by which, four of them being given, the rest can be found. The place of a planet at a given time is calculated by the law of gravitation; if it is half a second wrong, the fault is in the instrument, the observer, the clock, or the law; now, the more observations are made, the more of this fault is brought home to the instrument, the observer, and the clock. It is no wonder, then, that our student, contemplating these and many like instances, should be led to say: "I have been short-sighted; but I have now put on the spectacles of science which Nature had prepared for my eyes; I see that things have definite outlines, that the world is ruled by exact and rigid mathematical laws; *καὶ σύ, θεός, γεωμετρεῖς*." It is our business to consider whether he is right in so concluding. Is the uniformity of Nature absolutely exact, or only more exact than our experiments?

At this point we have to make a very important distinction. There are two ways in which a law may be inaccurate. The first way is exemplified by that law of Galileo which I mentioned just now: that a body falling *in vacuo* acquires equal increase in velocity in equal times. No matter how many feet per second it is going, after an interval of a second it will be going thirty-two *more* feet per second. We now know that this rate of increase is not exactly the same at different heights, that it depends upon the distance of the body from the centre of the earth; so that the law is only approximate; instead of the increase of velocity being exactly *equal* in equal times, it itself increases very slowly as the body falls. We know also that this variation of the law from the truth is *too small to be perceived* by direct observation on the change of velocity. But suppose we have invented means for observing this, and have verified that the increase of velocity is inversely as the squared distance from the earth's centre. Still the law is not accurate; for the earth does not attract accurately toward her centre, and the direction of attraction is continually varying with the motion of the sea; the body will not even fall in a straight line. The sun and the planets, too, especially the moon, will produce deviations; yet the sum of all these errors will escape our new process of observation, by being a great deal smaller than the necessary errors of that observation. But when these again have been allowed for, there is still the influence of the stars. In this case, however, we only give up one exact law for another. It may still be held that if the effect of every particle of matter in the universe on the falling body were calculated according to the law of gravitation, the body would move exactly as this calculation required. And if it were objected that the body must be slightly magnetic or diamagnetic, while there are magnets not an infinite way off; that a very minute repulsion, even at sensible distances, accompanies the attraction; it might be replied that these phenomena are themselves subject to exact laws, and that, when *all* the laws have been taken into account, the actual motion will exactly correspond with the calculated motion.

I suppose there is hardly a physical student (unless he has specially considered the matter) who would not at once assent to the statement I have just made; that, if we knew all about it, Nature would be found universally subject to exact numerical laws. But let us just consider for another moment what this means.

The word "exact" has a practical and a theoretical meaning. When a grocer weighs you out a certain quantity of sugar very carefully, and says it is exactly a pound, he means that the difference between the mass of the sugar and that of the pound-weight he employs is too small to be detected by his scales. If a chemist had made a special investigation, wishing to be as accurate as he could, and told you this was exactly a pound of sugar, he would mean that the mass of the sugar differed from that of a certain standard piece of platinum by a quantity too small to be detected by *his* means of weighing, which are a thousandfold more accurate than the grocer's. But what would a mathematician mean, if he made the same statement? He would mean this. Suppose the mass of the standard pound to be represented by a length, say a foot, measured on a certain line; so that half a pound would be represented by six inches, and so on. And let the difference between the mass of the sugar and that of the standard pound be drawn upon the same line to the same scale. Then, if that difference were magnified an infinite number of times, it would still be invisible. This is the theoretical meaning of exactness; the practical meaning is only very close approximation; *how* close, depends upon the circumstances. The knowledge, then, of an exact law in the theoretical sense would be equivalent to an infinite observation. I do not say that such knowledge is impossible to man; but I do say that it would be absolutely different in kind from any knowledge that we possess at present.

I shall be told, no doubt, that we do possess a great deal of knowledge of this kind, in the form of geometry and mechanics; and that it is just the example of these sciences that has led men to look for exactness in other quarters. If this had been said to me in the last century, I should not have known what to reply. But it happens that about the beginning of the present century the foundations of geometry were criticised independently by two mathematicians, Lobatschewsky[1] and the immortal Gauss;[2] whose results have been extended and generalized more recently by Riemann[3] and Helmholtz.[4] And the conclusion to which these investigations lead is that although the assumptions which were very properly made by the ancient geometers are practically exact—that is to say, more exact than experiment can be—for such finite things as we have to deal with, and such portions of space as we can reach; yet the truth of them for very much larger things, or very much smaller things, or parts of space which are at present beyond our reach, is a matter to be decided by experiment, when its powers are considerably increased. I want to make as clear as possible the real state of this question at present, because it is often supposed to be a question of words or metaphysics, whereas it is a very distinct and simple question of fact. I am supposed to know, then, that the three angles of a rectilinear triangle are exactly equal to two right angles. Now, suppose that three points are taken in space, distant from one another as far as the sun is from *a* Centauri, and that the shortest distances between these points are drawn so as to form a triangle. And suppose the angles of this triangle to be very accurately measured and added together; this can at present be done so accurately that the error shall certainly be less than one minute, less therefore than the five-thousandth part of a right angle. Then I do not know that this sum would differ at all from two right angles; but also I do not know that the difference would be less than ten degrees, or the ninth part of a right angle.[5] And I have reasons for not knowing.

This example is exceedingly important as showing the connection

[1] "*Geometrische Untersuchungen zur Theorie der Parallellinien*," Berlin, 1840. Translated by Hoüel, Gauthier-Villars, 1866.

[2] Letter to Schumacher, November 28, 1846 (refers to 1792).

[3] "*Ueber die Hypothesen welche der Geometrie zu Grunde liegen*," Göttingen Abhandl., 1866–'67. Translated by Hoüel in *Annali di Matematica*, Milan, vol. iii.

[4] "The Axioms of Geometry," Academy, vol. i., p. 128 (a popular exposition).

[5] Assuming that parallax observations prove the deviation less than half a second for a triangle whose vertex is at the star and base a diameter of the earth's orbit.

between exactness and universality. It is found that the deviation, if it exists, must be nearly proportional to the area of the triangle. So that the error in the case of a triangle whose sides are a mile long would be obtained by dividing that in the case I have just been considering by four hundred quadrillions; the result must be a quantity inconceivably small, which no experiment could detect. But between this inconceivably small error and no error at all, there is fixed an enormous gulf—the gulf between practical and theoretical exactness, and what is even more important, the gulf between what is practically universal and what is theoretically universal. I say that a law is practically universal which is more exact than experiment for all cases that might be got at by such experiment as we have. We assume this kind of universality, and we find that it pays us to assume it. But a law would be theoretically universal if it were true of all cases whatever; and this is what we do not know of any law at all.

I said there were two ways in which a law might be inexact. There is a law of gases which asserts that when you compress a perfect gas the pressure of the gas increases exactly in the proportion in which the volume diminishes. Exactly; that is to say, the law is more accurate than the experiment, and experiments are corrected by means of the law. But it so happens that this law has been explained; we know precisely what it is that happens when a gas is compressed. We know that a gas consists of a vast number of separate molecules, rushing about in all directions with all manner of velocities, but so that the mean velocity of the molecules of air in this room, for example, is about twenty miles a minute. The pressure of the gas on any surface with which it is in contact is nothing more than the impact of these small particles upon it. On any surface large enough to be seen there are millions of these impacts in a second. If the space in which the gas is confined be diminished, the average rate at which the impacts take place will be increased in the same proportion; and, because of the enormous number of them, the actual rate is always exceedingly close to the average. But the law is one of statistics; its accuracy depends on the enormous numbers involved; and so, from the nature of the case, its exactness cannot be theoretical or absolute.

Nearly all the laws of gases have received these statistical explanations; electric and magnetic attraction and repulsion have been treated in a similar manner; and an hypothesis of this sort has been suggested even for the law of gravity. On the other hand, the manner in which the molecules of a gas interfere with each other proves that they repel one another inversely as the fifth power of the distance; so that we here find, at the basis of a statistical explanation, a law which has the form of theoretical exactness. Which of these forms is to win? It seems to me, again, that we do not know, and that the recognition of our ignorance is the surest way to get rid of it.

The world, in general, has made just the remark that I have attributed to a fresh student of the applied sciences. As the discoveries of Galileo, Kepler, Newton, Dalton, Cavendish, Gauss, displayed ever-new phenomena following mathematical laws, the theoretical exactness of the physical universe was taken for granted. Now, when people are hopelessly ignorant of a thing, they quarrel about the source of their knowledge. Accordingly, many maintained that we know these exact laws by intuition. These said always one true thing, that we did not know them from experience. Others said that they were really given in the facts, and adopted ingenious ways of hiding the gulf between the two. Others, again, deduced from transcendental considerations sometimes the laws themselves, and sometimes what, through imperfect information, they supposed to be the laws. But more serious consequences arose when these conceptions derived from physics were carried over into the field of Biology. Sharp lines of division were made between kingdoms, and classes, and orders; an animal was described as a miracle to the vegetable world; specific differences, which are practically permanent within the range of history, were regarded as permanent through all time; a sharp line was drawn between organic and inorganic matter. Further investigation, however, has shown that accuracy had been prematurely attributed to the science, and has filled up all the gulfs and gaps that hasty observers had invented. The animal and vegetable kingdoms have a debatable ground between them, occupied by beings that have the characters of both, and yet belong distinctly to neither. Classes and orders shade into one another all along their common boundary. Specific differences turn out to be the work of time. The line dividing organic matter from inorganic, if drawn to-day, must be moved to-morrow to another place; and the chemist will tell you that the distinction has now no place in his science except in a technical sense for the convenience of studying carbon compounds by themselves. In geology the same tendency gave birth to the doctrine of distinct periods, marked out by the character of the strata deposited in them all over the sea; a doctrine than which, perhaps, no ancient cosmogony has been further from the truth, or done more harm to the progress of science. Refuted many years ago by Mr. Herbert Spencer,[1] it has now fairly yielded to an attack from all sides at once, and may be left in peace.

When, then, we say that the uniformity which we observe in the course of events is exact and universal, we mean no more than this: that we are able to state general rules which are far more exact than direct experiment, and which apply to all cases that we are at present likely to come across. It is important to notice, however, the effect of such exactness as we observe upon the nature of inference. When a telegram arrived stating that Dr. Livingstone had been found by Mr. Stanley, what was the process by which you inferred the finding of

[1] "Illogical Geology," in *Essays*, vol. i. Originally published in 1859.

Dr. Livingstone from the appearance of the telegram? You assumed over and over again the existence of uniformity in Nature. That the newspapers had behaved as they generally do in regard to telegraphic messages; that the clerks had followed the known laws of the action of clerks; that electricity had behaved in the cable exactly as it behaves in the laboratory; that the actions of Mr. Stanley were related to his motives by the same uniformities that affect the actions of other men; that Dr. Livingstone's handwriting conformed to the curious rule by which an ordinary man's handwriting may be recognized as having persistent characteristics even at different periods of his life. But you had a right to be much more sure about some of these inferences than about others. The law of electricity was known with practical exactness, and the conclusions derived from it were the surest things of all—the law about the handwriting, belonging to a portion of physiology which is unconnected with consciousness, was known with less, but still with considerable accuracy. But the laws of human action in which consciousness is concerned are still so far from being completely analyzed and reduced to an exact form, that the inferences which you made by their help were felt to have only a provisional force. It is possible that by-and-by, when psychology has made enormous advances and become an exact science, we may be able to give to testimony the sort of weight which we give to the inferences of physical science. It will then be possible to conceive a case which will show how completely the whole process of inference depends on our assumption of uniformity. Suppose that testimony, having reached the ideal force I have imagined, were to assert that a certain river runs up-hill? You could infer nothing at all. The arm of inference would be paralyzed, and the sword of truth broken in its grasp; and reason could only sit down and wait until recovery restored her limb, and further experience gave her new weapons.—*Advance Sheets from Macmillan.*

SKETCH OF PROFESSOR TYNDALL.

THE Tyndall or Tyndale family emerged into history about the same time as the American Continent. The first of whom we hear was William Tyndale, a contemporary of Columbus, and who was just of age when this country was discovered. It was the epoch of intellectual awakening in Europe, and the impulse was felt equally in geographical exploration and in religious reform. Tyndale took to the latter, and translated the Bible into English for the people. But he found worse navigation on the theological sea than Columbus encountered on the Atlantic, and was burned at the stake for his opinions in 1536.

About the middle of the seventeenth century some of the offshoots of the martyr's family emigrated from Gloucestershire, England, to Ireland, on the eastern or Saxon fringe of which some of their descendants are still scattered. Among these was John Tyndall, the Professor's father, who, although unknown to the public, was a man of unusual intellectual power and force of character. The Tyndall blood seems to have been rather fiery, as Prof. Tyndall's father had a "difference" with his grandfather, which cost him the inheritance that he would have otherwise received as the eldest son. He was therefore left to struggle without means, and learned a trade, but subsequently took a position on the police force of Ireland. But, being denied the usual facilities of education, he taught himself upon various subjects, and especially he became an able student of history. Prof. Tyndall's father inherited from his ancestors a taste for religious controversy, and threw himself zealously as an anti-Romanist into the Protestant and Catholic warfare. The fathers of the English Church, Chillingworth, Tillotson, Faber, Poole, Jeremy Taylor, and a host of others, were at his finger's ends. Young Tyndall's early intellectual discipline consisted almost wholly of exercises in theological controversy, on the doctrines of infallibility, purgatory, transubstantiation, and invocation of the saints. The boy knew the Bible almost by heart, and, with reference to this knowledge, his father used to call him Stillingfleet. But he had also an early interest in natural things, and his father flattered this tendency by calling him Newton, and by teaching him lines concerning the great natural philosopher, before he was seven years old, that are still remembered. The father of Prof. Tyndall was not only intellectually gifted, but he was a man of courage, independence, mental delicacy, and scrupulous honor. By the silent influence of his character, by example as well as by precept, he inspired the intellect of his boy, and taught him to love a life of manly independence. He died in May, 1847, quoting to his son the words of Wolsey to Cromwell—"Be just and fear nothing."

The subject of our present sketch was born in the village of Leighlin Bridge, Ireland, in 1820, and his earliest education was received at a school in that neighborhood. Through the influence of one of his teachers, he acquired an early taste for geometry. In 1839 he quitted school and joined the Irish Ordnance Survey. He acquired a practical knowledge of every branch of it, becoming in turn a draughtsman, a computer, a surveyor, and trigonometrical observer. In subsequent years he turned this experience to admirable account in his investigations of alpine glaciers. In 1841 an incident occurred which, although apparently trivial, had a powerful effect upon the young man's career. One of the officials, who had become interested in Tyndall's work, asked him one day how his leisure hours were employed. The answer not being satisfactory, he rejoined, "You have five hours a day at your disposal, and this time ought to be devoted to systematic study. Had I, when at your age, had a friend to advise me, as I now advise you, instead of being in a subordinate position, I might have been at the head of the Survey." Next morning Tyndall was at his books before five o'clock, and for twelve years never swerved from the pratice.

In 1844, seeing no definite prospect before him, Mr. Tyndall resolved to go to America, whither, in the early part of the present century, some members of his father's family had emigrated, and who now reside in Philadelphia.[1] This was, however, opposed by his friends, and, an opening occurring, he entered upon the vocation of a railroad engineer. To five years upon the Ordnance Survey succeeded three years of railway experience. But, this proving unpromising, and animated by a strong desire to augment his knowledge, Mr. Tyndall resigned his position, and accepted an appointment in Queenswood College, Hampshire—a new institution devoted partly to a junior school and partly to the preliminary technical education of agriculturists and engineers. Prof. Tyndall here developed a remarkable capacity as a teacher. Although totally inexperienced in this field, such was his magnetic influence over the students, that he was invariably called upon to compose their disturbances, which he did by moral influences and pure force of character. It was his experience in this institution that gave him the groundwork of his masterly address on education before the Royal Institution.[2]

In 1848, in company with his friend Frankland (now Prof. Frankland, of the Royal School of Chemistry), Tyndall quitted England, and, attracted by the fame of Prof. Bunsen, repaired to the University of Marburg, in Hesse-Cassel. Prof. Tyndall had the free use of the laboratory and cabinets of this institution, with the instructions of Bunsen, Gerling, Knoblauch, and Stegman. His first scientific paper was a mathematical essay on screw-surfaces, which formed the subject of his inaugural dissertation when he took his degree. But the investigation which first made him known to the scientific world was "On the Magne-optic Properties of Crystals, and the Relation of Magnetism and Diamagnetism to Molecular Arrangement." This investigation was executed in connection with Prof. Knoblauch, and was published in the *Philosophical Magazine* for 1850.

In 1851 Mr. Tyndall went to Berlin, and continued his researches in the laboratory of Prof. Magnus. He soon, however, returned to London, and was elected Fellow of the Royal Society in 1852. He was invited to give a Friday evening discourse at the Royal Institution, which he delivered February 14, 1853, and was so successful that

[1] One of these is Hector Tyndale, who distinguished himself as an officer in the late war. At Antietam he fought as major, and for his gallant behavior was subsequently made brigadier-general.

[2] *See* "Culture demanded by Modern Life." D. Appleton & Co.

he was at once offered a position in that establishment. His election to the appointment which he now holds, of Professor of Natural Philosophy at the Royal Institution, was unanimously made in June, 1853. The first three years of his residence in London he devoted to an exhaustive investigation of diamagnetism, the results of which were published in various memoirs that have since been collected in a volume.

Prof. Tyndall was first attracted to the Alps in 1849, for the sole object of healthful recreation and exercise. But he could not be long in the presence of the grand physical phenomena there displayed without becoming interested in the scientific questions they present. Accordingly, for more than twenty years, the Alps have served the double purpose to Prof. Tyndall of physical and mental reinvigoration, after being run down by his London work; and, at the same time, they have furnished him with a series of the most interesting scientific problems. In company with his friends Prof. Huxley and Prof. Hirst (an old and favorite pupil of Tyndall's, and to whom he dedicated his "Hours of Exercise in the Alps"), and often alone, usually in summer, but sometimes in winter, he has climbed the mountains and explored the Glaciers, to clear up the various questions that have arisen, and extend our knowledge of the subject. The description of his adventures and the results of his researches were embodied in his volume on "The Glaciers of the Alps," but which is now out of print. The reader will, however, find the records of adventure, and the results of study in the mountains, embodied in the "Hours of Exercise," published last year, and in a neat little volume on the "Forms of Water," now just issued from the press.

As we remarked last month, Prof. Tyndall's proclivity is for philosophic physics, and all his various lines of research, since he began in the Marburg laboratory, twenty-four years ago, have converged upon the great question of the molecular constitution of matter. The different forces of Nature, and the several divisions of physics, can only be brought into scientific harmony as they are harmonized in Nature, by arriving at some clear understanding of the common constitution of matter and how it is related to the action of forces. Prof. Tyndall has been a profound student of the correlation of these forces, and of the mechanism of that material substratum through which they are manifested. Taking up matter in its free or vaporous condition, his chief problem has been to explore or to *sound* it by the action of the radiant forces. In his work on "Heat as a Mode of Motion," published in 1863, he develops that modern view of the nature of heat which involves a molecular conception of the bodies displaying it. The results of his original researches into the relations of radiant heat to gases and vapors are there summarized, and his full memoirs upon these investigations have just been published in a companion volume to the work on diamagnetism. His interesting little volume on "Sound," although not designed as a statement of original work, takes up the subject of acoustics from the same general point of view, and deals with atmospheric wave-motion in connection with the properties and constitution of the various forms of matter. The researches on the formation of clouds in tubes filled with various gases and vapors under the influence of the electric beam, and the resulting inquiry into the subject of atmospheric dust, were but parts of the same comprehensive investigation into molecular conditions and transformations.

Prof. Tyndall has won his scientific reputation as an explorer in the field of experimental physics, but he has also a commanding position as a philosophic thinker. The questions that can be resolved by experiment lead on to questions that can be resolved only by reason. Philosophy is old and easy, and the human mind has overflowed with it from the beginning; but philosophy grounded in the knowledge and method of science is as yet rare, though it is nevertheless a glorious reality. If scientific thinking is the result of an apprenticeship of centuries in the management of the intellect, and if the mind's scientific action is its most perfect action, then must scientific men, as the world goes on, be more and more trusted in their opinions. Such is undoubtedly the present tendency. This is shown generally in the increasing recognition of the scientific school of philosophy, and it is specially exemplified, in the present case, by the interest that is taken in whatever Prof. Tyndall has to say to the public, and whatever the subject on which he speaks. This high scientific position gives acknowledged weight and force to his views. But Prof. Tyndall's philosophic cast of mind not only attracts him to the deeper questions of the time, but his courageous temper leads him to deal with them candidly and fearlessly. First of all, a devotee of science and a lover of truth, he gives to these his sole allegiance. An independent and intrepid inquirer, tolerant of honest error, but contemptuous of that timid and calculating spirit which would protect men's prejudices from the light of investigation, he is without fear in the free and manly expressions of his opinions. That these should often contravene prevailing beliefs is inevitable. A Protestant by hereditary instinct and in his blood, and long drilled in the severities of scientific logic, it is impossible that he should not find much in current opinion to excite continued and trenchant protest.

Allied with this cherished freedom of thought and utterance, there is in Prof. Tyndall's character an intense love of justice, and a passion for fair dealing that is quite chivalric. This temper has been displayed on various occasions, but in none more conspicuously than in his generous defence of the German physicist, Mayer, whose scientific claims he considered to be depreciated by English scientists. Mayer's had been a hard fate. An undoubted pioneer in establishing the important doctrine of the correlation of forces, working out its several lines of proof with marvellous sagacity and an amount of exhausting labor that resulted in mental derangement, and with little sympathetic recognition on the part of his own countrymen, Prof. Tyndall was indignant that Englishmen, who pride themselves upon fair play, should detract one iota from the just fame of the unfortunate foreigner. The man was unknown to him, but the rights of the discoverer and the honor of science were involved, and against the attacks of Professors Thomson, Tait, and others, Prof. Tyndall made a defence so effectual that the claims of the German philosopher will hardly be brought in question again.

Of Prof. Tyndall as an author, it is hardly necessary to speak, as his various works have been widely circulated, and the reading public is familiar with them. Yet his genius as a writer is so marked that it cannot be omitted even in the briefest sketch of his character. Among scientific writers he stands almost alone in the poetic vividness, force, and finish of his style. His descriptions and narrations are enriched by a bold and striking pictorial imagery, which presents the subject with almost the perspective and "coloring of reality." No man better understands the high office of imagination in science, or can more effectively employ it to fascinate and illuminate the minds of others. Of an ardent and poetic temperament, and at home among the grandeurs of natural phenomena, there is often an inspiration in his words that rouses and thrills our highest feelings.

Prof. Tyndall is now among us, to speak upon science in several of the chief cities of the country, and it is therefore as a lecturer that the public will be chiefly interested in him. We quote an excellent account of his characteristics as a public teacher from the October *Galaxy*:

"Prof. Tyndall's manner as a lecturer is in a remarkable degree individual and unique. He never reads, but holds his audience by the power of lucid and forcible extemporaneous statement. He is not what would be called a fluent or even speaker, who keeps up a continuous strain of agreeable utterance. He is not an elegant declaimer, whose measured cadences are accompanied by graceful and appropriate gestures. He is irregular and sometimes hesitating in speech, and unstudied in gestures and movements. His habit of speaking has been formed in connection with his habit of experimenting, and this latter is so essential a feature of his platform exercises that it greatly influences his manner of public address. Clearness, force, vividness of description, felicity of illustration, and the eloquence inspired by grand conceptions are the striking features of his style. Of a poetic and imaginative temperament, but with these traits under thorough discipline, he gives vivacity and attractiveness to accurate and solid exposition. Prof. Tyndall is a thoroughly-trained and well-poised enthusiast in science. He is intensely in earnest, and is always as much interested in the subject and the proceedings as the audience he carries with him. He is a remarkable example of self-forgetfulness upon the platform, being always absorbed in his subject. Strongly sympathetic with his audience, he seems animated by but one purpose: to make them understand the question before them, to make them see it and feel it as he sees and feels it. As an original and skilful experimenter Prof. Tyndall is unrivalled. Fertile and ingenious in contrivances for bringing out his points, the effects are always telling and impressive. Yet the experiments are never the main things; they are always subordinate to the idea with which he is dealing—helps to its presentation. He is never eclipsed by his own pyrotechny, but holds the attention of his listeners closely to the question under examination. Prof. Tyndall is remarkable for the combination of two traits which are but rarely united in a single individual. He is an original explorer of scientific truth, and a skilful and effective public teacher. Holding the truths of science to be divine, he is impelled to dedicate his life to their discovery; but holding them also to be a means of salvation to man, he is impelled also to the duty of their public interpretation. The Royal Institution, in which he is professor, is admirably constituted for the attainment of this twofold end; providing equally for carrying out systematic original researches and for expounding their results to the select audiences that gather in its lecture-room. Sir Humphry Davy first gave it a world-wide reputation in both these departments; he was a fertile discoverer and an eloquent lecturer. Dr. Faraday succeeded him, and probably surpassed him in both of these accomplishments. The mantle of Faraday has fallen upon Tyndall, and the fame of the establishment has not suffered from the change."

Prof. Tyndall has long desired to visit the United States, to see his many friends, and to observe the aspects of American life; while multitudes in this country have reciprocated the desire, that they might have the opportunity of listening to his lectures. Yielding to their numerous appeals, he has prepared a course of six lectures, and brought with him a large amount of new and delicate apparatus, for illustrating them. The lectures will embrace the phenomena and laws of light: reflection, refraction, analysis, synthesis, the doctrine of colors, and the extension of radiant action in both directions, beyond the light-giving rays into the region of invisible action. Then will follow the principles of spectrum analysis, the polarization of light, the phenomena of crystallization, the action of crystals upon light, the chromatic phenomena of polarized light, and the parallel phenomena of light and radiant heat. These lectures will be a source of rare intellectual enjoyment to those who will have the good fortune to listen to them, and of which our citizens will not be slow to avail themselves.

We give, in the present number of the MONTHLY, the best likeness we have ever seen of Prof. Tyndall. He is a man of medium stature, lithe-built, highly vitalized, alert and noiseless in his movements; a ready and effective talker, but an excellent listener, and his manners are genial and attractive. He is socially strong, a man of the world, as well as a philosopher, and at home in all relations. But, with all his passion for experiment, he has not yet made the experiment of matrimony.

EDITOR'S TABLE.

THE DOCTRINE OF EVOLUTION.

THE editor of *Scribner's Magazine*, in a leading article in the October number, attempts to bring THE POPULAR SCIENCE MONTHLY into reproach for its obnoxious opinions. There is a certain doctrine lately much talked about that is known to be odious among a great number of magazine-buying people. It is charged (on what authority is not stated) that the editor of THE POPULAR SCIENCE MONTHLY is an irrepressible partisan of this doctrine, and that, having made certain specious promises to its readers to furnish them with good, sound, scientific reading, he has betrayed their confidence by setting his pages ablaze with expositions of this doctrine, that so many people are known to regard with detestation. The little game here undertaken is old, and has been often played with success; but, with the growth of intelligence and liberality, it is getting disreputable, and our neighbor is welcome to all he can make by it. It is customary in such cases not to be very scrupulous about the means resorted to for effecting the object, and the present instance is no exception to the custom. The editor commences by trying to be ironical about the claims of science in culture, and quotes from our prospectus the remark that it is "of the highest concern that thought should be brought into the exactest harmony with things." We are still of opinion that the neglect of this requirement is the fundamental defect of education, and we venture to intimate to our critic that this is exactly "what's the matter with him." His statements not only fail to harmonize with the things he is talking about, but they grossly misrepresent them. After quoting some sentences from our prospectus, the editor says:

> "It is therefore painful to find that, when we pass from the well-taken prospectus to the actual monthly, the strict inductive inquiry fades softly away, as in a dissolving view, and in its place blazes out one of the most high-flown of human speculations. The strong bias of the editor as an evolutionist cannot be repressed, and the attempt is made to educate the public mind into the phraseology and methods of what is at best a speculation, under the name of science! If this were called the Youmans, or Evolution Monthly, the mischief would be circumscribed; but, as the doctrine of Evolution, with its offspring, Darwinism, is nothing more yet than a provisional hypothesis, based on *a priori* reasonings, and not on any valid induction of facts, the attempt to clothe it in the imperial garb of science, and set it for an arbiter of all beliefs, is greatly to be deprecated in the interest of true culture."

The statement here made, that under editorial bias our pages have been set ablaze with evolution speculations in violation of prospective pledges, is simply not true. We promised our readers to represent the present state of thought on the leading questions that are agitating the scientific world. The doctrine of evolution, as everybody knows, is one of these questions, and had we avoided it we should have broken our promise, and broken faith with our readers. Nor has the subject received the excessive attention that is charged. Our first volume, just completed, contains about a hundred main or leading articles, and of these but three deal with the subject of Evolution or Darwinism, and one of them is an attack upon its fundamental principle. Of the articles contributed by the editor, not one has been devoted to the object alleged—"that of educating the popular mind into the phraseology and methods of this speculation." Nor is there a single article in the whole volume that gives any explanation of either the phraseology or the methods of the doctrine of Evolution. A few references to it there have been, as in the addresses of Dr. Carpenter and Prof. Gray, before eminent scientific bodies, and as occurs in the able article of Prof. Clifford in the present number; but these references are incidental and unavoidable: they result from the prominence of the question in the scientific world, and its consequent recognition in current scientific literature. And yet it pleases the editor of *Scribner's* to tell his readers that under an uncontrolled personal bias our pages are so fired with this mischievous doctrine that the name of the MONTHLY ought to be changed to prevent its evil influence.

It now remains to consider the more serious imputation, that our pages have been perverted to the diffusion of spurious science. According to the editor of *Scribner's*, the doctrine of evolution is not a result of true science—not an induction from facts, but a "high-flown," "*a priori*" "speculation." And here, again, we have to note that this writer is not very particular to make his thought harmonize with the things he is talking about. His statement is as wrong as he could get it—just 180° from the truth; and, if the ignorance he evinces be any measure of the general ignorance, we cannot too quickly begin the neglected work of "educating the popular mind" into the rudiments of the subject. We purpose now to show that the Hypothesis of Evolution is not an *a priori* speculation, but a true scientific induction; and not only so, but it is the antagonist and successor of *a priori* speculations which had been in vogue for many centuries before the inductive method arose.

What is the fundamental conception of the doctrine of Evolution? It is "that the universe and all that it contains did not come into existence in the condition that we now know it, nor in any thing like that condition." It implies that the heavens as they appear above us, the earth as it exists beneath us, the hosts of living creatures that occupy it, and humanity as we now know it, "are merely the final terms in an immense series of changes, which have been brought about in the course of immeasurable time." It affirms vast changes in past periods; that these changes have been according to a method, and that this method has been of the nature of an unfolding. The essential changes of evolution have been comprehensively formulated as from the simple to the complex, from the homogeneous to the heterogeneous, from the general to the special. Is this an *a priori* speculation, that is, an idea formed before observation and experience of the facts to which it applies; or is it a scientific induction, that is, an idea formed after the facts are known, and based upon them?

As regards the stellar and planetary universe, its origin from an all-diffused nebulous mist was taught by Kant a century ago. This view was subsequently elaborated by Laplace the mathemetician, and Herschel the astronomer, into the Nebular Hypothesis, which was the outcome of the whole body of known astronomical facts. This hypothesis affirmed the progressive condensation and differentiation of the nebulous mass through successive stages to more and more concrete and specialized groups, systems, and orbs. That the solar system was gradually formed in the way the nebular hypothesis implies, and that its facts can be explained by that hypothesis and no other, is now the general belief of astronomers. Consisting of more than one hundred and fifty bodies, revolving and circulating according to one grand method, it has been pointed out by Prof. Leconte that there are no less than three hundred and seventy facts concerning the distribution, form, and motions, of the sun and planets, which are the simple consequences of the nebular hypothesis, and can be accounted for in no other way. The nebular hypothesis is the doctrine of to-day, in its application to the most perfect of the sciences, and it is nothing less or other than an hypothesis of astronomic evolution. Are we to be told that it is but an *a priori* speculation? On the contrary, has it not replaced an *a priori* cosmogony that swayed the human mind for thousands of years before the solar system was discovered?

As regards the earth, it has been studied by the method of science for more than a century, and the result is, a vast mass of facts and inductions which make up our knowledge of geology. All these go to establish one proposition, viz., that our planet is not what it was millions of years ago, but has undergone a series of developing changes resulting in the present order of things. Our eminent geologist, Prof. Dana, in his manual, says: "This law of specialization—the general being before the special—is the law of all development. The egg is at first a simple unit, and, gradually, part after part of the new structure is evolved, that which is most fundamental appearing earliest, until the being is complete in all its outer and minor details. The principle is exhibited in the physical history of the globe—which was first a featureless globe of fire, then had its oceans and dry land, in course of time received mountains and rivers, and finally all those diversities of surface which now characterize it. Again, the climates began with universal tropics; and at last the diversities of the present day." Is this to be accounted a high-flown *a priori* speculation, or a vast and valid induction from a hundred years' study of the facts of Nature? Let it be remembered that, according to the highest authorities, inductive geology was put back two centuries by the enslavement of the human mind to an old *a priori* speculation in regard to the age of the world.

The study of the course of life upon the earth shows that it conforms to the same great plan. The life of the globe a few millions of years ago was a very different thing from what it is now. Different races of plants and animals have appeared and disappeared in slow succession, and their remains are found entombed in successive rock-formations. The facts are a part of geology, and have been arrived at by the same processes of observation and induction that have revealed the order and history of the stratified systems. The course of life upon the earth has conformed to a method, and that method is universally described as a progress and a development. It shows an advance from the simpler to the more complex, from the general to the special, from the lower to the higher; in short, it is an evolution in the strictest sense. There was, first, a period of no life—the azoic age; then appeared the lower forms of life, vegetable and animal; then higher and higher kinds, until man, the highest of all, appeared last. The progress evinces continuity, harmony, and gradation. As remarked by Mr. Dana, "the beginning of an age will be in the midst of a preceding age; and the marks of the future coming out to view are to be regarded as prophetic of that future. The age of mammals was foreshadowed by the appearance of mammals long before in the course of the reptilian age, and the age of reptiles was prophesied in types that lived in the earlier Carboniferous age." The lower forms that perish do not reappear, and, as Mr. Wallace observes, "no group or species has come into existence twice," but "every species has come into existence coincident, both in space and time, with a preëxisting, closely-allied species."

That the great advancing movement of life has been a divergence, an opening out, or an evolution, is incontestable, and is admitted by the highest biological authorities. It is proved by the fact that, if we go back a million of years or so, there is an obvious convergence of types, or the different kinds of animals will have to be represented as nearer together in characters, and, as we recede still farther into the past, the approximation becomes still closer. Prof. Owen says he has "never omitted a proper opportunity for impressing the results of observations showing the more generalized structures of extinct, as compared with the more specialized form of recent animals." Prof. Agassiz takes a similar position, insisting strongly that "The more ancient animals resemble the embryonic forms of existing species." Mr. Wallace says: "As we go back into past time and meet with the fossil remains of more and more ancient races of extinct animals we find that many of them actually are intermediate between distinct groups of existing animals." Prof. Cope remarks: "That the existing state of the geological record of organic types should be regarded as any thing but a fragment is, from our stand-point, quite preposterous. And more, it may be assumed with safety, that when completed, it will furnish us with a series of regular successions, with but slight and regular interruptions, if any, from the species which represented the simplest beginnings of life at the dawn of creation, to those which have displayed complication and power in a later or in the present period. For the labors of the paleontologist are daily bringing to light structures intermediate between those never before so connected, thus creating lines of succession where before were only interruptions." Is the great conclusion of an unfolding method in the order of life which is based upon a vast body of biological facts, and supported by the powerful analogies of an unfolding order in other parts of nature, to be characterized as a high-flown *a priori* speculation? or is it a result of strict inductive inquiry, which replaces an *a priori* hypothesis of life that prevailed for ages before science had entered upon its study?

Again, humanity is not now what it was in ages long past. That man's existence upon earth dates back to a far profounder antiquity than has formerly been believed, is a clear induction from an extensive array of facts. Be the time longer or shorter, an immense series of changes has taken place in the history of the race. A few thousand years ago Europe was barbarous, and its inhabitants warred and worked with implements of stone. Society was rude, low, homogeneous, and undeveloped. Its movement has been a slow unfolding into diversity and specialty. There has been an increase of human capabilities, a rise in intelligence, an advance of morals, a growing capacity of social coöperation, a multiplication of arts and industries, augmented power over Nature, an emergence of institutions, and in short an evolution of civilization. This is a broad induction, from the facts of history, from the facts of prehistoric archæology, and from the facts of anthropology, and it is fast taking the place of the old *a priori* speculation that the course of humanity has been a degeneracy, and which was firmly believed until science reversed the method of studying the subject.

Sir Charles Lyell, it will hardly be denied, is one of the most learned and able of living geologists. His pains-taking conscientiousness as an observer and his judicial caution and calmness as an inductive reasoner are beyond question. For fifty years he has studied the subject of life in connection with the past changes of the globe, and has embodied his conclusions in his various geological works. In the earlier of these works, which passed through many editions, he accepted the old traditional view of the origin of life. But, as his studies enlarged, that view broke down so completely that he has formally abandoned it. In the tenth edition of his "Principles of Geology," published in 1867, and in the eleventh edition of the same work now just issued, he has adopted the theory of evolution in its application to the phenomena of terrestrial life. The presidents of the British Association for the Advancement of Science, Grove, Hooker, Huxley, and Carpenter, in their inaugural addresses, and Prof. Gray in his late address as president of the American Scientific Association, have proclaimed their adherence to the doctrine of evolution. Prof. Cope, one of the most able and accomplished of American zoologists, affirms that the truth of the development hypothesis is held "to be infinitely probable by a majority of the exponents of the natural sciences, and is held as absolutely demonstrated by another portion." It has been widely accepted by the younger naturalists of this country, more generally by those of England, and still more extensively by those of Germany, as a guiding principle in the work of investigation. An intelligent German naturalist said to Prof. Giekie, of the Edinburgh University: "You are still discussing in England whether or not the theory of Darwin can be true. We have got a long way beyond that here. His theory is now our common starting-point."

Facts like these will have weight with thoughtful persons, but the editor of *Scribner's* sees through the illusion. All these masters of science and working-students of Nature have been lured from the path of true induction by the *ignis fatuus* of a high-flown *a priori* speculation.

We have shown the separate establishment of a principle of evolution by independent workers in different branches of science. On the broad basis of the facts and inductions that have been reached by three centuries of investigation in the several domains of natural phenomena, rests the hypothesis of *universal evolution*. The coordination of these diverse and alien orders of facts, and the synthesis of inductions, by which the grand generalization was arrived at, we owe to the genius of Herbert Spencer. With a knowledge of modern science that John Stuart Mill has pronounced "encyclopedic," with a grasp of method and a capacity of organization which, on the authority of the *Saturday Review*, has not been equalled in England since Newton, and with the power of a "giant mind," as Dr. McCosh declares, to wield and shape his extensive scientific materials, Mr. Spencer has worked out the principle of universal evolution by the rigid logic of inductive science. In each division of his exposition the first step has been to marshal the facts; to sift and methodize the data. The next step has been to generalize the facts, or to establish the inductions warranted by the data. Finally he verifies these inductions by showing that they follow from previously established principles, and harmonize with them. The conditions by which all science has been created are thus strictly complied with. The conception of all nature, as in a slow process of movement to a higher state—of an ever-advancing and ever-perfecting order—of a *universe in evolution*, is no fantastic speculation brought down to us by tradition from the dreaming childhood of the race, but it is a definite verifiable principle educed from a more comprehensive range of facts than any other generalization ever attempted—the outgrowth of the ripest knowledge, and which is coercing the assent of the most disciplined intellects of the world. The principle in question is no barren formula to be classed with the empty *a priori* speculations which have figured so largely in the past career of the human mind. It is the result of the steady concentration of the intellect of man for hundreds of years upon the realities that surround us, and is the profoundest answer yet given to man's questionings of the mystery of being. It is the latest interpretation of the ongoings of the world, and brings with it the possibility of a new and more stable philosophy of things than we have yet known—a philosophy not spun from mystical *a priori* fancies, but constructed from the valid truths of science, and anchored in the depths of demonstrated knowledge.

An able writer in the *Quarterly Review* (London) for July, in discussing the modern school of thought and Herbert Spencer's relation to it, says: "The two deepest scientific principles now known of all those relating to material things are, the law of gravitation and the law of evolution." The principle is here recognized as more than a hypothesis and more even than a theory, it is a *law* in the same sense that gravitation is a law. The proof of evolution indeed is very far from being so complete as that of gravitation. But its claims as an established law are not therefore invalidated, for the accepted truths of science by no means rest upon equal amounts of evidence. From the newness of the systematic investigation of the principle, from the imperfection of knowledge in many spheres of its application, and from the stupendous reach of its operation, it is impossible that there should not be many deficiencies in its proof. It has its outstanding and unresolved difficulties which it may take long to clear up. Truths grow—they are examples of evolution. All great generalizations have been arrived at gradually; never at once by complete demonstration. There are first long foreshadowing preludes in which a principle is discerned as emerging into increasing distinctness. It is then accepted on grounds of probability, and preponderating proofs, and as an advance on previous beliefs. If a theory becomes increasingly consonant with facts, and steadily makes way against inexorable criticism, though it has grave difficulties, it will be accepted, and these difficulties will be left to the future. It was so with the law of gravitation. "The Newtonian theory was beset by palpable contradictions in its results till many years after Newton's death, yet all sound philosophers embraced it. The motion of the apsides of the moon's orbit was with singular honesty confessed by Newton to be, in fact, nearly twice as great as calculation from theory made it; and this contradiction remained an outstanding, palpable objection, yet without occasioning any misgiving as to the general truth of gravitation, until the error was explained and the calculation rectified by Clairault."

And so it is in other branches of science. The undulating theory of light is accepted by all physicists, but still has its difficulties. The theory of heat is not without its anomalies. The chemical theory of respiration is generally adopted, but there are facts that still oppose it. It is claimed by none, that the evidence of the law of evolution is complete, but it is a growing conviction of those who know the subject best, that the evidence in its favor preponderates overwhelmingly. Nor is it dependent upon any of its special interpretations. Darwin may be in error, Huxley may be wrong, Mivart may be wide of the mark, Haeckel may be mistaken, Cope may misjudge, and Spencer be at fault; but, in common with a large and increasing body of scientific men, they are all agreed as to one thing, that evolution is a great and established fact—a wide and valid induction from the observed order of Nature, the complete elucidation of which is the grand scientific task of the future. It is in this sense that we hold to the doctrine of evolution.

In our prospectus we referred to the increasing number of those who desire to know whither inquiry is tending, what old ideas are perishing, and what new ones are rising into acceptance; and we said that our periodical was commenced with the intention of meeting the wants of these more perfectly than any other. The editor of *Scribner's* refers to this as a "magnificent promise," and dilates upon the transcendent editorial attributes required to realize it. To this we reply, "Not if the specimen of Scribnerian science we have here considered is to be taken as the standard." And if we may be permitted to imitate the bad example of *Scribner's* editor, and meddle for a moment with what is none of our business, we should say that he had better stick to his fiction and his verse-making, and not deviate into that foreign field where nothing is to be gained by cajoling public ignorance or catering to public prejudice, and where "the supreme concern is, to bring thought into the exactest harmony with things."

LITERARY NOTICES.

Spectrum Analysis in its Application to Terrestrial Substances, and the Physical Constitution of the Heavenly Bodies. By Dr. H. Schellen. D. Appleton & Co., 1872.

The following able notice of Dr. Schellen's book is abridged from an article in *Nature:* It is not difficult to deliver interesting lectures or to write an instructive book on spectrum analysis. The rapid succession of brilliant discoveries in this new branch of science, the amount of fundamental facts added by it to human knowledge, especially in the field of the cosmical world, assure the lecturer or writer, appealing to the intelligent but not scientific public, of useful and legitimate success. But what is not so easy to do is, to interest at the same time the *gens du monde* and scientific men, by offering a selection of the most recent discoveries in a bright and literary form attractive to the former, and yet keeping for the latter the appearance of precision, and exactness of the numerical results. All these conditions are very happily filled in "Schellen's Spectrum Analysis," edited by Mr. W. Huggins from the second German edition.

The first part, introductory, is occupied by a description of the artificial sources of high degrees of heat and light, of which the study is so intimately connected with the chemical and astronomical phenomena embraced in the field of spectrum analysis; various apparatus, for instance, the gas-burner, the magnesium lamp, the Drummond lime-light, the electric spark of the induction coil, the Geissler's tube, and the electric light produced by voltaic batteries, are described, and the practical adjustments are briefly but sufficiently referred to for a good understanding of the subject.

The second part is devoted to an elementary abstract of the geometrical and mechanical properties of light. The fundamental analogy between light and sound is developed, in order to explain to a reader unlearned in optics how the color of a ray is the corresponding element of the pitch of a musical sound, and how it is possible to define a colored ray by the time of its luminous vibrations. The description of refraction phenomena, especially the paths of rays through a prism, leads naturally to the separating process of the different colors on which spectrum analysis is founded.

A considerable number of chapters is devoted to the construction of the simple and compound spectroscope. The chief points of this construction, especially the contrivances for the simultaneous comparison of two spectra, the determination of the position of lines in the spectrum, are carefully described. Afterward a practical account of the methods for exhibiting spectra of terrestrial substances, for instance, metallic salts volatilized in a gas-burner, etc., will certainly interest chemists.

An interesting chapter contains the theoretical and experimental explanation of the reversal of the spectra of gaseous substances. This phenomenon, studied independently by Foucault and Angström, and definitely generalized by Kirchhoff, is perhaps the chief point of the history of spec-

'rum analysis, and certainly the beginning of its utilization as a powerful method of investigation.

The third part of the book, the most important in extent and results, is devoted to the application of the spectrum analysis to the heavenly bodies.

The sunlight, according to its brightness and to the peculiarities of its spectrum, is the best and easiest example to study. The dark lines in infinite number which it shows, called "Frauenhofer lines," from the discoverer, deserve special attention; therefore the author has illustrated the description of the sun-spectrum with two sets of maps. The first is a reduction of Kirchhoff's maps engraved on wood, representing in several tints the lines from *A* to *G*; the second series is a reduction to about half size of the admirable *normal solar spectrum* of Angström, in which the Frauenhofer lines from *a* to H_1 H_2 are coördinated according to their wave-lengths. The accuracy of these lithographic plates is really wonderful; they will have the great merit of introducing among physicists and astronomers the wave-length scale for the designation of lines instead of Kirchhoff's scale, which is an arbitrary one; and in any case they will facilitate the transformation of the data from one to another. I must add that Angström's maps have been introduced into the present edition by the English editor, and that such an addition is certainly one of the greatest attractions of this book for scientific men.

A good abstract of Kirchhoff's and Angström's memoirs on the coincidence of the dark solar lines with the bright lines of metallic vapors leads to the hypothetical constitution of the sun; this problem is so difficult, that it is necessary to leave to every one the responsibility of his own ideas on this subject.

The remaining part of the book is entirely devoted to the most delicate applications of spectrum analysis to astronomy. A preliminary description of the sun-spots, faculæ, and other peculiarities of the surface of the sun, of the prominences round the disk, and so on, is given before the spectroscopic process for analyzing these appearances is introduced, and enables the reader to understand very well the difficulties of the problem and the interest of its solution. I must mention especially the interesting account of the three total solar eclipses of 1868, 1869 and 1870. A large series of drawings and photographic facsimiles give the best idea of the phenomena, and show the improvements due to photography and spectroscopy; the relatively great extent devoted to this account is justified by the importance of the subject; the spectrum analysis of the prominences is in fact one of the most considerable results obtained for a long time in the science of cosmogony.

The spectroscope, as it is known, is able to give an exact measurement of the proper velocity of the luminous bodies. A German physicist, Doppler, deserves to be mentioned as the first who called the attention of astronomers to this subject, though a good number of his assertions may be incorrect. After him, Fizeau, a French physicist, to whom we are indebted for the first determinations of the velocity of light on the surface of the earth, showed the errors of Doppler in a little paper not very well known, published in 1849, and calculated the apparent change of refrangibility which would be produced by the proper motion of some heavenly bodies; but no direct experiment was made before the complete application of spectrum analysis to the sidereal phenomena. In this way Schellen's book gives a good abstract of the works of Huggins and Secchi. In these researches the velocity of rotation of the sun was to be tested as a verification of the general law of the phenomenon. I ought to say that the rather discordant results want a theoretical analysis, because the problem seems to me, in the case of the sun, more complicated than it appears at first sight. However, the influence of the velocity of the gas streams, especially of hydrogen, which constitute the greater part of the prominences, is unquestionably verified by Lockyer's observations. In the same way Huggins has proved and determined the proper motion of Sirius by the apparent change of refrangibility of the F line.

The remaining part of the book is devoted to stellar and meteoric spectrum analysis. It is impossible to give a superficial notice of the beautiful researches of Huggins and

Secchi, researches which are always going on; the reader will find with interest various important results of these studies—for instance, the existence in many stars of a good number of terrestrial substances—hydrogen, nitrogen, magnesium, sodium, etc.

One of the most interesting facts is the observation of the temporary star which appeared in May, 1866; the great brightness of the star was due, as indicated by the spectroscope, to an immense mass of incandescent hydrogen.

At the end of the work the author gives some very important observations of Huggins and others on the spectrum of nebulæ; the chief result is the possibility, with the aid of the spectroscope, of distinguishing by the composition of their light the true nebulæ from the clusters of stars.

Finally, a description of the spectrum of the aurora borealis, the identification of its bright lines with some bright lines of the solar corona, a description of various meteors, lightnings and their spectra, show into what difficult objects this new branch of science has pushed its investigations.

On the whole, this book must be considered as a good type of a "popular work;" it deserves the attention of the public, and the esteem of scientific men; and, finally, it recommends itself by a gracious side. It was translated into English by two ladies, who have had the double merit of giving a proof of their good scientific taste, and of showing an example of the help which their sex is able to afford to science.

Life in Nature.—Man and his Dwelling-Place. By James Hinton. New York: D. Appleton & Co.

These works are unique in the scientific literature of the present time, and, although treating of different topics, are so characterized by a common spirit and method, that they may properly be considered together. Their author is a London surgeon in busy practice, but who has not permitted the pressure of professional duties to prevent him from giving close attention to the grave questions by which the mind of the age is agitated. Nor is Mr. Hinton a mere amateur who recreates with philosophy; he is a pioneer investigator in the field of science, and has occupied himself much with those new and large dynamical questions, and their various applications, with which scientific philosophers have been so intently engaged during the last quarter of a century. His inquiry into the physical conditions of vegetable growth, showing that it is governed by definite and traceable forces, and takes place in the direction of least resistance, like all mechanical effects, forms an important contribution to biological science, and was arrived at independently by Mr. Hinton and Herbert Spencer. Yet the author of these works has not dedicated himself to any line of special research (although from the fertility of his ideas, and the acuteness and originality of his views, he might, undoubtedly, have done so with eminent success); but, having mastered the more vital and comprehensive principles of modern research, he takes them as the starting-point for still larger views. Science, indeed, in its ordinary acceptation, is not to him an end. Though deeply imbued with its spirit, and equipped with its latest results, he is not satisfied to rest in this sphere of ideas: it is as leading to something beyond, or as furnishing a basis for something higher, that they have to him their principal value. As Bacon holds science subordinate to the ends of utility, and the practical service of humanity, Mr. Hinton would make it subordinate to the unfolding of man's spiritual nature. He prizes science chiefly for its religious uses, or as an interpretation of the divine order of the world. Maintaining the fundamental harmony of all truth, and that religion represents a verity of the universe as much as astronomy, he has taken it as his task to elucidate the harmonies that must prevail among the different aspects of truth in order that religious faith may be grounded in scientific principles. The results of science, and the knowledge we have of man and the external world, are the author's postulates; and from these he aims to pass, by unbroken logic, to the spiritual order of being. Holding Nature to be a sphere divinely designed for man's highest development, he admits no breaks in the order, and insists that the former must be understood before the latter can be determined. Science, therefore, according to Mr. Hinton, is the foundation and prerequisite of man's true spiritual unfolding.

It has been made a criticism of Mr. Hinton's books, that their arguments are not fully sustained; or that, while their first portions are clear and cogent, the latter parts are indefinite and less conclusive. But this criticism attributes to defect in discussion that which is due to the nature of the subject-matter, for the ideas successively dealt with are so different as almost to appear contrasted. In the sphere of physical Nature, there are a definiteness, a quantitative sharpness, and a kind of tangibleness in the truths established, which disappear as we pass into the domain of moral and religious conceptions. This contrast of the phenomena in the two spheres, which are precisely conceived in the one case and not in the other, has been made the ground for denying that there can be any true science in the higher realm of man's moral and spiritual activity. But the objection is not valid; for, wherever there is an orderly and coherent body of truths, though they cannot be formulated with exactness, there is the legitimate basis of science. It may be long before the reconciliation and unification of unlike ideas and diverse systems of opinion will be completely accomplished; but it is no longer regarded as impossible, and every able attempt to realize it brings us a step nearer to the final and desirable result. Much is said, in these times, of the conflict of science and faith, and many maintain that they are invincibly hostile and must be permanently alienated. Mr. Hinton holds that this is an error due to the incompleteness and imperfection of present knowledge which the advance of thought is certain to correct, and all who read his works must confess that they are able and original contributions to this end.

"Life in Nature," aside from the higher purpose for which it was written, is one of the most charming studies in biology that our language affords. It abounds in interesting facts illustrating the beautiful laws of vital phenomena, and stated with unrivalled clearness, and is marked by keen and original insight into the old obscurities of the subject. The first chapter treats of "Function, and how we act;" the second of "Nutrition, and why we grow." The subsequent chapters take up the "Vital Force and Laws of Form," the "Universality of Life," "The Living World," "The Phenomenal and True," the "Organic and the Inorganic," and "Nature and Man." The volume is neatly illustrated, and we recommend it to all who care either for the strict science of the subject, or for the larger questions to which it leads.

"Man and his Dwelling-Place" was written fifteen years ago, has been recast, condensed, and made to embody the author's maturer views. Its perusal should follow that of "Life in Nature," as it deals with a higher range of questions, and is of a more speculative and metaphysical quality.

Mr. Hinton writes in a lucid, attractive, and eloquent style, and his books contain many passages of remarkable impressiveness and beauty. In the felicity of his delineations he often reminds one of Ruskin; but, unlike the great Rhapsodist of art, he is never run away with by his rhetoric. The intensity of his convictions and the earnestness of his feelings give warmth and force to his language, which is still chastened and restrained by the discipline of refined scholarship.

BOOKS RECEIVED.

Intermembral Homologies. The Correspondence of the Anterior and Posterior Limbs of Vertebrates. By Burt G. Wilder, S. B., M. D. Boston, 1871.

Apparatus for Electric Measurement, with Rules and Directions for its Practical application. By L. Bradley. Jersey City, 1872.

Proceedings at the Fifth Annual Meeting of the Free Religious Association. Held in Boston, May 30 and 31, 1872.

Papers relating to the Transit of Venus in 1874, prepared under the Direction of the Commission authorized by Congress, and published by Authority of the Hon. Secretary of the Navy. Washington, 1872.

A Classified Catalogue of the Birds of Canada, including every Species known to visit the Several Provinces which now form the Dominion of Canada. By Alexander Milton Ross. Toronto, 1872.

A Classified Catalogue of the Lepidoptera of Canada. By Alexander Milton Ross. Toronto, 1872.

Report submitted to the Trustees of Cornell University in behalf of a Majority of the Committee on Mr. Sage's Proposal to endow a College for Women. By Andrew D. White. Ithaca, 1872.

Report on the Climatology and Epidemics of Minnesota. By Charles N. Hewit, M. D. Philadelphia, 1872.

Short-hand and Reporting. A Lecture. By Charles A. Sumner, with Appendix. San Francisco, 1872.

MISCELLANY.

The Ground Connection of Lightning-Rods.—It is asserted, by all the later authorities on the subject of lightning-rods, that a proper ground termination of the rod is of the very first importance to its efficiency as a protection against accidents by lightning. The electricity of the cloud will select the easiest path into the earth, or, as it is technically stated, follow the line of *least resistance :* and it is to furnish a path less resisting than the building itself that the lightning-rod is erected. But it is not enough that the rod have a sufficient conducting capacity. The current must be able to leave it, at the place where it terminates in the ground, as fast as it passes along the rod, else there is an accumulation, or damming up as it were, in the rod, which, when it has attained a certain volume or intensity, will relieve itself with explosive violence; and thus the appliance becomes an actual source of danger to the building, rather than a means of protection. Mr. David Brooks, in an able paper on "Lightning and Lightning-rods," published in the August number of the "Journal of the Franklin Institute," says on this point: "I do not say that a greater proportion of buildings *having* lightning-rods are destroyed or injured than of those not having them, although those making careful observations do give that as a result of their statistics. I shall undertake to show that this difficulty *consists in the defective connection of these plates with the earth*, and also that with a proper connection with the earth they are almost, if not an absolute, means of protection." Says Prof. John Phin, in his admirable *brochure* on "Lightning-Rods and how to construct Them :" "Upon the perfection of the ground termination mainly depends the value of the lightning-rod. If this be defective, no other good features can possibly make up for it. And yet, so little is it understood, that a careful examination of a very large number of rods leads us to believe that fully one-half the lightning-rods in existence are defective in this respect, and consequently furnish but an insufficient protection."

All objects may be said to conduct electricity, but they vary greatly in their conducting capacity. Copper conducts six times as well as iron, and iron thousands of times better than water, and water again thousands of times better than dry earth. That is to say, a rod of iron, to have the same conducting capacity as a rod of copper, would require to be of six times the sectional area, while, if a rod or column of water were employed, it would require to be many thousands of times greater in sectional area than the iron, and dry earth again many thousands of times larger than the column of water. In connecting a rod with the ground, allowance has to be made for this difference in conducting capacity, sufficient earth-surface being joined to the rod to give a conducting capacity approaching to or equalling that of the rod. Otherwise the lightning discharge, unable to find a free passage into the ground, accumulates until the tension becomes so great that it bursts from the rod with explosive violence, taking the track which affords the readiest means of escape, and often doing serious damage in its progress.

Accidents of this character are by no means rare. Mr. Henry Wilde, in a communication to the *Mechanic's Magazine*, gives two cases of fire, resulting from the ignition of the gas by lightning in buildings where it left the conductor and took to the gas-pipes. In one instance, the discharge passed down a wire rope suspended by the side of a tall chimney, and, leaving the lower end of the rope, which was some ten feet from the ground, darted across a space of sixteen feet to a gas-meter in the cellar of an adjoining cotton-warehouse, where it fused the lead-pipe connections, and set fire to the gas. In another instance, that of a church, provided with a lightning-rod, a lightning discharge left the rod at a point in close proximity to the gas-pipes, ignited the gas in the vestry, and the church was consumed. In a third case, the discharge descended a rod on a church-steeple, and, when within five feet of the ground, left the conductor, pierced a wall four feet thick, and disappeared in the gas-pipe under the floor of the church. Silliman's "Physics" gives a similar example, where, in a church in New Haven, the lightning has twice penetrated a twenty-inch brick wall at a point opposite a gas-pipe twenty feet above the earth, although the conductor, of three-quarter-inch iron, was well mounted, but its connection with the earth was less perfect than that of the gas-pipe.

It being established that the lightning will take the easiest track into the ground, it follows, from what occurred in each of the above cases, that the least-obstructed path was by way of the gas-pipes, with their extended ground connections. In the first example, although there was a lightning-rod on the chimney, the lightning took to the rope, and, instead of leaving it at the lower end for the rod, which was near by, found an easier passage through the air to the gas-pipes of the cotton-factory, which differed from the rod in having an extensive ground contact. The same was true in the other cases—the gas-pipes furnishing a readier path to the ground than the rods themselves. On account of the great surface contact with the ground, which gas and water pipes present, it has been recommended that lightning-rods be connected with these, as affording an excellent means for the escape of the electric discharge. At first glance, this might seem a dangerous expedient so far as gas-mains are concerned, the accidents above mentioned pointing to the danger of setting fire to the gas. This accident arose from the use of lead-pipe in making the connections with the meter. Had the gas-pipe throughout been of iron or brass, nothing of the kind could have occurred. Unmixed with atmospheric air, gas will not burn, and it was only through the melting of the lead-connections by the lightning that the gas was liberated and then ignited. Brass or iron pipes would have carried off the discharge without becoming fused, no gas would have been liberated, and no fire could have occurred. Commenting upon these accidents, Mr. Wilde says: "In my experiments on the electrical condition of the terrestrial globe, I have already directed attention to the powerful influence which lines of metal, extended in contact with moist ground, exercise in promoting the discharge of electric currents of comparatively low tension into the earth's substance, and also that the amount of the discharge from an electro-motor into the earth increases conjointly with the tension of the current and the length of the conductor extended in contact with the earth. It is not, therefore, surprising that atmospheric electricity, of a tension sufficient to strike through a stratum of air several hundred yards thick, should find an easier path to the earth by leaping from a lightning-conductor through a few feet of air or stone to a great system of gas or water mains, extending in large towns for miles, than by the short line of metal extended in the ground which forms the usual termination of a lightning-conductor."

But in the country no such system of gas and water pipes is at hand—the connection of the rod with the earth must therefore be made in some other way. On this point Mr. Brooks remarks: "Unless a hundred square feet of metal can be laid in the bed of a spring or body of water, I believe the building is safer without the lightning-rod." The advice generally given is to bury the lower end of the rod in charcoal or coke. Prof. Phin says, use coke, not charcoal; and, "whether iron or copper is employed, it will be well to sprinkle the coke copiously with a strong solution of washing-soda, for the purpose of neutralizing any acids that might corrode the metal. If a trench ten feet long be sunk to the depth of permanent moisture, and filled to a depth of twelve inches with coke, it will be ready to receive the end of the rod, and will furnish a path for all the electricity that will ever tend to escape from the clouds to the earth."

Foul Air.—The condition of the air commonly breathed in the workshop and school-room is fairly indicated by the following statistics, the result of a large number of observations made by Mr. Richard Weaver in the schools and manufactories of Leicester, England: As carbonic-acid gas is usually the chief impurity in rebreathed air, being produced in large quantities by both breathing and combustion, Mr. Weaver takes it as the measure of aërial contamination, the amount present under ordinary circumstances enabling us to judge of the degree of vitiation caused by the other products of respiration and combustion. Setting out with the established fact that free or what is commonly called pure air contains, for every thousand parts, very nearly four-tenths of one part of carbonic acid, Mr. Weaver found in the air of a room where six persons worked at boot and shoe finishing, each person having 51 cubic feet of space, that the proportion of carbonic acid was 5.28 parts per thousand, or more than thirteen times as much as Nature, when let alone, allows. In another instance, where the air-space to each of fourteen individuals was 186 cubic feet, with fourteen gas-lights burning, the amount of carbonic acid, to a thousand parts of air, was 5.32. In a class-room of one of the national schools, and the science class-room at that, seventeen pupils, each with 200 cubic feet of space, were breathing an atmosphere containing 2.41 parts per thousand of carbonic acid, or six times as much as the air contains in exposed situations. In no case examined was the proportion of carbonic acid as low as one part in a thousand of air; the average in fifteen places being 3.14 per thousand, or nearly eight times as much as in pure air. It is hardly necessary to add that the provisions for ventilation, where any thing of the kind was attempted, were of the most imperfect character. But what may be effected by ventilation was strikingly shown in the instance of a boy's day-room in one of the national schools, where there were one hundred pupils, each with 236 cubic feet of air-space. The ventilators were placed in the roof, and, though very far from perfect, the air in the room contained only 1.16 parts of carbonic acid to the thousand, the lowest proportion observed in any of the fifteen cases examined. Mr. Weaver states that the atmosphere in several of the rooms was very offensive, and in every case a pleasurable sense of relief was experienced on entering the outer air. Large space, without ventilation, he considers of little avail, as it has no advantage over a small room except that the air is a little longer in attaining the same degree of contamination.

Careless Disinfection.—In cleansing and disinfecting rooms that have been occupied by persons sick with contagious diseases, mere exposure to disenfecting vapors is not enough to thoroughly rid the apartment of danger to future inmates. The floors and wood-work require thorough scouring with some disinfecting fluid, and the walls and ceiling should also be carefully cleaned. If the walls are covered with paper, nothing short of its removal will be effectual, as it unquestionably has the power of absorbing and retaining contagious matters, that are not reached by the ordinary processes of disinfection. And its removal is all the more necessary where several thicknesses are plastered on the wall, for then the deeper layers are quite beyond any possibility of being cleansed; and, apart from the danger of contagion, the presence of paste in such quantities, as several thicknesses of paper involve, liable in warm weather to ferment and decompose, and at all times furnishing a nest for hosts of vermin, is certainly most objectionable. That wall-paper does actually furnish lodgment for contagion, and the paste with which it is stuck on food for vermin, is proved by the following cases reported in the *Lancet*: The workmen engaged in stripping the paper from the walls of a house in Manchester, that had previously been occupied by persons ill with fever, nearly all came down with the same fever, although previous to their visit the house had been disinfected with chlorine and carbolic acid. In the Knightsbridge barracks, where numerous layers of paper and paste had been allowed to accumulate, the walls when examined were found to be literally swarming with maggots, that were leading a most flourishing existence while subsisting on the paste between the several thicknesses of paper. The practice of freshening the walls of rooms by covering up, instead of removing the filth, has become extremely common, hundreds of houses in this city being yearly rejuvenated in this way, to the serious injury, no doubt, of their subsequent inmates.

Trees and Rain.—A correspondent writes thus to the *Bulletin of the Torrey Botanical Club:* "The influence of trees upon rain and the general moisture of the atmosphere, which has been much discussed of late, receives a strong illustration from the island of Santa Cruz, West Indies. A friend who spent the months of February, March, and April last, upon this island, informs me that, when he was there twenty years ago, the island was a garden of freshness, beauty, and fertility. Woods covered the hills, trees were everywhere abundant, and rains were profuse and frequent. The memory of its loveliness called him there at the beginning of the present year, when, to his astonishment, he found about one-third of the island, which is about twenty-five miles long, an utter desert. The forests and trees generally had been cut away, rainfalls had ceased, and a process of desiccation, beginning at one end of the land, had advanced gradually and irresistibly upon the island, until for seven miles it is dried and desolate as the seashore. Houses and beautiful plantations have been abondoned, and the people watch the advance of desolation, unable to arrest it, but knowing almost to a certainty the time when their own habitations, their gardens, and fresh fields, will become a part of the waste. The whole island seems doomed to become a desert. The inhabitants believe, and my friend confirms their opinion, that this sad result is due to the destruction of the trees upon the island some years ago."

Poisonous Paper-Hangings.—In his valuable paper "On the Evil Effects of the Use of Arsenic in Certain Green Colors," published in the third annual report of the Massachusetts State Board of Health, Dr. Frank W. Draper gives the following, among other startling cases of arsenical poisoning from green-colored paper-hangings:

In 1862, a case of fatal poisoning under the conditions in question occurred in the suburbs of London, the victim being a child. The cause of death was made the subject of an investigation before a coroner's jury. In the course of the evidence, it transpired that the deceased was the last of four children who had died within a period of two months, under exposure to the poison contained in the paper-hangings of the room they habitually occupied. They had all been attacked in the same manner, the prominent symptoms being referred to the throat. The color was loosely applied, having no glazing. It was very deliquescent; at 50° it was quite damp, and the stain came off on the hand like paint. Three grains of arsenic were found in a square foot of the paper. The symptoms were attributed by the surgeon in attendance, Mr. Orton, and by Dr. Letheby, who made the *post-mortem* chemical examination, to arsenical poisoning.

But greens are not the only colors which contain arsenic, nor wall-paper the only fabric colored with arsenical pigments. A correspondent of the *Chemical News*, who is in a position to know, states that the French use the following-named pigments, containing arsenic, in calico-printing, and that they are equally suitable, and doubtless used, in the color of paper-hangings: *Light scarlet pigment* contained alumina, arsenious oxide, and aurine; *scarlet poneeau* contained carbonate of lime in addition to above ingredients; *dark green*, a preparation of aniline green and arsenious oxide; *steam chocolate*, and *catechu pigment*, both contained arsenious oxide. Hallwachs has demonstrated the presence of arsenic in red, as well as in green-colored wall paper.

Volcanic Dust.—The dust discharged at the last eruption of Vesuvius, though very heavy, was carried in one direction to a distance of twenty-five miles, where it fell in quantities sufficient to cause great annoyance to the inhabitants. It consisted of aggregations of crystallized quartz, dotted over with the magnetic oxide of iron. The grains were very uniform in size, and would pass through a wire gauze the apertures of which measured the sixteen thousandth of a square inch. By boiling in hydrochloric acid, the whole of the iron can be removed, and nothing but crystals of fine white quartz remain. Its composition is the same as that of the iron-sand which is found in the soil in some parts of the country round Vesuvius, and which is the product of former eruptions; the latter, however, contains a larger relative proportion of iron, and the grains show a water-worn appearance under the microscope. Neither of the Vesuvian specimens contains titanium, which is found in the magnetic iron-sand of New Zealand, which has most likely been ejected from the great volcano of Mount Egmont.

Transfusion of Blood.—Dr. Aveling reports in the *Lancet* a case where life was saved by the transfusion of blood, by what is known as the "immediate" method. The patient was a lady dying from hæmorrhage. Her pulse had become imperceptible both at the wrist and in the temporal arteries; the heart's action was very feeble, and steadily growing more so; she was insensible, with dilated pupils that refused to contract on the approach of a light; the extremities were cold, and the lips and face blanched. Blood was pumped, by means of a suitable apparatus, directly from a vein in the arm of a man, into a vein of the lady's arm, without exposure to the air, and in a duly-regulated stream. Some eight ounces of blood were thus transfused. As the operation proceeded, the pulse at the wrist became perceptible, the lips less blanched, and warmth returned to the hands. In a few hours consciousness returned, the patient took nourishment, and afterward fully recovered.

Habits of the Opossum.—We gather from the *American Naturalist*, for September, the following interesting particulars concerning the habits of the opossum: The animal is widely distributed in the United States. It dwells in hollow logs, stumps, and in holes at the roots of trees, does not burrow, but takes possession of holes that it finds ready made. Into these it will carry leaves—using its tail for the purpose—and provide itself with a comfortable bed, when bad weather threatens. It does not hibernate, but hunts its food at all seasons, is slow of foo , and not very wild. It will eat bacon, dry beef, carrion, any kind of fowl, rabbits, any sort of small game, almost all the insects, and fruits of every variety, being especially fond of muskmelons; and is eaten in turn by many people, the flesh being considered delicious. This has a flavor resembling that of the flesh of the young hog, but is sweeter and less gross. Negroes and others are exceedingly fond of it; dogs, however, hold a very different opinion, and will sooner starve than consume it. The animal is habitually incautious, and when attacked seems to possess little power of resistance; literally suffering itself to be eaten alive by the turkey-buzzards, while it lies on its side and protests against the proceeding by a succession of grunts. Exceedingly tenacious of life, it will survive a vigorous crunching by the dogs, when it seems as though every bone in its body had been cracked. Although sometimes found concealed under the floors of houses and out-buildings, it refuses to be domesticated, and is believed to dwell but a short time in any one place.

Dr. Carpenter against Materialism.—Dr. Carpenter, having been charged with attacking the philosophy of Profs. Huxley and Tyndall in his late address, replies, in a letter to the London *Echo*, as follows:

"Nothing was further from my intention than either to give a theological turn to my address, or to make any attack upon the philosophy of my two valued friends, whom I believe to be, in regard to most, if not all, of the philosophical questions I have treated, at one with me.

"But I did set myself to combat a mode of thought on scientific subjects which I know to be very prevalent among half-educated scientific men, who have never studied the constitution and working of their own minds, and which has been carried out most fully by a certain school of (so-called) Nature Philosophers in Germany. Of the tenets of this school, a small work by Dr. Buchner, entitled 'Kraft und Stoff'—Force and Matter—which has run through many editions, and has been translated into French, may be considered an exponent. The tenets are (I write from recollection, not having the book at hand) somewhat as follows:

"1. That we know, and can know, nothing of the external save matter, and the laws of matter.

"2. That these 'laws' are fixed, unchangeable, and self-acting.

"3. That there is consequently no necessity for a God, since Nature can do very well without one.

"4. That, if there be a God, he is limited in his action—just as man is—by the 'laws of matter,' which he can no more control than man can; and that he is, therefore, in his relation to Nature, only a higher kind of man.

"Now, my object was to show:

"1. That what we call 'laws of Nature' are simply our own expressions of the orderly sequence which we discern in the phenomena of the universe; and that, as all the history of science shows how erroneous these have been in the past, so we have no right to assume our present conceptions of that sequence to be either universally or necessarily true.

"2. That these so-called 'laws' are of two kinds, one set being mere generalizations of phenomena, of which Kepler's 'laws of planetary motion' or the 'laws of chemical combination' are examples, while another set express the conditions of the action of a force, of which the existence is, or may be, made known to us by the direct and immediate evidence of our own consciousness—our cognition of matter being indirectly formed through the medium of force.

"3. That 'laws' of the first kind (which we may for convenience term phenomenal) do not really explain or account for any thing whatever. Nothing is more common than to hear scientific men speaking of such laws as 'governing phenomena,' or of a phenomenon being 'explained' when it is found to be consistent with some one of such laws; though the fact is that the law is a law merely because it is a generalized expression of a certain group of phenomena; and to say that any new phenomenon is 'explained,' by its being shown to be in conformity to a 'law' is merely to say (as Prof. Clifford well put in his lecture) that a thing previously unknown is 'explained' by showing it to be like something previously known.

"4. That, on the other hand, every 'law' of the second kind (which we may distinguish as dynamical) is based on the fundamental conception of a force or power; so that if the existence of such a force (as that of gravity or electricity) be admitted, and the conditions of its action can be accurately stated, then the law which expresses them may be said to 'govern' the phenomenon; and any phenomenon, which can be shown to be necessarily deducible from it, may be said to be 'explained,' so far as science can explain it. But the utmost that science can positively do, as I stated toward the conclusion of my address, is to demonstrate the unity of the power of which the phenomena of Nature are the diversified manifestations, and to trace the continuity of its action through the vast series of ages that have been occupied in the evolution of the universe.

"5. I expressed the opinion that science points to (though at present I should be far from saying that it demonstrates) the origination of all power in mind; and this is the only point in my whole address which has any direct theological bearing. When metaphysicians, shaking off the bugbear of materialism, will honestly and courageously study the phenomena of the mind of man in their relation to those of his body, I believe that they will find in that relation their best arguments for the presence of infinite mind in universal Nature.

"Now, the only expression I have ever met with, in our own language, of the philosophy which (as I have said) worships the order of Nature as itself a God, was uttered by Miss Martineau, in the book on 'Man's Nature and Development,' which she produced some twenty years ago in conjunction with Mr. Atkinson. Not having the book at hand, I cannot cite any passage from it; but I well remember the general drift of its argument (putting aside mesmerism, phrenology, etc.) to have been that, whereas mankind formerly believed the phenomena of Nature to be expressions of the will of a Personal God, modern science, by reducing every thing to 'laws,' had given a sufficient 'explanation' of these phenomena, and made it quite unnecessary for man to seek any further account of them.

"This is precisely Dr. Buchner's position; and it seems to me a legitimate inference from the very prevalent assumption (which is sanctioned by the language of some of our ablest writers) that the so-called laws of Nature 'govern' the phenomena of which they are only generalized expressions. I have been protesting against this language for the last quarter of a century; and, as I know that Dr. Buchner's views are extensively held among the younger thinkers of Germany and France, and have reasons to fear their extension to this country, I thought it well to take the opportunity which has been recently afforded me of calling the attention both of scientific men and of the general public to what I consider the true functions of man as the scientific interpreter of Nature. It was not because I had any thing to say on this subject that would be new either to men of science or to theologians, who have already gone through a like course of thought with myself, but because I hoped to lead some to think upon it who have never so thought before, and to help others to a clearer view of it than they might have themselves attained, that I chose it as the topic of my address. And, so far as I have the opportunity of judging, my hope is being fully realized."

Artificial Butter.—At the request of the victualling department of the French Navy for some wholesome substitute for butter that would keep well, Mege Mouriez, after a long course of experiments, has succeeded in producing an excellent substitute for genuine butter, that does not become rancid with time, and is otherwise highly recommended. Experiments made with cows, submitted to a very severe and scanty diet, led to the discovery that they continue to give milk, though in greatly diminished quantity, and that this milk always contains butter; whence it was inferred that this butter was formed from fat contained in the animal tissues, the fat undergoing conversion into butter through the influence of the milk-secreting glands. Acting on this hint, Mouriez's process begins with splitting up the animal fats. Finely divided fresh beef-suet is placed in a vessel containing water, carbonate of potash, and fresh sheep's stomachs, previously cut up into small fragments. The temperature of the mixture is then raised to about 112° Fahr., when, under the joint influence of the pepsin and the heat, the fat becomes separated from the cellular tissue. The fatty matter floating on the top is decanted, and after cooling submitted to very powerful hydraulic pressure. The semi-fluid oleo-margarine is thus separated from the stearine, and becomes the basis of the butter to be afterward produced. One hundred pounds of this oleo-margarine, along with about twenty-two quarts of milk and eighteen quarts of water, are poured into a churn, and to this mixture are added a small quantity of annatto and about three ounces of the soluble matter obtained by soaking for some hours in milk cows' udders and milk-glands. The mixture is then churned, and the butter obtained, after being well washed with cold water and seasoned, is ready for use. If required to be kept for a long time, it is melted by a gentle heat in order to eliminate all the water.

Ventilation and Warming.—In a lecture on ventilation, lately delivered before the Franklin Institute, Mr. L. W. Leeds, after detailing the abominations he encountered in his examination of the ventilating arrangements of the Treasury Building at Washington, gives the following practical directions concerning provisions for ventilation and warming in the construction of buildings. First, never have long underground fresh-air ducts. Second, never allow a sewer, soil-pipe, foul-air flue, or smoke-flue, to come near the fresh-air supply-flue, for fear of some connection being made between them by carelessness or accident. Third, never heat a building exclusively by currents of warm air. Fourth, always put the heating flues on the outside walls instead of on the inside walls. Fifth, endeavor strenuously to avoid the fresh-air chamber becoming a common receptacle for all the rubbish of a filthy cellar.

Sardines.—Mr. N. S. Dodge has given a very complete and interesting account of the "Natural History and Preparation of Sardines" in *Hearth and Home*, from which we gather the following: In natural history the sardine is the young of the pilchard, a fish resembling the herring in size, but thicker. They get the name of sardines, from having been formerly found in great quantities off the coast of Sardinia. They make their appearance about the coast of the Armorican Peninsula early in spring, and succeed each other in countless shoals throughout the summer months. These shoals are marvellous for their size and the number of fish they contain. Each one takes the shape of a huge fish, bulging out toward the middle and tapering toward either end. The shoals vary from ten to thirty yards in width and from fifty yards to half a mile in length. The fish are sometimes so closely packed that numbers are constantly being shoved out of water. They are caught with nets, much in the same way as herrings, only the nets are provided with much smaller meshes. Although nets are employed, bait is also used. This bait is called *rogue;* and is imported in barrels from Norway.

In catching the fish, several boats go together, a man standing in the bow of each to give notice of the approach of a shoal. Upon the cry of "*Voila!*" the boats make for the head of the shoal, the nets are cast, and bait is thrown overboard. The fish in their eager pursuit after the bait get entangled in the net, when a second net is thrown out and the first one hauled in. When a boat is loaded, the fish are taken ashore and immediately sold. The process of preserving is as follows: As soon as the sardines are landed the greatest activity is necessary to get them "*sain et sauf*," since exposure to the air depreciates their freshness and much handling impairs their flavor. First, the fish are thoroughly washed and scraped, so as to free them from every impurity. They are then sprinkled with fine salt which crystallizes upon the surface and is almost immediately removed. Heads and gills are then taken off, a new washing undergone, and the fish laid to dry in the sunshine, on frames of wire or green withes. After drying they are thrown into caldrons of boiling olive-oil and cooked for two hours, when, after a second drying, they are transferred to the tables to be packed. Here women only do the work. To put the fish nicely in their places, to smother them with boiling oil, to fit the lid of the tin box, turn a jet of hot steam on the joints, and toss it hermetically sealed to the inspector, is but the work of a moment. Perhaps the one essential element in the curing of sardines is perfect olive-oil. If it be not entirely tasteless, it destroys what the Sardinians call the "*aramato*," the delicate, volatile flavor of the fish.

Sprats, shiners, roach, herrings, dace, and carp, when young, and with their heads off, have sufficient resemblance to sardines to pass for the genuine article. They are put up at various places on the southwestern coast of France, and are largely exported, probably comprising three-quarters of all that are sold in the United States under the name of sardines. When well cured, preserved in good oil, and hermetically sealed, these small fry are savory and palatable, but they lack the delicate volatile flavor of the real fish.

Ancient Engineering Among the Chinese.—The most remarkable evidence of the mechanical science and skill of the Chinese so far back as 1,600 years ago is to be found in their suspended bridges, the invention of which is assigned to the Han dynasty. According to the concurrent testimony of all their historical and geographical writers, Sangleang, the commander of the army under Baou-tsoo, the first of the Hans, undertook and completed the formation of the roads through the mountainous province of Shense, to the west of the capital. Hitherto its lofty hills and deep valleys had rendered the communication difficult and circuitous. With a body of one hundred thousand laborers he cut passages over the mountains, throwing the removed soil into valleys, and, where this was not sufficient to raise the road to the required height, he constructed bridges which rested on pillars or abutments. In another place he conceived and accomplished the daring project of suspending a bridge from one mountain to another across a deep chasm. These bridges, which were called by the Chinese writers, very appropriately, flying bridges, and represented to be numerous at the present day, are sometimes so high that they cannot be traversed without alarm. One still existing in Shense stretches four hundred feet from mountain to mountain, over a chasm of five hundred feet. Most of these flying bridges are so wide that four horsemen can ride on them abreast, and balustrades are placed on each side to protect travellers. It is by no means improbable (as M. Panthier suggests), as the missionaries to China made known the fact more than a century ago that the Chinese had suspended bridges, that the ideas may have been taken thence for similar construction by European engineers.

NOTES.

The *Spectator*, in its notice of M. Touchet's work, "The Universe," says: "Man generally flatters himself that his anatomy is about the highest effort of Divine skill; yet that of the insect is far more complicated. No portion of our organism can compare with the proboscis of the common fly. Man can boast 270 muscles. Lyonet, who spent his whole life in watching a single species of caterpillar, discovered in it 4,000. The common fly has 8,000 eyes, and certain butterflies 25,000. M. Touchet treats it as an established fact that so fine are the sensory organs of ants that they converse by means of their antennæ. Consequently the strength and activity of insects far surpass ours in proportion. In the whole field of natural science there is nothing more astounding than the number of times a fly can flap its wings in a second; it must in that point of time vibrate its wings five or six hundred times. But in rapid flight we are required to believe that 3,600 is a moderate estimate."

The following, according to Prof. Palmieri, are the signs of an approaching eruption of Vesuvius: When the crater fills up and the vapor from it diminishes in quantity; when the vapor from the crater yields a heavy deposit of iron or sodium; when the water sinks in some of the springs of the neighborhood. The phenomena more nearly preceding an eruption are, the occurrence of earthquakes, increasing in intensity and frequency for some days beforehand; also the irregularity of the diurnal variations of the magnetic needle. One of the remarkable attendants of an eruption is the frequence of lightning flashes accompanying the condensation of vapor of water from the crater; just as in an ordinary thunder-storm lightning occurs at the time the vapor is condensing, as is proved by the rain that follows.

Prof. Muir has been investigating the effects of various saline solutions on lead by suspending pieces of bright lead of of known area, each in a solution of known composition, for a given time, and then estimating the amount of lead dissolved, by Wanklyn and Chapman's color-test. He finds the greatest solvent power exerted by solutions of the nitrates, ammonium nitrate being especially active. The carbonates, as was before known, have the greatest protecting power, and next to them come the sulphates; so that, when either of these are present, even if the water contain a considerable proportion of nitrates, the solvent action on the lead is very slight.

It is well known that all alloys containing copper, even in minute proportions, are readily acted on by acids, which makes them dangerous when used for household utensils. M. Helouis has proposed an alloy, under the name of platinum bronze, which is entirely inoxidizable. It is a nickel alloy, prepared from nickel made thoroughly pure by various processes and maceration in concentrated nitric acid. The proportions employed are nickel 100, tin 10, and platinum 1—the two latter metals being added to the fused nickel in the proportion of 4 of tin to 1 of platinum, and the remaining six parts of tin added subsequently. For bells and sonorous articles the proportions are slightly varied, viz., nickel 100, tin 20, silver 2, and platinum 1.

M. Renault has lately brought to the attention of the Paris Academy of Sciences a simple and effective method for reproducing drawings. The drawing is first made with sticky ink on highly-glazed paper, and afterward dusted with bronze-powder. Sheets of sensitized paper are then pressed upon the former, when the lines of the drawings are reproduced upon the paper by the chemical action which takes place between its sensitive surface and the metal. Impressions may be taken at any time, by softening the ink on the original with vapor of alcohol, and then redusting with the bronze-powder.

Sulphuric acid, according to Dr. L. de Martin, when added to the sweet juice of the grape (*must*) in the proportion of from fifteen to forty-five grains of the concentrated acid to twenty-two gallons of *must*, exerts a favorable influence on the process of fermentation. The process is hastened and rendered more complete, and a better and more beautiful color is given to the wine. Analysis shows no more sulphuric acid in this wine than in samples not so treated. When the *must* is alkaline, as it sometimes is, the process of fermentation produces lactic acid instead of alcohol; hence the utility of sulphuric acid, which sets up the alcoholic fermentation of the sugar.

Dr. Virchow has been experimenting with reference to the influence of coal-gas on vegetation, when diffused through the soil. He finds, after a long series of carefully-conducted researches, that coal-gas is an active poison to vegetation, trees, shrubs and ornamental plants, being killed by it when it is allowed to permeate the soil about their roots.

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THE EARLY DISCIPLINE OF MANKIND.[1]

By WALTER BAGEHOT, Esq.

BY far the greatest advantage is that on which I observed before —that to which I drew all the attention I was able by making the first of these essays an essay on the Preliminary Age. The first thing to acquire is, if I may so express it, the *legal fibre;* a polity first—what sort of polity is immaterial; a law first—what kind of law is secondary; a person or set of persons to pay deference to—though who he is, or they are, by comparison scarcely signifies.

"There is," it has been said, "hardly any exaggerating the difference between civilized and uncivilized men; it is greater than the difference between a tame and a wild animal," because man can improve more. But the difference at first was gained in much the same way. The taming of animals, as it now goes on among savage nations, and as travellers who have seen it describe it, is a kind of selection. The most wild are killed when food is wanted, and the most tame and easy to manage kept, because they are more agreeable to human indolence, and so the keeper likes them best. Captain Galton, who has often seen strange scenes of savage and of animal life, had better describe the process: "The irreclaimably wild members of every flock would escape and be utterly lost; the wilder of those that remained would assuredly be selected for slaughter whenever it was necessary that one of the flock should be killed. The tamest cattle—those which seldom ran away, that kept the flocks together, and those which led them homeward—would be preserved alive longer than any of the others. It is, therefore, these that chiefly become the parents of stock and bequeath their domestic aptitudes to the future herd. I have constantly

[1] From advance-sheets of "Physics and Politics," forming vol. ii. of "The International Scientific Series." The present article is a portion of Mr. Bagehot's chapter on "The Use of Conflict."

witnessed this process of selection among the pastoral savages of South Africa. I believe it to be a very important one on account of its rigor and its regularity. It must have existed from the earliest times, and have been in continuous operation, generation after generation, down to the present day." [1]

Man, being the strongest of all animals, differs from the rest; he was obliged to be his own domesticator; he had to tame himself. And the way in which it happened was, that the most obedient, the tamest tribes are, at the first stage in the real struggle of life, the strongest and the conquerors. All are very wild then; the animal vigor, the savage virtue of the race has died out in none, and all have enough of it. But what makes one tribe—one incipient tribe, one bit of a tribe—to differ from another is their relative faculty of coherence. The slightest symptom of legal development, the least indication of a military bond, is then enough to turn the scale. The compact tribes win, and the compact tribes are the tamest. Civilization begins, because the beginning of civilization is a military advantage.

Probably if we had historic records of the ante-historic ages—if some superhuman power had set down the thoughts and actions of men ages before they could set them down for themselves—we should know that this first step in civilization was the hardest step. But, when we come to history as it is, we are more struck with the difficulty of the next step. All the absolutely incoherent men—all the "Cyclopes"—have been cleared away long before there was an authentic account of them. And the least coherent only remain in the "protected" parts of the world, as we may call them. Ordinary civilization begins near the Mediterranean Sea; the best, doubtless, of the ante-historic civilizations were not far off. From this centre the conquering *swarm*—for such it is—has grown and grown; has widened its subject territories steadily, though not equably, age by age. But geography long defied it. An Atlantic Ocean, a Pacific Ocean, an Australian Ocean, an unapproachable interior Africa, an inaccessible and undesirable hill India, were beyond its range. In such remote places there was no real competition, and on them inferior, half-combined men continued to exist. But in the regions of rivalry—the regions where the better man pressed upon the worse man—such half-made associations could not last. They died out, and history did not begin till after they were gone. The great difficulty which history records is not that of the first step, but that of the second step. What is most evident is not the difficulty of getting a fixed law, but getting out of a fixed law; not of cementing (as upon a former occasion I phrased it) a cake of custom, but of breaking the cake of custom; not of making the first preservative habit, but of breaking through it, and reaching something better.

This is the precise case with the whole family of arrested civiliza-

[1] "Ethnological Society's Transactions," vol. iii., p. 137.

tions. A large part, a very large part, of the world seems to be ready to advance to something good—to have prepared all the means to advance to something good—and then to have stopped, and not advanced. India, Japan, China, almost every sort of Oriental civilization, though differing in nearly all other things, are in this alike. They look as if they had paused when there was no reason for pausing—when a mere observer from without would say they were likely not to pause.

The reason is, that only those nations can progress which preserve and use the fundamental peculiarity which was given by Nature to man's organism as to all other organisms. By a law of which we know no reason, but which is among the first by which Providence guides and governs the world, there is a tendency in descendants to be like their progenitors, and yet a tendency also in descendants to *differ* from their progenitors. The work of Nature in making generations is a patchwork—part resemblance, part contrast. In certain respects each born generation is not like the last born; and in certain other respects it is like the last. But the peculiarity of arrested civilization is to kill out varieties at birth almost; that is, in early childhood, and before they can develop. The fixed custom which public opinion alone tolerates is imposed on all minds, whether it suits them or not. In that case the community feel that this custom is the only shelter from bare tyranny, and the only security for what they value. Most Oriental communities live on land which in theory is the property of a despotic sovereign, and neither they nor their families could have the elements of decent existence unless they held the land upon some sort of fixed terms. Land in that state of society is (for all but a petty skilled minority) a necessary of life, and, all the unincreasable land being occupied, a man who is turned out of his holding is turned out of this world, and must die. And our notion of written leases is as out of place in a world without writing and without reading as a House of Commons among Andaman-Islanders. Only one check, one sole shield for life and good, is then possible—usage. And it is but too plain how in such places and periods men cling to customs because customs alone stand between them and starvation.

A still more powerful cause coöperated, if a cause more powerful can be imagined. Dryden had a dream of an early age, "when wild in woods the noble savage ran;" but "when lone in woods the cringing savage crept" would have been more like all we know of that early, bare, painful period. Not only had they no comfort, no convenience, not the very beginnings of an epicurean life, but their mind within was as painful to them as the world without. It was full of fear. So far as the vestiges inform us, they were afraid of every thing; they were afraid of animals, of certain attacks by near tribes, and of possible inroads from far tribes. But, above all things, they were frightened of "the world;" the spectacle of Nature filled them with awe and dread. They fancied there were powers behind it which must be pleased, soothed, flattered, and this very often in a number of hideous ways. We have too many such religions, even among races of great cultivation. Men change their religions more slowly than they change any thing else; and accordingly we have religions "of the ages" (it is Mr. Jowett who so calls them)—of the "ages before morality;" of ages of which the civil life, the common maxims, and all the secular thoughts, have long been dead. "Every reader of the classics," said Dr. Johnson, "finds their mythology tedious." In that old world, which is so like our modern world in so many things, so much more like than many far more recent, or some that live beside us, there is a part in which we seem to have no kindred, which we stare at, of which we cannot think how it could be credible, or how it came to be thought of. This is the archaic part of that very world which we look at as so ancient; an "antiquity" which descended to them, hardly altered, perhaps, from times long antecedent, which were as unintelligible to them as to us, or more so. How this terrible religion—for such it was in all living detail, though we make, and the ancients then made, an artistic use of the more attractive bits of it—weighed on man, the great poem of Lucretius, the most of a nineteenth-century poem of any in antiquity, brings before us with a feeling so vivid as to be almost a feeling of our own. Yet the classical religion is a mild and tender specimen of the preserved religions. To get at the worst, you should look where the destroying competition has been least—at America, where sectional civilization was rare, and a pervading coercive civilization did not exist; at such religions as those of the Aztecs.

At first sight it seems impossible to imagine what conceivable function such awful religions can perform in the economy of the world. And no one can fully explain them. But one use they assuredly had: they fixed the yoke of custom thoroughly on mankind. They were the prime agents of the era. They put upon a fixed law a sanction so fearful that no one could dream of not conforming to it.

No one will ever comprehend the arrested civilizations unless he sees the strict dilemma of early society. Either men had no law at all, and lived in confused tribes, hardly hanging together, or they had to obtain a fixed law by processes of incredible difficulty. Those who surmounted that difficulty soon destroyed all those that lay in their way who did not. And then they themselves were caught in their own yoke. The customary discipline, which could only be imposed on any early men by terrible sanctions, continued with those sanctions, and killed out of the whole society the propensities to variation which are the principle of progress.

Experience shows how incredibly difficult it is to get men really to encourage the principle of originality. They will admit it in theory, but in practice the old error—the error which arrested a hundred civilizations—returns again. Men are too fond of their own life, too credulous of the completeness of their own ideas, too angry at the pain of new thoughts, to be able to bear easily with a changing existence; or else, *having* new ideas, they want to enforce them on mankind—to make them heard, and admitted, and obeyed before, in simple competition with other ideas, they would ever be so naturally. At this very moment there are the most rigid Comtists teaching that we ought to be governed by a hierarchy—a combination of *savants* orthodox in science. Yet who can doubt that Comte would have been hanged by his own hierarchy; that his *essor matériel*, which was, in fact, troubled by the "theologians and metaphysicians" of the Polytechnic School, would have been more impeded by the government he wanted to make? And then the secular Comtists, Mr. Harrison and Mr. Beesly, who want to "Frenchify the English institutions"—that is, to introduce here an imitation of the Napoleonic system, a dictatorship founded on the proletariat—who can doubt that, if both these clever writers had been real Frenchmen, they would have been irascible anti-Bonapartists, and have been sent to Cayenne long ere now? The wish of these writers is very natural. They want to "organize society," to erect a despot who will do what they like, and work out their ideas; but any despot will do what he himself likes, and will root out new ideas ninety-nine times for once that he introduces them.

Again, side by side with these Comtists, and warring with them—at least, with one of them—is Mr. Arnold, whose poems we know by heart, and who has, as much as any living Englishman, the genuine literary impulse; and yet, even he wants to put a yoke upon us—and, worse than a political yoke, an academic yoke, a yoke upon our minds and our styles. He, too, asks us to imitate France.

Asylums of commonplace, as Béranger hints, academies must ever be. But that sentence is too harsh; the true one is, the academies are asylums of the ideas and the tastes of the last age. "By the time," I have heard a most eminent man of science observe, "by the time a man of science attains eminence on any subject, he becomes a nuisance upon it, because he is sure to retain errors which were in vogue when he was young, but which the new race have refuted." These are the sort of ideas which find their home in academies, and out of their dignified windows pooh-pooh new things.

I may seem to have wandered far from early society, but I have not wandered. The true scientific method is to explain the past by the present—what we do not see by what we see. We can only comprehend why so many nations have not varied, when we see how hateful variation is; how everybody turns against it; how not only the conservatives of speculation try to root it out, but the very innovators invent most rigid machines for crushing the "monstrosities and anomalies," the new forms, out of which, by competition and trial, the best is to be selected for the future. The point I am bringing out is simple: one most important prerequisite of a prevailing nation is that it should have passed out of the first stage of civilization into the second stage—out of the stage where permanence is most wanted, into that where variability is most wanted; and you cannot comprehend why progress is so slow, till you see how hard the most obstinate tendencies of human nature make that step to mankind.

Of course the nation we are supposing must keep the virtues of its first stage as it passes into the after-stage, else it will be trodden out; it will have lost the savage virtues in getting the beginning of the civilized virtues; and the savage virtues which tend to war are the daily bread of human nature. Carlyle said, in his graphic way, "The ultimate question between every two human beings is, 'Can I kill thee, or canst thou kill me?'" History is strewn with the wrecks of nations which have gained a little progressiveness at the cost of a great deal of hard manliness, and have thus prepared themselves for destruction as soon as the movements of the world gave a chance for it. But these nations have come out of the "preëconomic stage" too soon; they have been put to learn while yet only too apt to unlearn. Such cases do not vitiate, they confirm, the principle—that a nation which has just gained variability, without losing legality, has a singular likelihood to be a prevalent nation.

No nation admits of an abstract definition; all nations are beings of many qualities and many sides; no historical event exactly illustrates any one principle; every cause is intertwined and surrounded with a hundred others. The best history is but like the art of Rembrandt: it casts a vivid light on certain selected causes, on those which were best and greatest; it leaves all the rest in shadow and unseen. To make a single nation illustrate a principle, you must exaggerate much and you must omit much. But, not forgetting this caution, did not Rome—the prevalent nation in the ancient world—gain her predominance by the principle on which I have dwelt? In the thick crust of her legality there was hidden a little seed of adaptiveness. Even in her law itself no one can fail to see that, binding as was the habit of obedience, coercive as use and wont at first seem, a hidden impulse of extrication *did* manage, in some queer way, to change the substance while conforming to the accidents—to do what was wanted for the new time, while seeming to do only what was directed by the old time. And the moral of their whole history is the same: each Roman generation, so far as we know, differs a little—and in the best times often but a *very* little—from its predecessors. And, therefore, the history is so continuous as it goes, though its two ends are so unlike. The history of many nations is like the stage of the English drama: one scene is succeeded on a sudden by a scene quite different—a cottage by a palace, and a windmill by a fortress. But the history of Rome changes as a good diorama changes: while you look, you hardly see it alter; each moment is hardly different from the last moment; yet at the close the metamorphosis is complete, and scarcely any thing is as it began. Just so in the history of the great prevailing city: you begin with a town and you end with an empire, and this by unmarked stages. So shrouded, so shielded, in the coarse fibre of other qualities, was the delicate principle of progress, that it never failed, and it was never broken.

One standing instance, no doubt, shows that the union of progressiveness and legality does not secure supremacy in war. The Jewish nation has its type of progress in the prophets, side by side with its type of permanence in the law and Levites, more distinct than any other ancient people. Nowhere in common history do we see the two forces—both so necessary, and both so dangerous—so apart, and so intense: Judea changed in inward thought, just as Rome changed in exterior power. Each change was continuous, gradual, and good. In early times every sort of advantage tends to become a military advantage; such is the best way, then, to keep it alive. But the Jewish advantage never did so; beginning in religion, contrary to a thousand analogies, it remained religious. *For* that we care for them; *from* that have issued endless consequences. But I cannot deal with such matters here, nor are they to my purpose. As respects this essay, Judea is an example of combined variability and legality not investing itself in warlike power, and so perishing at last, but bequeathing, nevertheless, a legacy of the combination in imperishable mental effects.

It may be objected that this principle is like saying that men walk when they do walk, and sit when they do sit. The problem is, Why do men progress? And the answer suggested seems to be, that they progress when they have a certain sufficient amount of variability in their nature. This seems to be the old style of explanation by occult qualities. It seems like saying that opium sends men to sleep because it has a soporific virtue, and bread feeds because it has an alimentary quality. But the explanation is not so absurd. It says: "The beginning of civilization is marked by an intense legality; that legality is the very condition of its existence, the bond which ties it together; but that legality—that tendency to impose a settled customary yoke upon all men and all actions—if it goes on, kills out the variability implanted by Nature, and makes different men and different ages facsimiles of other men and other ages, as we see them so often. Progress is only possible in those happy cases where the force of legality has gone far enough to bind the nation together, but not far enough to kill out all varieties and destroy Nature's perpetual tendency to change." The point of the solution is not the invention of an imaginary agency, but an assignment of comparative magnitude to two known agencies.

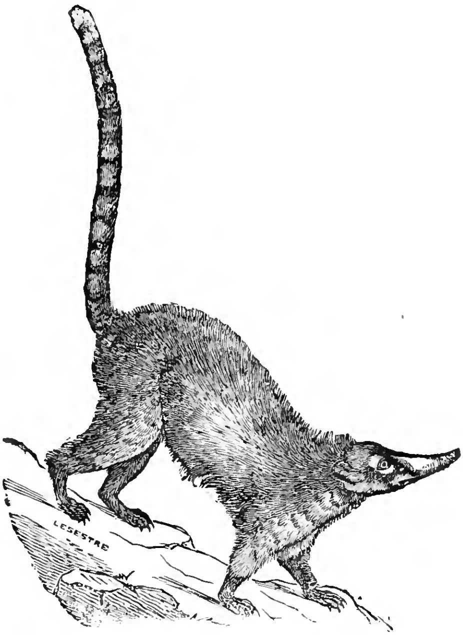
THE COATI-MONDI AND ITS COUSINS.

By Rev. S. LOCKWOOD, Ph. D.

SAILORS from South America occasionally, among other pets, bring a small animal, which, because of its long nose, they invariably call an Ant-eater. Thus was a little stranger introduced to our care a few years ago. A glance was enough to see that it was no ant-eater at all, but a pretty female Coati-Mondi. Gallant Jack Tar, her master on ship, unconscious of the incongruity, had made a namesake of her, and called her Jack. Science had already named her Nasua, and in a matter-of-fact way, for the word interpreted just means—Nosie. The animal was about the size of a cat, with a thick, coarse fur, of a brownish hue on the back and sides, and underneath shades from yellow to orange. The long tail was ornamented by a series of black and yellowish-brown rings. Her nasal prominence reminded me of a queer Spaniard, once employed in the government service to detect spurious coin. His "counterfeit detector" was a sensitive proboscis. By sticking this organ into the glittering heaps he literally "nosed" out the bad from the good. To that man his nose was the instrument of his profession; and to Nasua her nose was equally important. It even prompted a nick-name and a juvenile pun—"Nosie's nose knows too much!" Inappeasably inquisitive, she was incessantly intruding that organ into every thing. Having made no allowance for an extra-tropical temperature, this little South American made a failure in an attempt to lift with her nose the lid of a pot in the cook's domain. The next attempt, a successful one, was on the knife-box, whose closely-fitting lid was pried open, and every article inspected, in happy ignorance of the proverb about edged tools. It was enough that any thing was hollow to excite her curiosity, which was of a thoroughly simian type. The dinner-bell was turned over; but, unable to detach the clapper and chain, it was soon abandoned in disgust. A round sleigh-bell received more persevering attention. Unable to get her nose or paws into the little hole at the side, the clatter within set her wild with excitement, and evoked a desperate attack on the little annoyance with her teeth. She then gave it up as a bootless job. A bottle of hartshorn was next made the subject of investigation. We had purposely loosened the cork, and promised ourselves a "nice sell;" and *we* got it—not Nosie. She was not in the least disconcerted by the drug. In fact, she had a strong nose for such things. A man gave her his tobacco-box. Resting it on the floor between her two paws, which possessed uncommon flexibility, she turned it over and over, round and round, exercising alternately her nose, claws, and teeth upon it with great energy, but to no avail. It seemed that the smell of its contents infatuated her, as she showed no disposition to stop. The man opened the box for her. She was in rapture. In went the nose, also both front paws. Very soon that wonderfully mobile organ had separated every fibre, so that the mass seemed trebly increased. The same man let her have his dirty pipe, when her velvety nose was instantly squeezed into the rank nicotian bowl.

It would be wrong to infer that Nasua's prying propensity never got her into trouble. In the following instance, speaking metaphorically, she put her foot into it: The old cat had just finished her nap, and was stretching herself, an operation which means that she stood with her four feet close together, the limbs elongated, the back rounded up like that of a camel, the head erect and drawn back, and the mouth yawning widely. Such a sight Nosie had never seen, hence it must

Fig. 1.



Coati-Mondi (Nasua fusca) A native of South America. The full-grown animal is about the size of the domestic cat. Compare its bear-like step with Fig. 4.

be looked into. So in a trice, erect, and resting flatly on her hind-feet like a little bear, she put her arms round Tabbie's neck, and, reeking with nicotine, down went that inquisitive nose into the depths of the feline fauces. This unwarrantable intrusion was met by a reception more feeling than felicitous, judging from the haste in which Nasua withdrew to a corner of the room to ruminate on the untoward incident. Her method of relieving the injured member was itself original. She placed it between her paws, holding it tightly, then jerked it through them, giving a violent sneeze every time it came out. That sneezing was genuine, because it was involuntary. Both hartshorn and nicotine had signally failed to get up any thing respectable in that line; but that cat-nip, pure and simple, did the business finely.

Quite pretty was the pattern of the animal's ears—they were so clean, trim, soft, and small. Though rather pert, they had an air about them that was really amiable, and such as the canine fancier would pronounce elegant. She was not averse to a little fondling, and I well remember the first time she climbed upon my lap. Those pretty ears suddenly quivered. The ticking of my watch had excited her. Down goes that ubiquitous utilitarian organ into the watch-pocket. Failing with the nose, she makes a desperate effort with that and both fore-feet all at once. Still unable to evict that case of mystery, she thrusts her nose down by its side, and for several minutes, with simian quaintness, listens to the ticking of mortal Time.

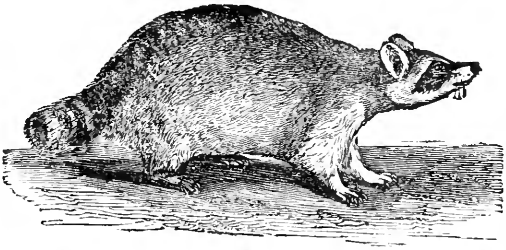
Fig. 2.

Coati-Mondi asleep. (Original.) Compare the snout with those of the three pachyderms, Figs. 5, 6, and 7. It agrees functionally, and, in the main, structurally, with that of the Swine, Fig. 6, and with that of the Peccary, Fig. 5. The Peccary snout, too, approaches it in flexibility. But the Tapir, Fig. 7, surpasses it in this particular. In the cut, which is excessively foreshortened, the sleeping animal is using its tail as a cushion for the head.

On the above occasion Coati was allowed the liberty often taken by the little dog, of going to sleep on my lap, while I gave myself up to the enjoyment of my book. Her nap finished, I did not notice when she left my lap. Soon a noise was heard like the tearing of paper. The wonderful little beast had abstracted my pocket-diary, and in violation of all propriety was making heavy extracts in a litter-ary way. Those keen incisors were scissoring away—a full leaf at a time! She had even filched a five-dollar note out of the pouch of the book, and, by way of change, had converted it into fractional currency.

In the same manner, though not to the same extent, the nose of the Nasua, like the same organ of the elephant, projects far beyond the mouth. At our first acquaintance with the animal, we were anxious to see if it could drink out of a deep, narrow vessel. So a mug, containing about a gill of milk, was set before her. She instantly turned up the proboscis toward her forehead, and, in the easiest way imaginable, lapped the vessel dry. The organ was not even wet. The sight, though comical, was really pretty. It was the only time that I had ever seen the turning up of the nose at one's friends so deftly and gracefully done. And she could turn the same organ in a contrary way quite as easily. The first time she confronted a mirror, startled at beholding her own counterfeit presentment, instantly her countenance fell—very low indeed; for her nose bent downward, and actually curved under the chin. Of course the word chin is not here anatomically correct. Her proboscis now looked like that of a tapir in repose. This singular grimace, with its squeaky little grunts, presented a very funny manifestation of surprise.

Fig. 3.



Raccoon (Procyon lotor). A near ally of the Coati-Mondi, having the same plantigrade, or bear-like step, and certain other resemblances of form and habit. The tail is too short in the cut, which is due to the foreshortening.

Sometimes for an airing the animal was tied by a long tether to a flower-stand on the lawn. It should have been mentioned that she was literally omnivorous. She would catch a mouse and eat it all up. The heads of poultry given her in the kitchen would be eaten ravenously. The same is true of sweetmeats, which she occasionally got by stealth. She would drink every thing, not even stopping at brandy. She had nearly all the appetencies of the domestic swine; and the end of her proboscis was essentially a swine's snout. I now beheld the use of this singularly-tipped organ. And an interesting sight it was to see that little thing plough up the greensward with the tip of her nose—and so easily. Here appeared the veritable swinish acuteness of scent for insects and worms, and the swinish facility for rooting in the ground. With surprising rapidity furrow after furrow was made, of about the width of a man's thumb. Whenever a worm or insect was discovered, as when drinking, the nose was curved up, so that the mouth could extract the object from the furrow.

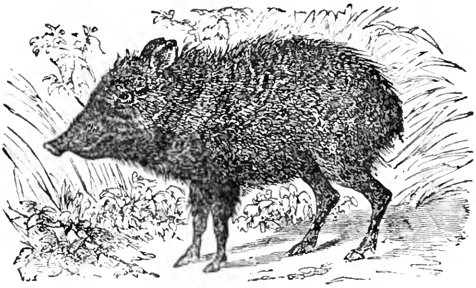
The tail of Nasua is quite suggestive of the raccoon; but Nasua's tail is a much handsomer affair—longer, and with rings more numerous and of gayer colors. With admirable intelligence, our pet put this beautiful appendage to a remarkable use. She was tethered by a string to a chair, and an egg was put on the floor at a tantalizing distance. She could just touch it with a paw, and that touch caused the coveted prize to roll out of reach. She then turned her hind-feet toward it, pulling hard so as to stretch her neck; still even with a hind-foot she could not touch it. The logic of events was now, "Get it if you can!" All this Nasua well understood, for she turned tail on the subject altogether—not, however, as did Reynard on the grapes, but strategically. She gathered herself up, and looked at the coveted object with speculative eyes. Then she swung herself round again, pulling hard on the tether by the neck. She then curved the tip of the tail so as to make a little hook. Now she grasps the base of the tail

Fig. 4.

Brown Bear (Ursus arctos). This cut shows the plantigrade step, in which the entire sole of the foot is put down at once. The same step characterizes the Coati-Mondi and Raccoon. In the Bear this characteristic finds its highest expression.

with one paw, as with a hand, thus stiffening and steadying the organ. She next slowly and cautiously rolled the egg, by the curved tip of the tail, through a section of a circle, until it was brought within reach of one of the front-feet. The egg now seized, sitting on her hind-feet, like a bear, she cracks it, extracts the contents, and neither spills a drop on the floor, nor so much as soils that wonderful nose; for, among her many gifts, is her soft and extensile tongue. This caudal expedient is sometimes found with the American show-monkey, when a bit of gingerbread is put by the roguish boys at an inconvenient distance; but, as, in such instance, the tail is prehensile, is in fact the monkey's fifth hand, such feat is no great shakes after all, but is quite in keeping with what the organ is cut out for. It is, at most, but little more than that instinct which structural or functional capacity might evolve. But, in Nasua's case, it is animal contrivance, pure and simple. There is, too, a latent fact which peeps out here: for this bending of the caudal tip looks to the faculty possessed by its cousin, the Kinkajou, the extremity of whose tail has a prehensile or grasping faculty of high perfection.

Fig. 5.



White-lipped Peccary (Dicotyles labiatus). Snout hog-like, but flexible.

She showed considerable attachment—her preference being the ladies. She would often, when tied up in the kitchen, sit for many minutes, her little black eyes looking wistfully at the door through which the mistress of the house had passed, and all this time crying pitifully. It was a plaintive cry, in the minor key, and yet a little funny, for it greatly resembled the chirping of a cricket, though not quite so shrill, and the intervals between the notes were a little longer. This tiny cry required for every note a muscular exertion, extending far down the sides of the body, which led to the suggestion that "the plaint came from the depths of the heart."

Though at times somewhat irascible, this little animal was very playful with those who could understand and humor her ways. And her method in play was a good deal like that of a dog. She would take my fingers into her mouth, and make believe to bite, and would roll on her back in manifest glee. It required at first some courage to take part in her gambols. On one occasion, thinking that she gave me too hard a nip with her teeth, I returned her a smart slap in the face. This experience was novel and startling, and caused her to open her mouth and chatter as a terrified monkey does. On one occasion she so far forgot herself as to bite me quite severely. It was but one snap of the mouth—a mere spurt of temper. I gave her such punishment as I considered judicious. For a while she kept up a snapping at me, accompanied by a monkey-like chattering of rage and fear. At last she laid down her head in submission. I then stroked and patted her. It was now all made up, and we were friends again. On this subject

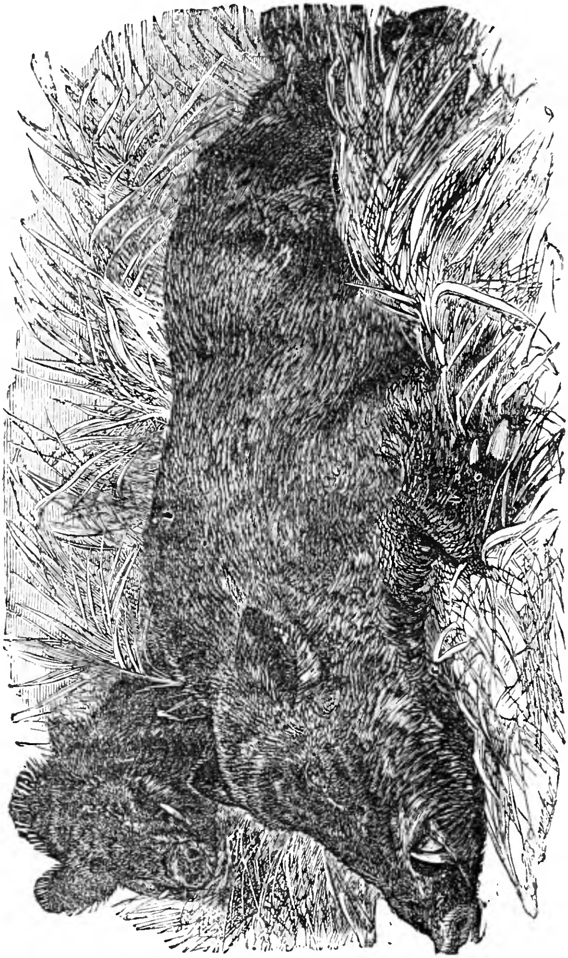


Fig. 6.

Wild-Boar (Sus scrofa). In this animal the snout has attained perfection as an organ for upturning the ground, but it has slight flexibility.

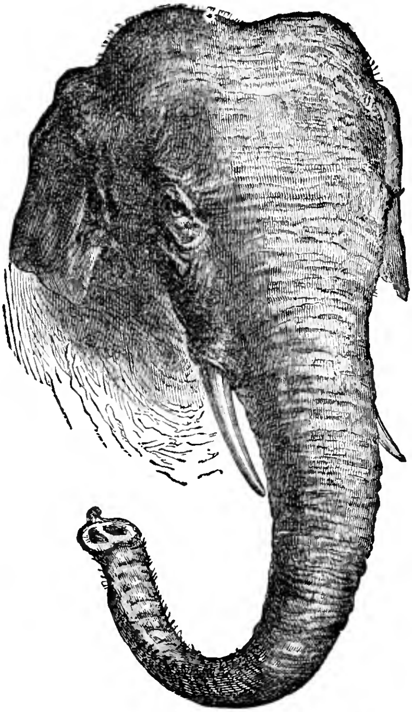
of punishment I soon learned an important fact. You might slap and shake this little thing quite severely, when her will was crossed, or a slight fit of temper was upon her, without subduing her. She had, however, a wholesome dread of the rod. A twig not thicker than a straw was sufficient. A blow from this, although it scarcely ruffled the fur, would reduce her to instant and complete submission. The exhibitor of wild animals understands the virtue of his little whip.

The attachment of this interesting animal to her new home was intense. I frequently caused her to be taken to the commons and set at liberty among the trees. Considering that the coati is a thoroughly arboreal animal, and such its agility that it descends trees head first, one would suppose that this would awaken the dormant natural habits; but she would invariably hasten home by the shortest route possible; and, if, on her return, she found the door closed, would sit on the steps and cry.

American Tapir (Tapirus Americanus). The snout of this animal is a proboscis, to some extent prehensile; hence approaching that of the Elephant.

One morning, at an early hour, coati was missed from the kitchen. A search was set up. The ringing voice of our little boy was heard, with the occasional word, "Jack." And so it was—Jack was in bed with the little three-year-old, and they were having a high time together. This trick she played whenever opportunity allowed. Often, at an early hour before the child was awake, have we found Jack self-ensconced in the arms of his little master. Of course, prudence dictated that this should not be permitted; but Jack would steal upstairs so noiselessly that the thing was often done before we had time to suspect.

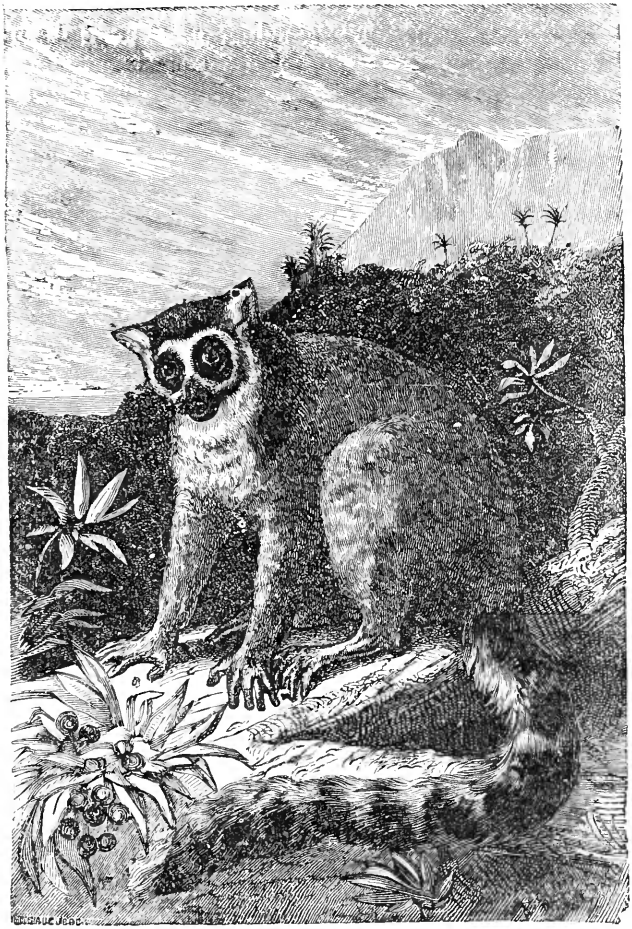
Fig. 8.



Asiatic Elephant (Elephas Indicus). Here the snout (proboscis) has attained the perfection of flexibility and prehensility.

A word is necessary as to the peculiar temerity of this animal. From two points it was liable to give way to extreme impulsiveness—the excitement of opposition, or of inquisitiveness. If any thing attacked her, whatever the object or the odds might be, she would face the assailant, and close in with her shrill little squeaks of rage, and in a wild sort of dash. If one slapped her, whatever might be her terror, she would rush upon and snap at the hand. The dog-like sagacity of running under the table or chair was not her way. Hers was the peccary instinct of running upon danger. No monkey could be a more importunate or impertinent teaser than was our coati; but Jocko shows sagacity with his jokes—for he always adroitly leaps aside of consequences. I have watched our pet tease the cat with imperturbable persistency, until Tabbie, unable to tolerate matters any longer, has struck her sharp claws into that soft proboscis, then moved away, leaving her persecutor dazed with astonishment. Then, in a moment, forgetting all, she would turn her attention to the setter-dog, and, despite his growls and menacing teeth, would keep up a systematic worrying, catching at his tail, nipping at his legs, and even poking her nose into

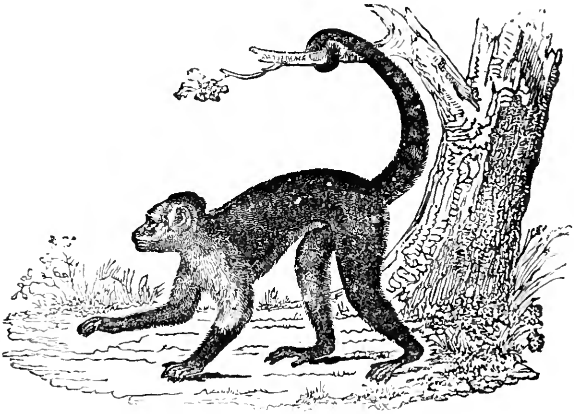
FIG. 9.



Ring-tailed Lemur (Lemur catta). The Lemurs constitute the lowest family of the Monkeys. A little animal of South America, known as the *Kinkajou*, is, in external aspect and general habit, very like the Lemurs, and yet is placed by systematists close to, and in the same family with, the Coati-Mondi, to whom its plantigrade feet show its near relationship. But this first-cousin of Coati-Mondi is also not unlike the Sapajous, or hijar monkeys, for it has a head like them, and also their accomplishment of a long prehensile tail. (See Fig. 10.) Coati-Mondi has Lemurine traits also.

his ears. At length, the poor brute, fairly goaded into rage, seized her like a rat, and, but for my prompt interference, that would have been the last display of Nasua's rashness. One morning she got into the dining-room as we were at breakfast. She took possession of madam's lap. Her first act was to poke her nose at the coffee-urn. This evoked a squeak of pain. It was supposed that she had had enough. Not quite. Her next essay was on a cup of hot coffee, with a similar result. She now smelt the contents of the sugar-bowl. This discovery so excited that "sweet will" of hers that instant removal became imperative. Later in the day she tried to capture a wasp. She struck it down, and held it a second under her foot. This was met by an appeal addressed solely to her understanding, of so pointed a nature as made her chatter with distress. Disabled in one wing, the insect could not fly away. Although still smarting from the wounded foot, the moral of the lesson is only half learned. Coati cannot give "little yellow-jacket" up. So she tries the wasp again—this time with her nose. Alas, that sting! Miss Nasua now finds that other little folks, besides herself, can utilize their tails; for, in proof of this, she receives

Fig. 10.



The Sai (Cebus capucinus). One of the South American Sapajous. The tail prehensile, but probably not more so than that of the Kinkajou, the close ally of Coati-Mondi.

not merely a duplicated, but an intensified experience, such as exacts a staccato outgush of agony, of truly simian expression. We can recall but one lesson which she took sincerely to heart. The old cow was quietly ruminating near the house. With her usual temerity, for she was always ready to "go it blind," Coati made an attempt to climb one of Cushie's legs. The cow raised her foot to shake the annoyance off, and in setting it down she put her hoof on Nasua's tail, and there standing, gravely ruminating, held her fast to the ground. Her rapid, chattering cry brought one of the ladies to her rescue. The tail was very badly hurt. Ever after, between Coati and Cushie, a respectful distance was maintained.

We now call attention to one of the most interesting facts in modern zoology. Agassiz pointed out, with much precision, the existence in certain animals, both fossil and recent, of two sets of traits —one proper to, and marking their peculiar individuality as members of an order, tribe, or family; and the other set, although found in them, yet destined to a fuller unfolding in animals yet to be created, and to mark their peculiarities. In a word, the species in question was regarded as looking forward to or foreshadowing, in these seemingly eccentric traits, the characteristics of tribes yet to come. As, for example, take the ancient Ganoids, or fishes, covered with shining, bony scales, as the word signifies. Their common representative, now, is the sturgeon, which, though a fish, has structural and physiological points that belong to the reptiles. Regarding these curious traits as put together in one individual, and in a sense to be yet separated from it, and specialized in other and higher animals, Agassiz invented, felicitously, as we think, a term to express these facts, namely, "synthetic type." Dana prefers the phrase "comprehensive type," and Guyot uses the term "undivided type."

The study of this almost grotesque little animal has proved singularly suggestive of certain points of structure and habit, usually regarded as peculiarities of other animals. In Nasua are found features which elsewhere are sufficiently dominant to warrant generic distinction—as the architect can specify certain points in the Composite order which are derived from several other orders. To designate the parts that make up this strange unity in our subject may not be easy. The botanist is, at times, perplexed in his effort to formulate the specific distinctions of a simple plant. Let him take an oak, for example—and it may be that the analysis is unsatisfactory; yet the specific conception of the tree, taken from its contour and entirety, may, for all that, be quite trustworthy. To the writer, the Nasua, viewed as a whole in the matter of structure, form, and habit, has appeared to be a synthetic, or comprehensive type—not, perhaps, a composite, as made up of what had been before, but possibly typical of what was to come. Limited strictly to anatomical analysis, the typical range would be narrowed; but, studied in the above more exhaustive method, the diagnosis must, we think, be highly significant. It may appear a superficial resemblance that is presented in the ornamentation of the respective tails of the coati and the raccoon. But these animals have also anatomical parallels of structure. Both have a similar dental arrangement, and both have plantigrade limbs. Here, again, the coati, with the coon, becomes cousin to the bear, for all three have that structure which compels that setting down at once the entire great sole of the foot, and that walking thereon, which the books denominate plantigrade. The three, also, have similarly-shaped heads, similar small eyes, small, trim ears, and peculiar claws, which are, all and several, known as ursine traits. They have also not unlike appetencies of food. They are plantigrade carnivora, and have in common a striking habit which removes them from the pure or digitigrade carnivora, namely, that of raising their food with the paws toward the mouth, and bowing the head to meet it half-way. The coati and raccoon will tear the food into fragments, and sticking into it the claws, like an improvised fork, will thus convey it to the mouth. Who ever saw a dog or cat raise its food from the ground, except by its mouth? Our Nasua, then, has elements of ursine structure, aspect, and habit.

But this little animal has also something of the appetency, structure, and habit of the swine. Look only at the cut of Nasua asleep, and mark the resemblance of the end of its proboscis to the snout of the hog. The engraving is from a photograph, and gives an admirable foreshortening of the organ. We have shown that in function it is identical; for the animal roots precisely as a hog. Here it looks toward the swine through the peccary, that hog-like animal of its own country. We have also noticed that, in a common recklessness, they—the coati and the peccary—bear a psychic similitude. Both have a habit of wildly confronting danger, and both have been known to overcome great perils, and to repulse superior enemies, by actual temerity—real sauciness, or sheer effrontery of dash.

And there is that remarkable proboscis, which actually supplies the generic name—an organ so mobile, and so effective, and so facile of disposition and adjustment. Herein, through the tapir, appears an elephantine expression point of relationship.

Then come those traits so simian—that inappeasable inquisitiveness, and that capacity for quasi-human expedients, and that monkey vice of incessant teasing, and that monkey chattering, expressing terror or distress. It is true that here we seem to stand entirely on metaphysical ground, as we cannot demonstrate any anatomical points of structure related to these traits. And we admit that, in these matters, we have no right to demand conviction unless from logic so formulated. Still the traits are there; and we feel that these traits, physiognomical and psychic, cannot stand unrelated to some important physiological data, which may perhaps place Nasua a little below the Lemurs in rank, through which inchoate monkeys it may look toward the Cebidæ, to its distant relatives, the South American Sapajous. And what striking resemblances to these well-known monkeys are noticeable in the Kinkajou, first cousin of the Coati-Mondi.

We close with a great truth which this little creature unfolds, of surpassing interest. As a synthetic type, this little being is very ancient, even on the geological record. Its lineage goes high up the stream of animal life. The first coati-mondi told off certain points of the great zoological plan yet to be unfolded. It typified the raccoon yet to come, and the peccary, and the swine, and the bear, the tapir, and the elephant; and, as a faint, yet expressive signification, it told, on its psychic side, at least, of the monkey, as the crown of the dumb creation. And by the same record we read the superior antiquity of the so-called New World to the Old: for the ancestors of Nasua were pursuing their prey in the American woods ere Asia and Europe had risen from their baptism under the sea.

And not zoological only, but may we not read, in this "comprehensive type," a geological prophecy also, that, in the far-off future, our continent shall again sink into the transforming waters, when His behest cometh, who maketh all things new?

WEATHER PROPHECIES.

THE science of the weather may be said to have sprung up within the last half century, and we must not therefore wonder that, until very recently, meteorological science has rather been concerned with the weather as it has been, than in prophesying what kind of weather may be expected. Indeed, this is almost the case at the present day; for, were it not for the telegraph, storm-signals would be of little avail. Much was gained when, from the conclusions drawn from a large number of observations, a storm could be telegraphed from any place as *coming*, instead of as happened. This stage of the science is perhaps as far as can be usually attained in the present day; in some future time, from the careful study of the laws, it may be possible to predict, with average certainty, the state of the weather from day to day, or even for several days to come. It remains to be seen how far this power has been attained; and it may not be uninteresting to notice, in passing, the very unstable ground upon which weather predictions were founded before meteorology included this second division.

Whether we take as type the old dame's faith in the gambols of her cat, the high flight of some birds and the low flight of others, the "camel" in the clouds, or the chirruping of grasshoppers, we have much the same arbitrary system, or, rather, want of system, although these signs may not be without some definite cause, more or less remotely connected with coming changes in the weather. In many country places it is common to hear it remarked that "the rain will soon clear up, for the birds are singing;" the coming change is perhaps already sensible to their more delicate organization. There is also the appearance of the clouds; and to this indication even the lamented Sir John Herschel attached somewhat of a reliance, in that "anvil-shaped clouds" portended a gale of wind. But, as a rule, the moon may be considered to hold the first place of influence upon weather predictions. Halos round the moon are the phenomena most commonly observed, and are readily explained by the laws of the reflection of light from the particles of aqueous vapor suspended in the atmosphere. When these halos are colored, we may infer the presence of watery particles in the higher regions of the atmosphere; when the halos are white, we may conclude that the particles are frozen, and expect cold weather. Crossed halos, mock moons, or highly-developed phenomena, indicate larger crystals of ice, and probably frost, hail, snow, or heavy rain, after three or four days, according to the season of the year. Similarly the laws of reflection of light indicate that the cause of a deep-purple morning or evening sky is the large amount of moisture present in the atmosphere. Another effect of the moon, when at the full, is to clear the sky of cloud, traceable, says Sir John Herschel, to a distinct physical cause, the warmth radiated from its highly-heated surface; though, why the effect should not continue for several nights after the full, remains, in the opinion of the same accurate observer, problematic. Other lunar prognostics, founded on arbitrary rules, as to the time of the day or night at which the changes or quarterings take place, are worse than useless, for they are calculated to mislead, and are generally included in almanacs or note-books intended for sale only, being in some cases attributed to an eminent meteorologist or astronomer—Sir W. Herschel or others.

It is of course far from our purpose to enter here into a disquisition on the theory of the trade and anti-trade winds, and their barometrical indications—subjects that can be usefully discussed only in a treatise on meteorology: we limit ourselves to the present position of weather prognostics, although it must be admitted that any advance yet made or likely to be made in prognosticating the weather arises from the study of such recurrent phenomena, the investigation being much aided by the highly-developed character of the laws of the expansion of gases, upon which laws the theory of the wind is founded. Thus we know that a rise in the barometer, together with a fall in temperature, as shown by the thermometer, indicates the approach of a cold, northerly current of air; while a fall of the mercury in the barometer, with a rise of that in the thermometer, indicates that a southerly or warm air-current is on its way. Northerly currents may include winds from the northwest and northeast, as well as from the north; similarly, southerly currents may include winds from the south, southeast, or southwest. When the barometer rises while a northeast wind is blowing, with prevalent hail, rain, or snow, there may be no change. Of barometrical indications alone, it is generally known that a rapid rise portends changeable weather; a slow rise, the contrary; a rapid fall, heavy wind, rain, and snow; while a fluctuating height of the column of mercury indicates unsteady weather. With a heavy gale of wind in the east or southeast, changing south, the barometrical column may fall until the wind shifts its quarter. Upon such observations did Admiral Fitzroy base his code of instructions, now to be found by the side of every barometer, his forecasts depending on the indications of the barometer and thermometer, with observations as to the direction and force of the wind with regard to time and place, and its previous course taken altogether. These indications are thus not absolute, but relative to the preceding state of the weather. But also these indications are valid for only a short interval before the actual advent of the storm; and in some instances, as in the Hyperborean storm of the 2d and 3d of October, 1860, the interval is too short for any advantage to be taken of the notice. The particulars of this storm, which present in true character the difficulties which the meteorologist must encounter, are too interesting to be omitted, and we shortly recount them from the complete and admirably-conducted investigation published by Prof. C. Piazzi Smyth, in the "Annals of Scottish Meteorology for 1856 to 1871." The term *Hyperborean* has been employed to prevent confusion with tropical hurricanes; it has also been called, from its essential locality, the Edinburgh storm. We have to consider only the practical lessons to be deduced from the observations of this storm; the account of the actual observations must be read from the before-mentioned report of Prof. Piazzi Smyth. First, then, the barometric notice was insufficient and too local to be of service, while the storm was too quick in its movements. St. Hilda is the most westerly station; and, even if the storm could have been telegraphed thence, the message would have allowed only two hours for preparation, and would have arrived while the eastern men were sound asleep. If a message could have been sent from Iceland the day previous to the arrival of the storm, many wrecks would have been prevented. So that we see the present system of meteorology necessitates not only diligent but earnest watching of the signals that should be afforded by a net-work of cables and overland wires, for it is by a series of connected observations, extended over a large area, that the usefulness of this branch of meteorology is alone likely to be advanced.

But, it may be asked, what definitive knowledge can be gained, say not of storms, but of average weather for some future period? Here we must again refer to Prof. Piazzi Smyth's report on the rock-thermometers at the Royal Observatory, Edinburgh, and to the Proceedings of our own Royal Society for the 2d of March, 1870, in which predictions of the weather during the winters of 1871–'72 are attempted. The rock-thermometers have by their readings shown some well-marked supra-annual cycles, the relation of which to the sun-spot cycles will be known to our readers. And on this point it may be stated that the Radcliffe astronomer announces, in his report for 1871, that the *mean* azimuthal direction of the wind at Oxford, rigorously computed from automatic records during the last eight years, varies year by year through a range of 58° on the whole, between maximum and minimum of visible sun-spots, the tendency of the wind to a westward direction increasing with the number of spots, and with such west wind, it is to be presumed, the amount of rain also. "The most striking and positive feature of the whole series of observations," continues Prof. Piazzi Smyth, "is the great heat-wave which occurs every eleven years and a fraction, and nearly coincidently with the beginning of the *increase* of each sun-spot cycle of the same eleven-year duration. The last observed occurrences of such heat-wave, which is very short-lived, and of a totally different shape from the sun-spot curve, were in 1834.8, 1846.4, 1857.8, and 1868.8; whence, allowing for the greater uncertainty of the earlier observation, we may expect the next occurrence of the phenomenon in or about 1880.0. The next largest feature is the extreme cold close on either side of the great heat-wave: this phenomenon is not quite so certain as the heat-wave, partly on account of the excessive depth and duration of the particular cold-wave which followed the hot season of 1834.8. That exceedingly cold period, lasting as it did through the several successive years 1836, 1837, and 1838, was, however, apparently a rare consequence of an eleven-year minimum, occurring simultaneously with the minimum of a much longer cycle of some forty or more years, and which has not returned within itself since our observations began. Depending, therefore, chiefly on our later observed eleven-year periods, or from 1846.4 to 1857.8, and from the latter up to 1868.8, we may perhaps be justified in concluding that the minimum temperature of the present cold-wave was reached in 1871.1; and the next similar cold-wave will occur in 1878.8." Between the dates of these two cold-waves there are located, according to all the cycles observed, even including that earlier one otherwise exceptional, three moderate and nearly equidistant heat-waves, with their two intervening and very moderate cold-waves, but their characters are quite unimportant. With regard to all the waves, it may be just to state that there has been in observation more uniformity, and will be therefore in prediction more certainty, for their dates than for their intensities.

We have thus very briefly surveyed the position of meteorology, and little remains to be said beyond that the results are highly in favor of the hopes of physicists to render meteorology an exact science. —*Quarterly Journal of Science.*

A NEW PHASE OF GERMAN THOUGHT.

HARTMANN'S PHILOSOPHY OF THE UNCONSCIOUS.

TRANSLATED FROM THE FRENCH OF LEON DUMONT, BY A. R. MACDONOUGH, ESQ.

I.

IN an age like ours, when philosophical criticism, applied to all ideas, has dissipated most of the fictitious charms lent to existence by the imagination of mankind—when the advance of science leads us more and more to look on the world as it is—when, no longer able to find consolation in creeds and myths, we grow more closely and constantly familiar with inflexible reality, there is no reason for surprise if, in the moment of reaction from the illusions of the past, certain spirits, unable to keep the golden mean, permit themselves to be led captive by exaggerations of quite another kind, and, taking the leap over realism, fall into a pessimism which shows things to them, no longer such as they are, with the impress of facts, hard and brutal enough already, upon them, but even more sad and evil than the reality. But we may well think it strange that such exaggerations, heavy discouragements as they are to humanity, should win their growth and start into theories in the very country of Leibnitz, and of systematic optimism—the country seemingly destined, by the political events of our times, to lead all others in giving brightness and cheer to all judgments of the aspect of the world.

There has arisen in Germany a philosophic school built on the belief that, in existence taken as a whole, evil prevails over good—a school that sighs for the annihilation of being as the sole relief from its miseries. It is one of Cousin's most just remarks that the path of German metaphysics, opened by Kant, must find its logical issue in nihilism. Indeed, the romantic writers, relying on Schelling's half-mystical system, did not hesitate to preach a sort of quietist indolence as the highest aim given to man to reach. Thus Schlegel, with other critics of the same school, was led to envy for man "the divine idleness and happy life of plants and flowers;" and, in his famous work "On the Language and Wisdom of the Indians" (Heidelberg, 1808), to admire the calm and passionless life of Oriental ascetics. Homer, whom romanticism had already sacrificed to Ossian, saw himself ere long dethroned by Buddha. The political events of this lower world had no power to shake souls permeated by so lazy a wisdom. Yet it was the hour of storms raging everywhere—the hour for the crash and downfall of the old Germanic edifice, when Austria and Prussia trembled for their threatened successive overthrow under the blows of Napoleon; but all this mattered little to those mystic spirits who persisted in living in an ideal world, careless of French bayonets, or the embargo, or the Confederation of the Rhine. They averted their looks, especially from those low creatures who struggle on the earth's surface to win their bread, and proclaimed that the perfection of the science of life is to do nothing. It is true these fine theories were put forth in a highly-emphatic style, which provoked Richter's raillery, and gave a flat contradiction to the quietist doctrines they upheld.

In 1819, Schopenhauer's great work appeared, "The World regarded as a Manifestation and a Will." Though this philosopher was an independent thinker, disconnected with any school, he too had yielded to the influence of Eastern studies. "I have been fortunate enough," he said, "to be initiated into the Vedas, access to which was opened to me by the Upanishad's, a great enlargement of my mental vision, for I believe this age is destined to receive from Sanscrit literature as strong an impulse as the sixteenth century owed to the revival of the Greeks." Foucher de Careil, who had occasion to visit Schopenhauer, relates that "he had imported at great expense a Buddha, and showed it to his visitors with mischievous pride. He had no patience with English missionaries who undertake to convert their elders in religion." According to Schopenhauer, there is nothing but wretchedness in the world; evil alone is positive; pleasure is a mere negation of pain, and thus has no reality. As to happiness, it is an empty word —progress, a sheer Utopia; history, nothing more than the long-drawn-out torment of humanity's nightmare. What is life? A fabric that is not worth what it costs—an endless hunt in which, sometimes pursuing, sometimes pursued, men fight over the fragments of their slain victims—a war of all against all, *bellum omnium contra omnes*—death discounted, Parmenides called it—and, to sum up all, a sort of natural history of misery, that may be thus rendered in brief: "To wish without a motive; always to suffer; always to strive; and then to die, and so over and over again 'in sæcula sæculorum,' till the crust of our planet scales away into little bits." What are the practical consequences of such teaching? That the mere fact of being born is a misfortune, and that to give life to a new being is a bad action. Hence, this strange analysis of modesty: "See these two beings whose glances seek each other. Why that mystery they shroud themselves in? Why their timid and shamefaced air? Because they are two traitors, who fly to the darkness to perpetuate in another all those tortures and sorrows that would reach a speedy end but for their treachery. And there will always be such criminals, who will ogle and caress after the same fashion, to perpetuate life, to live again in another being." And what is the moral principle of the system? Pity; nothing else than pity. The ascending series of living beings ends with man, because a being superior to man, and more intelligent, would not consent to live and keep up this wretched comedy a single day. The aim of philosophy is to enlighten man as to his deplorable condition—to inspire him with longing to be annihilated, and never again to live after death, under any form whatever, and to unfold to him at length the means of gaining this annihilation. Remark that in all these teachings there is not a trace of sportiveness, none of the ironic sallies of the humorist, the inspiration of a misanthropic fit; temperament has nothing to do in producing them. We are brought face to face with a profoundly and learnedly elaborated system, one that criticism must treat with all gravity. Is this the dawn of a Western Buddhism? Are the European offshoots of the Aryan race, like their brothers of the East, about to aspire to the supreme *Nirvana*, and petrify themselves in asceticism?

It is a fact that Schopenhauer did not remain an isolated phenomenon. The pessimist doctrine gathered a school, and we might name its distinguished disciples—the Frauenstadts, the Gwiners, the Ashers.

The book before us is one full of vigorous discussion, first published in 1869, repeated in the fourth edition already, which has made a powerful impression in Germany, and would assuredly have been heard of in France if the deplorable events of later years had not distracted attention from speculative studies. The book we speak of is the "Philosophy of the Unconscious," by Edward de Hartmann.

Though Hartmann adopts a very different system of metaphysics from Schopenhauer's, he admits having borrowed from that philosopher the point of departure of his system; his moral views are similar, if not identical; he has the same fellow-feeling with Eastern philosophies, the same pessimist color in his view of the world and of existence in general. Besides, Hartmann announces himself as a disciple of Schelling, and thus links himself with the romantic school. Just as he has a strongly-marked leaning toward eclecticism, and fancies he can reconcile the two systems of Hegel and of Schopenhauer, so too he attempts to fuse together optimism and pessimism: but it is for the sake of maintaining that even in the best of possible worlds, which naturally is our own, evil still prevails immeasurably over good. For him, as for Plato, for the old religions, existence is a fall. The human race, like all beings in the universe, is the prey of many miseries while tasting but few joys, and the advance of philosophy consists in gaining an ever-clearer conviction of this sad truth. Meanwhile, man is deluded by instincts that make him cling to life, and urge him to cares for its preservation and reproduction. These instincts are a divine blessing, since they were necessary to keep life going, to make civilization possible, to give man time for climbing toward philosophic intelligence, and in a word to invest triumphant science with the power to unseal his eyes to the wretchedness of his state: man at the outset must needs be sustained by the delusive love of life, that he might some day win the power of willing, not merely his own non-existence, which Schopen hauer contented himself with, but the non-existence of the whole race too, and even, if we clearly take in Hartmann's doctrine, the annihilation of all real being. When sufficiently enlightened, man will acknowledge the vanity of his desires, and let himself die of disgust. If high intellects, great poets, thinkers of genius, are for the most part melancholy, it is because they draw nearer to the truth than the ignorant crowd, ruled wholly by its instincts. The discovery that life is unendurable is pregnant perhaps with awful catastrophes for the future; the masses will grow more and more restive in their misery; formerly they felt little of it except when their stomachs grumbled, but the older the world gets, the more threateningly the spectre of pauperism rises. The social question of our time rests, in the last analysis, only on the stronger sense of their sufferings that has seized the working-classes, although their situation is a golden one compared with what it was two centuries ago, when the social question had no existence. And yet the rich are even more to be pitied than the poor, the educated classes more than the ignorant, for the same reason that fools are generally happier than people of sense, and the savage happier than the civilized races. Happiness, in fact, is in an inverse ratio to the quantity of existence, and the more developed, the less coarse, a man's nervous system is, the more he suffers; now, the progress of humanity, wealth, culture of mind, multiply man's needs and refine his nervous sensibility. Wretchedness grows, then, with the consciousness of wretchedness. But, thanks to the sovereign wisdom of the unconscious principle that rules the universe, the world will at last arrive, through social cataclysms and by force of that very conviction of its misery, at annihilation, which will be the term of all its woes.

Hartmann seems, therefore, to concede the position to those who argue that religions and creeds in general are all that has made human life endurable and civilization possible. There will be more minds ready to accept his testimony in favor of the usefulness of illusions than there will be to adopt that Utopia of annihilation which in his view must take their place in the future. Three grand illusions have in turn sustained humanity, up to this day: The first, the illusion of childhood and the ancient world, consisted in the dream that happiness might be actually attained by the individual, and during the present life. The second illusion, which replaced this, was the fancy that the individual will attain happiness after his death, in a life transcending the present. The last is the grand modern illusion, that of progress, which teaches that happiness, as it cannot be the individual's aim, either in this life or in another, must be sought for the species in the future of humanity, in the evolution of the world. To all these illusions succeeds the deception of humanity's old age, reaching the term of its development of consciousness, and recognizing at last that happiness is nothing else than the absence of pain, and can only be realized by the annihilation of being.

Hartmann takes care to warn his readers that they deceive themselves if they look for consolation and hope in philosophy. For such objects, books of religion exist. But philosophy pursues truth exclusively, careless whether its acquirement sustains or contradicts the sentiments inspired by the illusions of instinct. Philosophy is hard, cold, insensible as stone. Floating in the ether of pure thought, it gravitates toward the icy knowledge of existence, its causes, and its nature. And if man fails in the moral strength to endure the overwhelming results of his thought, if his heart yields to the spasm of despair, if he gives himself up to desolation, what will philosophy do? Will it revive his courage? No! it will merely note down these facts of despair and desolation as a precious contribution to its materials for physiological observation. And when, on the other hand, meditation upon the truth fills stronger souls with sacred indignation and noble rage, a repressed wrath against this empty masquerade of existence or if that wrath breaks into bursts of Mephistophelian humor, or pours its disdainful pity, mingled with irony, upon the unfortunates cheated with the shows of happiness as upon those who yield to despair—when, at last, the soul, bracing its strength to fight this fatality, discerns a plain escape and issue from this hell—these again are but facts which philosophy, still calm and impassive, verifies and records, and its work is done.

We readily admit that there is a grandeur in these ideas of humanity and philosophy. But the critic's duty is, to ascertain whether they are correct, and do not merely create still a new illusion to add to those the world has hitherto been cradled in—one equally empty with the rest, and only perhaps differing from them by the disadvantage of being far less cheerful and helpful to humanity. As it relates to the world's progress, all these systems may be reduced to two classes: on the one side, those which hold up the universe as tending toward a designed aim, and guided by an intelligent principle toward a providential end, such as the realization of happiness for the individual, or a certain perfection of humanity, or, still more generally, some kind of cosmic condition: on the other side must be placed all those systems according to which the world is not moving toward a foreseen and chosen end, and is ruled only by the force of things, intelligence itself, wherever it is manifested, being nothing more than a resultant and a particular phenomenon. According to these latter systems, if humanity and our world were to come to an end, these results would only flow from the necessary relations between the facts of the universe; and these systems, if they are pantheistic ones, can find a very clear expression for their doctrine in the formula that the occurrences of the universe have as their principle not a divine will, but merely the eternal nature of God.

Hartmann, who belongs, at several points, to the traditioned spiritualistic philosophy, displays a strong attachment to the idea of an intelligence presiding over the destiny of the world. Although a pantheist, he continually reasons as a mere deist, a contradiction which seems to us to be the source of most of his errors. His God, who is supremely wise, omniscient, and prescient, but who is not omnipotent, for he had not the power to prevent the production of this evil world, ought *a priori* to govern every thing toward the best end. Now, this end cannot be individual happiness, for the individual dies, and Hartmann does not admit the survival of personality. It cannot be the perfection of the race, for humanity is doomed to perish whenever the burnt-out sun shall cease to furnish its conditions of existence. Must the end proposed by Providence be sought for in the destiny of our world itself? But modern science teaches us that the world also is doomed to inevitable destruction. Thus, from the necessity of rejecting all these positive ends, nothing remained but to seek the solution of the problem in a purely negative end, and this is what Hartmann, following Schopenhauer, has undertaken. The best possible end for the world is its annihilation, and it is toward this term of all evils that the supreme intelligence is leading us.

To establish the truth of this doctrine, Hartmann has elaborated his theory of the unconscious. Is it science? or is it really nothing else than a metaphysical romance? It is this that we propose in the next part to investigate.

HOW THE FEELINGS AFFECT THE HAIR.

By DANIEL H. TUKE, M. D.

THE influence of grief or fright in blanching the hair has been generally recognized.

> "For deadly fear can Time outgo,
> And blanch at once the hair."—Marmion.

It has been a popular rather than a physiological belief that this can occur "in a single night." No one doubts that the hair may turn gray, gradually, from moral causes, and this is sufficient proof of the mind's influence upon the nutrition of the hair. I have known alternations in the color of the hair (brown and gray) corresponding to alternations of sanity and insanity. Some entertain doubts as to sudden blanching of the hair, but I do not believe them well founded, and can vouch for the truth of the following interesting cases·

"Thomas W., about twenty years of age, the son of a milkman, was tall, fleshy, good looking, slightly bronzed, hair intensely black, stiff, wiry, and rather inclined to curl. His general appearance was that of a healthy and well-formed man, used to light work, but much exposure in the open air. In the year 18— one of his thoughtless companions told him (what was not true) that a girl in the town was going before the magistrate on the morrow to swear him father of her child. Poor W. was dumfounded. The announcement had given his whole frame a severe shock; the gall of bitterness had entered his heart, and the mind was under the baneful influence of its power. He hastened home, and sought relief in his bedroom. Sleep was denied him, for his brain was on fire. He saw nothing but disgrace coming from every angle of the room. Such was the mental agitation produced by a silly trick. Early morning brought no relief; he looked careworn, distressed, and his hair was changed from its natural tint to that of a light 'iron-gray color.' This, to him, was a great mystery. In the course of the following day the stupid trick was explained, but the ill effects of it lasted for a long period. Nearly twenty years after, although his health was fair, the mental powers retained signs of the severe shock they had received; his hair was perfectly gray, and a medical friend of mine who met him received the impression that he would carry the marks of this folly to his grave.

"I know of a captain of a vessel, under forty years of age, who suffered shipwreck twice. On the first occasion (in which he lost all hope) his hair quickly turned gray; and on the second, some considerable time afterward, his hair became still further blanched. He resolved never to go to sea again, and kept his resolution.

"A lady, travelling in France subsequently to the Franco-Prussian War, heard of a considerable number of cases of hair blanching (more or less marked) in consequence of fright."

Dr. Laycock, in speaking of pigmentation of the hair, asks whether grayness and baldness are due to loss of tone of the hair-bulbs solely, or are ultimately associated with trophic nervous debility of certain unknown nerve-centres. He points out that the regional sympathy which characterizes trophesies is well marked, and that, as regards baldness, it extends from two points, the forehead and the vertex, ending at a line which, "carried round the head, would touch the occipital ridge posteriorly, and the eyebrows anteriorly." So with the beard, etc. In connection with a succeeding remark, that the eyebrows are a clinical region in brow-ague, herpes, and leprosy, the case already referred to, of a woman who suffered in the night from a severe attack of tic, and found in the morning that the inner half of one eyebrow and the corresponding portion of the eyelashes were perfectly white, may be mentioned. Laycock points out the fact that the hair over the lower jaw is almost always gray earlier than that over the upper jaw, and that tufts on the chin generally turn white first.—(*Op. cit.*, May 13.)

"Mr. Paget, in his 'Lectures on Nutrition,' has recorded the case of a lady with dark-brown hair, subject to nervous headache, who always finds, the morning afterward, patches of her hair white, as if powdered with starch. In a few days it regains its color. Dr. Wilks says he has on more than one occasion had a lady visit him with jet-black hair, and on the morrow, when seen in bed, it had changed to gray. Bichat, opposing the skepticism of Haller, asserted that he had known at least five or six examples in which the hair lost its color in less than a week; and that one of his acquaintance became almost entirely blanched in a single night, on receiving some distressing news. There is no reason to call in question the statement that Marie Antoinette's hair rapidly turned gray in her agony. We have it on the authority of Montesquieu himself that his own hair became gray during the night, in consequence of receiving news of his son which greatly distressed him. Dr. Landois, of Griefswalde, reported not long ago a case in 'Virchow's Archives,' in which the hair rapidly turned white. But I have not any particulars at hand beyond the fact that, on carefully examining the hair, he found that there was 'an accumulation of *air-globules* in the fibrous substances of the hair.' Erasmus Wilson read a paper at the Royal Society in 1867 on a case of much interest, a *résumé* of which I subjoin in a note." [1]

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[1] Every hair of the head was colored alternately brown and white from end to end. The white segments were about half the length of the brown, the two together measuring about one-third of a line. Mr. Wilson suggested the possibility of the brown portion representing the day-growth of the hair, and the white portion the night-growth, and this opinion was corroborated by the remarks of Dr. Sharpey and others of the Fellows who took part in the discussion. Under the microscope, the colors of the hair were reversed, the brown became light and transparent, the white opaque and dark; and it was further

The falling off of the hair is too frequent a result of anxiety, or other depressing emotion, to escape common observation. A case reported in the *Lancet*, of May 4, 1867, forms an excellent illustration:

"A man of nervous temperament began business as a draper in 1859. At that time he was twenty-seven years of age, in good health, though not very robust, unmarried, and had the usual quantity of (dark) hair, whiskers, and beard. For two years he was in a state of *perpetual worry and anxiety of mind*, and his diet was very irregular. Then his hair began to come off. He declares that it literally fell off, so that when he raised his head from his pillow in the morning, the hair left on the pillow formed a kind of cast of that part of his head which rested on it. In a month's time *he had not a single visible hair on any part of his body*—no eyebrows, no eyelashes; even the short hairs of his arms and legs had gone; but on the scalp there could be seen, in a good light, patches of very fine, short down. This was in 1861. Medical treatment proved of no avail, and he was finally advised to do nothing. So long as his anxiety continued, the hair refused to grow, but by the latter part of 1865 his business became established, and, coincidently, his hair reappeared; and when Mr. Churton, of Erith, reported the case, he had a moderately good quantity of hair on the head, very slight whiskers, rather better eyebrows, and the eyelashes pretty good."

The influence of painful emotions in causing gray or white hair and alopecia has been sufficiently illustrated, and it would have been interesting to adduce a reverse series showing the opposite effects of joy. But it is a very different thing to restore to its healthy habit the function of a tissue whose pigment has been removed by slow mal-nutrition, or by sudden shock. I may adduce such a circumstance as the following, however, to show that hair, which has turned gray in the natural course of life, may, by the stimulus of specially-favorable events, become dark and plentiful again:

"An old man (aged seventy-five), a thorough out-and-out radical—even the cancelli of his bones were so impregnated with a thorough disgust of the Government of George IV. that he threw up a lucrative situation in one of the royal yards, and compelled his youngest son to follow his example—insisted that his wife, also aged (about seventy), toothless for years, and her hair as white as the snow on Mont Blanc, should accompany them to the land where God's creatures were permitted to inhale the pure, old, invigorating atmosphere of freedom.

obvious that the opacity of the white portion was due to a vast accumulation of *air*-globules, packed closely together in the fibrous structure of the hair, as well as in the medulla. There was no absence of pigment, but the accumulation of air-globules veiled the normal color and structure. Mr. Wilson observed that, as the alteration in structure which gave rise to the altered color evidently arose in a very short period, *probably less than a day*, the occurrence of a similar change throughout the entire length of the shaft would explain those remarkable instances, of which so many are on record, of sudden blanching of the hair; and he ventured to suggest that, during the prevalence of a violent nervous shock, the normal fluids of the hair might be drawn inward toward the body, in unison with the generally contracted and collapsed state of the surface, and that the vacuities left by this process of exhaustion might be suddenly filled with atmospheric air.—*Lancet*, April 20, 1867.

About six or seven years after their departure, a friend living in New York gave an excellent account of their proceedings. Not only could the old man puff away in glorious style, and the son do well as a portrait-painter, but old Mrs. —— had cut a new set of teeth, and *her poll was covered with a full crop of dark-brown hair!*"

—*Journal of Mental Science.*

COTTON FIBRES AND FABRICS.

By Dr. SACC,

PROFESSOR IN THE ACADEMY OF NEUFCHÂTEL.[1]

COTTON owes its kingship quite as much to the tenacity with which its fibres adhere to one another, as to their length or fineness; and were it not that the fibre produced by the *bombax*, or silk-cotton tree, is too smooth, cotton would find in it a powerful rival. Cotton-wool is the downy bed in which the seeds of the cotton-plant are enveloped, and is the product of hot countries. It has several varieties, that cultivated in Algeria and in Southern Europe seldom attaining a height of over twelve inches, while at the equator the plant grows as high as an apple-tree, and bears a fruit twice as large as that of the Algerian species. The cotton grown in the East Indies is of very inferior quality, its fibre being short and hard; yet it was largely used in manufacture, during the war in the United States. Chinese cotton is yellow, and hence the peculiar color of the fabric called nankeen.

The cotton-plant is probably a native of Africa, and Livingstone found it in the interior of that country along the banks of all the rivers. The ancient Egyptians doubtless imported from Abyssinia their cotton cloths for mummy-wrappings and for the garments of priests and nobles, and from them the Jews inherited the employment of that texture for the robes of their priests: for, where the Bible makes mention of *fine linen*, we must read *cotton*, as flax does not grow in hot climates. From Africa cotton-culture passed into Persia and Georgia; then into India, and from India into China. In the latter empire all the clothing of the poorer classes is of cotton, of extremely firm texture. Indeed, so strong is the cotton cloth manufactured by the Chinese, that it is impossible for a man to tear a piece of it across; and the people of China and India refuse to buy European cotton manufactures, calling them mere spiders' webs.

If the true aim of prudent industry be to produce good fabrics at

[1] Translated and abridged from the *Annales du Génie Civil.* Dr. Sacc is the grandson of Dupasquier, who introduced into Switzerland the English process of printing calico. The author is responsible for his own political economy.

the lowest price, then the cotton manufacture is a failure. Instead of even studying to improve the fabric, manufacturers have, ever since the manufacture of carding and spinning machines, thought only of the problem of cheapness. The fabrics they produce are of the worst quality, and quickly wear out; and it may be doubted if there can be found in all Europe, to-day, a single piece of such cotton cloth as used to be manufactured twenty years ago, which gave many times as much wear as the present textures.

The United States annually produce 4,000,000 bales of cotton for the European market, or 1,200,000,000 of pounds, which sells at an average price of one franc per pound. Europe thus pays to the United States 1,200,000,000 of francs every year, simply for cotton, and the 1,200,000,000 pounds of cotton is spun by 50,000,000 of spinning-jennies and wove by 625,000 looms. In the process of manufacture there is a waste of 25 per cent.; hence 1,200,000,000 pounds of raw material give only 900,000,000 pounds of manufactured cotton goods, worth two and one-half francs per pound, being a total of about 2,250,000,000 francs. The process of manufacturing, therefore, does not even double the value of the raw material.

If, now, we estimate the number of workmen engaged in the cotton manufacture from beginning to end, on the basis of six workmen to every 160 spinning-jennies, we shall have 1,875,000 hands so employed. Add to this the number of those employed in raising the cotton-crop, and the crews of the ships which bring it to Europe, and it will be no exaggeration if we estimate the number of employés at 3,000,000, and the amount of capital at 3,000,000,000 francs. No other industry can compare with this for magnitude, and the epithet *King Cotton* is well deserved. If we do not take care, this industry will prove the ruin of Europe, whence it annually drains 1,200,000,000 francs, without making any return. Cotton alone is answerable for the ever-increasing wealth of the United States, and the relative misery of European countries. It is full time to put an end to this state of affairs, by compelling the manufacturers hereafter to produce only firm and durable textures. But, inasmuch as the state can scarcely interfere in such questions, it remains for individuals to apply the remedy. It is in the power of the consumer to apply this remedy, as he alone is accountable for the present painful crisis of the cotton-manufacturing industries of Europe.

We have grown so accustomed to cheap cotton fabrics, that, when prices are advanced, we turn to linen, hempen, or woollen textures, and then the manufacturer is forced to adulterate his products, the consumer shutting his eyes to all defects, provided the article is cheap. It will scarcely be believed, and yet it is the simple truth, that, whereas ten years ago the *piece* of cotton weighed eight pounds, it now weighs but six, or even less, and thus is 25 per cent. less strong than it used to be. But, further, instead of employing good United States cotton, which is high-priced, the manufacturers make large use now of the wretched cottons of India, which are cheap, but which make a weak texture, mere cobweb. An appearance of firmness is given to these worthless fabrics by a liberal use of sizing, which deceives the eye; but, apply a little lye-water, and the material will be found to be mere lint.

The evil consequences flowing from the false principles which govern the manufacture of cotton are enormous, and it is time to apply a remedy. If Europe goes on thus, ever giving, and receiving from the United States nothing in return, our material prosperity will soon be at an end. The ladies of Austria would appear to stand alone in justly appreciating this danger, and have resolved to eschew cotton fabrics, and use linen in place of muslin. Let Europe follow their example; let muslin be banished from our households, and the immediate result will be, that Europe will stand at the head of civilized nations.

As it is at present carried on, the cotton industry is the opprobrium of humanity and the curse of Europe. Why is it that this manufacture has come to be regarded as a prime necessity of the civilized world? Simply because fashion has backed it, and preached it up: and fashion is a power before which we all bow in submission.

When Indian tapestries and those admirable Mosul textures were first imported into Europe, there arose a universal demand for them, nor could all the looms of the East furnish the supply required. In time the raw material was brought hither, and we spun and wove it by hand; we printed and dyed it. At first no evil consequences flowed from the new industry, because cotton goods, being yet too costly to be used by the poor, were bought only by the rich, who found them really cheap, on account of their great durability. It was only at the beginning of the present century that we first experienced the evils of which we here speak. Then it was that the invention of machinery for the manufacture of the raw material enabled cotton to drive all other textile fabrics out of the market, and forced on Europe the most deplorable of economies.

But our eyes are at last opened to see the calamities which threaten us, and there is now very little danger that this industry will expand any further. It has owed its past prosperity to frauds of the most consummate nature, and now it is undergoing a crisis which cannot fail to turn to the advantage of other textures, and from which it is not likely to recover. We have reason to rejoice at the fall of King Cotton; and now let us keep for Europe all its own resources, by purchasing only fabrics of hemp and flax, wool and silk, instead of muslin; thus shall we give a mighty impetus to home agriculture and home industry.

For certain purposes, however, cotton cloth is indispensable; thus printed fabrics will ever be of cotton, for no other textile fibre takes colors so well. This is due to the fact that cotton-fibre is flat, while that of flax and hemp is cylindrical; then, too, cotton is more readily bleached than hemp or flax. The manufacture of calico came, as the name implies, from India; and the first printed textures thence brought to Europe were very coarsely printed, with figures in black, red, or blue, the colors being dull, but very fast. Imitation calico was first manufactured at Bordeaux, and from that city the industry passed over into Switzerland and Germany, with the Protestants who were driven from France by the *dragonnades* of Louis XIV. It quickly attained exceptional importance at Neufchâtel and at Mühlhausen, which then belonged to Switzerland; but it is in Alsace that it has made most progress, and taken the lead of all other industries.

Chaptal, the famous Minister of Commerce under Napoleon I., said that the manufacture of calico is the most difficult of industries, for it requires most capital, most patience, the longest training, and the largest amount of good sense and intelligence. Chaptal was in the right; for all the great manufacturers of cotton-prints take rank among men of note. I need only cite a few names. In Switzerland we have our Dupasquiers, Bovets, and Verdans; France has her Haussmanns, Schlumbergers, Koechlins, and Dolfus; and this roll is sufficient to show the justice of Chaptal's assertion. Every year, every day, has witnessed some new improvement in the manufacture of calico; the dull colors of former times have been superseded by a series of novel shades, and coarse patterns have given way before artistic designs which may well compare with the finest designs on paper.

The fixation of colors was the result of chance, aided more or less by the manufacturer's experience, which was not unfrequently nonplussed by a change of the atmosphere, or by a variation in the quality of the drugs employed. In such a state of things, which threatened to ruin the manufacture, recourse was had to science, and the dyers became chemists and physicists. But then the charm was broken: there was no more chance, no more tentative; the fabrication of printed tissues was now a science, and soon, in addition to liquid dyes, we had our dye-stuffs in the shape of vapor, which yield brilliant tints indeed, but not very stable. Finally, besides cotton fabrics, we began to print textures of silk and of wool, or of mixed wool, silk, and cotton, which have given rise to an entirely new class of tissues called *chalys* or barèges, when they contain wool and silk, and cotton warp when they are comprised of cotton and wool.

In order to form some idea of the cotton industry, let us go back to the gathering-in of the crop. The cotton-wool, when it starts from the pod, contains three times its own weight in large oily seeds. These are separated from the cotton by means of machines which are in fact cards, and which seize the cotton, suffering the seeds to drop out. During this process the seeds will be more or less crushed, and give out an oil, which is absorbed by the cotton. If, now, there flows in a current of hot air, the cotton takes fire. This is the cause of the fires which so frequently break out in cotton-factories, always originating in the rooms where the raw material is set to dry. The minute quantity of oil contained in raw cotton is also the reason of its turning yellow in store, though it was white when gathered in. The fabric has, therefore, to be lixiviated and bleached before being printed. The process of bleaching begins by washing the cotton in lime-water, after which the fabric is passed through a weak acid solution, in order to remove the lime, which else would burn the tissue. It is then thoroughly washed, treated anew with soda, then with a soap of colophony, and finally passed through water.

The cloth is then free from oily matter, but not yet bleached, and it must yet pass through a solution of chloride of lime, and then through another solution of hydrochloric acid. These last two operations take but a moment, and they constitute the very crisis of the process; for, if the solutions be too strong, the tissues are burnt, and considerably weakened, a thing of very frequent occurrence. Formerly, the cloth used to be bleached in the sun; but this tedious and costly process, where the present one requires only a few days, took up weeks, and yet did not bleach the fabric so thoroughly.

Next the white cloth is sent to the printer, who gives it the figures desired. At first plates of wood with the figures in relief were employed in the printing; this was the infancy of the art. Later, plates of copper were used, having the figures cut into their surface; this was a step in advance. Finally the English, whose industrial genius is most fruitful of useful applications, originated the idea of printing with copper cylinders, beneath which the cloth would pass, receiving impressions *ad infinitum.*

Dupasquier introduced from England into the Continent this beautiful invention, which is even yet in process of improvement. From that moment printed cottons grew ever cheaper, although the printing was executed far better than formerly; and the fall in prices became simply enormous when machinery took the place of human hands. Then calico came into universal use, without, however, superseding textures of hemp and flax, which were still employed for table and body linen; it was only at a later day, and when prices were still further reduced, that the less opulent classes began to wear muslin instead of linen. This example was soon followed by the wealthy classes, who little suspected the snare that they were walking into, nor understood that, in substituting cotton for flax and hemp, they were selling out to America one of our most abundant sources of wealth, and of agricultural and industrial prosperity.

Such was the state of the textile market in Europe, when the United States war broke out; a war brought about by Palmerston, who wished England to receive the 1,200,000,000 francs annually paid by Europe for cotton. We know too well how far he was successful in his hateful design; for, ever since that time the East Indies share with the United States in the privilege of carrying off our millions, under the pretext of selling us cotton. Never was there a more perfect act of piracy; never was piracy better organized than this, or more kindly received, to our shame be it said.

As now the price of cotton was increased, muslin was rejected, and fabrics of hemp and flax used instead; for the latter textures could be had for the same price as cotton goods, while they were of far better quality. Then it was that certain ingenious swindlers conceived the idea of weaving the threads wider apart, so as to yield an increase of 25 per cent. of cloth, with the same amount of cotton; and, to conceal this base fraud, recourse was had to a paste of starch, soap, and pipe-clay, stopping up thus the interstices, and giving the article the appearance of a first-class fabric.

This abominable invention once introduced, cotton fabrics fell to their former price, and found a market. During the ten years which have passed away since public credulity was first duped in this way, every one has to his cost learned of the trick. Hence I suppose I am addressing an audience already convinced; and I repeat again my advice, Buy only linen.

Textures intended for printing were deteriorated in the same proportion, and hence it became very difficult to print or to wash them, and they had to be heavily starched in order to find purchasers, so flimsy were they. But people soon quit using them, and bought mixed textures of wool and cotton, or wool and linen, which came into fashion, and which gave such satisfaction that they will not again be laid aside.

We now come to speak of the lighter tissues—the finest grades of muslin, jaconets, and organdies.

All these tissues are very costly, because they require cotton of the best quality, and it is upon these that the manufacturer of printed goods displays all his artistic skill—all the magic of design. He stops at nothing, for these brilliant artistic effects give him a reputation, and serve as a letter of introduction for his products. I have seen as many as thirty-five different colors, or shades of color, in the large bouquets printed on certain fabrics. But, like natural flowers, these printed flowers quickly fade.

Only the very costliest of textures are now printed by hand—that process being so tedious and so difficult that but few workmen are qualified to perform it. The printing, therefore, is usually done by means of a roller of copper or brass. This roller has the figures cut into its surface either directly by the burin, or by an acid; or, as is more usual, it gets the required impress from the *molette*. Engraving with the burin being very costly, it is employed only in the manufacture of the very choicest fabrics. Engraving with acid is done as follows: The roller is first coated with asphaltum, and on this is counter-drawn with the burin the figure required. The burin may be worked by hand, or may be guided by means of a pantograph. The figure having been thus traced on the roller, the latter is plunged into a bath of nitric acid, which cuts into the metal at all points where the asphalt coating has been displaced. Finally, the asphalt is washed off with essence of turpentine.

But the figures are usually produced on the roller by means of the *molette*. This is a small cylinder of steel, into the surface of which the engraver first cuts the design. This cylinder then gives to another an impress in relief; and, finally, from this latter a concave impress is taken on the large copper roller of the printing-press. It is plain that as many rollers will be required as there are colors to print; and, owing to the difficulty of preventing the colors running into one another, not more than four are commonly employed—black, red, rose, and violet; or black, brown, red, and cashew. In twelve hours, 100 to 120 pieces, of 50 yards each, may be printed in one color, though not more than 60 to 80 could be printed in four.

The capital employed in the manufacture of printed goods of mixed fibre is enormous, and yields a large return. This manufacture gives also good remuneration to the operatives, and there is every reason why it should be as zealously fostered as the manufacture and employment of muslins and calicoes are to be discouraged, as tending to draw off to America all the wealth of Europe.

THE PHYSIOLOGICAL POSITION OF TOBACCO.

BY W. E. A. AXON, M.R.S.L.

IN speaking of the physiological position of tobacco, we have to deal with the action of the essential principles of that plant upon the human system. The peculiar effects of tobacco are due to the action of the essential oil of tobacco in the case of chewing and snuffing, and to that combined with the empyreumatic oil in smoking. Nicotine, as this essential principle is called, is so deadly an alkaloid, that the amount of it contained in one cigar, if extracted and administered in a pure state, would suffice to kill two men. According to the experiments of Vohl and Eulenberg, the nicotine is decomposed, in the process of smoking, into pyridine, picoline, and other poisonous alkaloids, which can also be obtained in varying quantities by the destructive distillation of other vegetable substances.

Nicotine, as for convenience we may continue to call the poisonous principles of tobacco, can enter the body through various channels—by the stomach, by the lungs, by subcutaneous injection, and by the skin itself. But, in whatever manner it enters the human system, its effects are, in the main, uniform.

The most immediately noticeable symptom following smoking is the undue acceleration of the laboring forces of the heart. Under the stimulus of tobacco the heart beats more quickly, as is evidenced by the rising pulse. We have not the mass of detailed evidence as to this fact which exists in relation to alcohol, but the experiments made by Dr. Edward Smith, and related to the British Association in 1864, are full of interest. "The experiments were made at 10 P. M., when the rate of pulsation naturally declines (as he had proved by hourly experiments published in his work on the 'Cyclical Changes of the Human System'), and at least four hours after any fluid or solid food had been taken. They were made in the sitting posture, after it had been maintained fifteen minutes, and with the most absolute quietude of body and mind; and thus all influences were eliminated but those due to the tobacco. The rate of the pulsation was taken every minute for a period beginning two or three minutes before the smoking began, and continuing during twenty minutes, or until the pipe was exhausted.

The following are the chief results obtained:

EXPERIMENT 1.

Pulsation before smoking was 74½ per minute.

Smoking 6 minutes—79, 77, 80, 78, 78, 77 per minute=78.1 average.

Smoking 7 minutes—83, 87, 88, 94, 98, 102, 102 per minute = 93.4 average.

Smoking 8 minutes—105, 105, 104, 105, 105, 107, 107, 110 per minute = 106 average.

After smoking 11 minutes—112, 108, 107, 101, 101, 100, 100, 100, 100, 98, and 91.

There was thus a maximum increase of 37½ pulsations per minute.

EXPERIMENT 2.

(Smoking through camphor julep in a hookah.)

Pulsation before smoking, 79½ per minute.

Smoking 6 minutes—81, 81, 81, 83, 82, 82 per minute = 81.6 average.

Smoking 17 minutes—85, 89, 89, 93, 96, 90, 94, 94, 93, 92, 95, 95, 95 96, 94, 97, 93 = 93.

The maximum increase was 17½ pulsations per minute.

EXPERIMENT 3.

(Smoking an empty pipe.)

Pulsation before smoking, 78 pulsations per minute.

Smoking 11 minutes—76, 78, 77, 76, 79, 79, 80, 80, 79, 78, and 79.

There was no increase in the rate of pulsations from the effort of smoking, or from its interference with the respiration.

EXPERIMENT 4.

(To ascertain if, after smoking 6 minutes, during which the effect is very small, and then ceasing smoking, any increase in the effect would follow.)

Pulsation before smoking, 75 pulsations per minute.
Smoking 6 minutes—76, 75, 79, 79, 76, 78.
Smoking 1 minute—82. Cease smoking.
Smoking 10 minutes—81, 88, 83, 82, 84, 83, 83, 80, 82.

The rate of pulsations was maintained, but was not materially increased.

EXPERIMENT 5.

(To prove if the rapidity of smoking causes a variation in increase of pulsation.)

a. Greater volume of smoke.

Pulsation before smoking, 70½ per minute.
Smoking 6 minutes—68, 70, 71, 70, 72, 74 = 70.8 average.
Smoking 6 minutes—76, 77, 86, 89, 91, 94 = 85.5 average.
Smoking 4 minutes—98, 95, 96, 95 = 96.0 average.

The maximum effect was thus 27½ pulsations per minute.

b. Smoking faster.

Pulsation of the last minute in the previous part of this experiment, viz., 95 per minute—smoking 3 minutes, 94, 49, 96.

c. The pipe recharged.

Smoking 5 minutes—87, 93, 96, 96, 96.

There was, therefore, a large effect upon the pulsation, but probably not more than would have occurred with ordinary smoking.

Numerous other experiments were made with tobaccos of different reputed strengths and upon different persons, and the author gave minute directions as to the proper method of making such inquiries."

The heart, then, during the act of smoking, was doing extra work; in some of the experiments this additional labor amounting to more than 50 per cent.

The effect upon the heart is not caused by direct action upon that organ, but by paralyzing the minute vessels which form the batteries of the nervous system. Thus paralyzed, they can no longer offer effectual resistance, and the heart, freed from their control, increases the rapidity of its strokes, expanding the vessels, with an apparent accession, but real waste of force.

Its effect in lowering the animal temperature is very striking. When the walls of the blood-vessels are distended with that fluid, the increase in volume decreases the rapidity of the circulation and augments the local warmth. When the walls partially collapse, the circulation becomes quicker, but the heat diminishes. The heat, in fact, is transformed into motion.

The action of nicotine upon the iris is well known, yet, while some consider it to produce dilatation, others affirm its effect to be contraction. The iris is composed of two orders of muscular tissue. The circular fibres influenced by the *motor oculi*, and the radiating fibres obeying the great sympathetic, perform the two functions of the iris, dilatation and contraction. The stimulation of the third pair of nerves causes a contraction of the pupil; a larger dose of nicotine destroys its susceptibility and dilatation follows, the upper lid falls, strabismus ensues, the eyeball becomes fixed—in short, the motor power of the eye is paralyzed. M. Blatin considers that the muscular fibre of the eye is not at all affected by the poison.

Blatin proposes to divide tobacco-poisoning into two classes, acute and chronic. The first is the result of a large or unaccustomed dose; the second, the accumulative consequences of doses, perhaps small, but continually repeated.

The unpleasant experiences of the first pipe will enable most smokers to understand the nature of this acute poisoning. Children have even been made ill by sucking at pipes, empty, but already coated with tobacco-juice. Sometimes a very slight dose exercises a fatal effect upon systems in which tolerance has not been established. Thus a youth of fourteen, having smoked fifteen cents' worth of tobacco as a remedy for toothache, fell down senseless and died the same evening.[1] Blatin also tells us of a medical student, aged twenty-two, who, after smoking a single pipe, fell into a frightful state—the heart became nearly motionless, the chest constricted, his breathing was extremely painful, the limbs contracted, the pupils insensible to light, one dilated, the other contracted. These symptoms gradually lessened, but did not disappear until four days after.[2]

But it is chronic nicotism which has the greatest interest for us. The poisonous effects of tobacco in larger doses are too evident for denial, and need scarcely be insisted upon. Far more important is it to learn whether tobacco, in the quantities daily consumed by its habitual users, has a permanently injurious effect upon the human system.

It is often only after a number of years that nicotic symptoms appear, as though the poison acted by a process of accumulation, until the system was charged to satiety. And thus any thing which disturbs the equilibrium of the functions, and so diminishes the elimination of the poison, may give rise to morbid phenomena.

There is a theory not unknown, even among medical men, that the toxic influences of tobacco are only transitory, and that all the poison is ultimately expelled from the system. But it is certain, from an experiment of M. Morin,[3] that the nicotine can be detected in the tissues of the lungs and liver after death.

M. Blatin regards the various local affections as trifling, when compared with the gradual saturation of the system with nicotine, which, accumulating in the tissues, waits for the opportunity, varying, according to individual habits and constitution, of declaring its poisonous nature.

The trembling, which is one of the usual symptoms of acute, is

[1] Druhen, p. 44. [2] Blatin, p. 76.

[3] Year Book of Medicine (New Sydenham Society), 1861, p. 447, and Blatin, p. 93.

also a common result of chronic, nicotism. A very distinguished Parisian physician had hands which shook so much that he could not write. Whenever he remained without tobacco for any length of time, these tremblings disappeared. Another case mentioned by Blatin is noteworthy. A man of forty-five years consulted him respecting violent and numerous attacks of vertigo. When he felt one of them approaching, he was obliged to lie down wherever he might be, in order to avoid falling. In the country, where he had plenty of exercise, they were less frequent than in the town, where his occupation was sedentary. Cessation from tobacco and a tonic regimen quickly restored him.

A physician of fifty-two was afflicted with similar disagreeable symptoms, and was also cured by abstinence. Habit had become so strong that he could not resist at times the temptation to slight indulgence. Finding that these returns to tobacco were immediately followed by his old painful attacks, he renounced it forever.

The circulatory system presents in chronic nicotism similar symptoms to those found in acute poisoning. The most noticeable of these is the intermittent pulse, of which many cases have been collected by Decaisne and others.

Decaisne speaks of narcotism of the heart, but Blatin does not consider the action to be directly upon that organ, but considers the effects described to result from an irregular relaxation of the ganglia of the great sympathetic nerve.

When a person suffering from intermittent pulse was carefully examined, Blatin found the stoppage in the heart's beat followed a series of apparently normal movements. The systole and diastole succeeded in due regularity, and nothing in the play of the central organ indicated trouble, when the heart suddenly stopped in diastole, sometimes for the space of three arterial pulsations. When it awakens from this syncope its action is abnormally quick, as if it wished to make up for the lost time, and force the mass of blood across the organs at one stroke. But, with force insufficient for this purpose, it is exhausted in fruitless efforts, hesitates, wavers, acquires fresh power, commences again, now violent, now feeble, and fulfils very imperfectly the duties which it should perform. Gradually it calms; a foreign element seems to appease the tumult, the heart again becomes regular. The explanation appears to be that the irritation of the sympathetic nerve stops short the movements of the heart, and thus causes the intermittence; then the susceptibility of the nerve is lessened or paralyzed, and the cardiac functions are left to the sole direction of the auto-motor ganglia; hence the disordered beats, which decrease as the nervous force coming afresh from the pneumogastric moderates and regularizes it.

From intermittent pulse to angina pectoris the distance is not far. That tobacco may produce all the usual symptoms of that painful disease has been abundantly shown by Beau. To the cases which he has cited may be added an epidemic of this nature noted by M. Gelineau, with which a great part of the crew of the Embuscade were struck. The patients were all great smokers. It is worthy of notice that this disease is much more common among men than women.

Difficulty of breathing approaching asthma has also been recorded. Blatin gives a case of a young officer whose asthma could be attributed to no other cause, and who was cured by a simple abstinence and tonic medicines.[1]

Tobacco, acting upon the cardiac and pulmonary branches of the pneumogastric, is not likely to leave untouched its gastric terminations. In an animal under the influence of small doses of nicotine the gastric juice is secreted with increased rapidity, and the action of the walls of the stomach is more noticeable. With strong doses or long-continued usage this secretion is very considerably diminished, and the peristaltic motion enfeebled. That is to say, the tobacco acts upon the pneumogastric, excites it in small, and paralyzes it in large, doses. The smoker takes his after-dinner pipe or cigar to aid digestion. Undoubtedly, it excites the par vagum, increases the gastric secretion, and accelerates the peristaltic motion. Undoubtedly, also, this daily stimulation enfeebles the nerve, and digestion becomes more difficult. The swing back from the excitement causes a reaction, which only an increase in the doses can overcome. The nerve is partially paralyzed. The appetite fails, nutrition is impeded, dyspepsia reigns conqueror.

A military man of thirty-seven years fell into a consumption without any other affection antecedent or concomitant than distaste for food, and salivation. Dr. Roques, after various essays, learned that he was a great user of tobacco, which had led to a sort of chronic fluxion of the salivary glands, and an almost total cessation of the digestive functions, and consequently caused the feeble and consumptive state into which he had fallen. Gradual diminution and ultimate abandonment of tobacco led to a cure in about three months.[2]

The influence of tobacco upon vision is well known. One of the symptoms produced in acute nicotism is blindness, and chronic nicotism gives rise to similar affections. Thus Mackenzie found that patients afflicted with amaurosis were mostly lovers of tobacco in some form. Sichel found cases of complete amaurosis, which, incurable by other means, were easily conquered by cessation from the weed. Hutchinson found, out of thirty-seven patients, twenty-three were inveterate smokers. The observations of Wordsworth and others have so clearly established the fact that the continued excitement of the optic nerve by tobacco sometimes produces amaurosis, that it is now generally cited in text-books as one of the causes of that disease.

We have completed our brief examination of the physiological ac-

[1] Blatin, p. 159, from l'Abeille Méd., t. iii., 1846.

[2] Ibid., p. 265, from Mémoire de Med., et de Chir. Prat., t. v.

tion of tobacco, but in concluding it may be well to point to some portions of the evidence which are especially noteworthy.

The fact that tobacco reduces the animal temperature is an important one. It shows the fallacy of those who smoke to keep the cold out, and proves conclusively that tobacco is neither a generator nor conserver of vital heat, but, on the contrary, a wasteful destroyer of it.

The influence of tobacco, in liberating the heart from those restraints which regulate its healthy action, naturally leads to the conclusion that in frequent doses that organ must, sooner or later, undergo a structural transformation. Although when thus excited it has less pressure to overcome than when in a normal condition, yet the extra exertion cannot but be evil in its results, since it causes an irregularity in the supply of blood, and thus degrades tissue.

Tobacco belongs to the class of narcotic and exciting substances, and has no food-value. Stimulation means abstracted, not added, force. It involves the narcotic *paralysis* of a portion of the functions, the activity of which is essential to healthy life.

It will be said that tobacco soothes and cheers the weary toiler, and solaces the overworked brain. Such may be its momentary effects, but the *sequelæ* cannot be ignored. All such expedients are fallacious. When a certain amount of brain-work or hand-work has been performed, Nature must have space in which to recuperate, and all devices for escaping from this necessity will fail. It is bad policy to set the house on fire to warm our hands by the blaze. Let it, then, be clearly understood that the temporary excitement produced by tobacco is gained by the destruction of vital force, and that it contains absolutely nothing which can be of use to the tissues of the body.

Tobacco adds no potential strength to the human frame. It may spur a weary brain or feeble arm to undue exertion for a short time, but its work is destructive, not constructive. It cannot add one molecule to the plasm out of which our bodies are daily built up. On the contrary, it exerts upon it a most deleterious influence. It does not supply, but diminishes, vital force.

It has been denied that tobacco leads to organic disease, but the evidence is very strong the other way, and it would be very remarkable if continued functional derangement did not ultimately lead to chronic derangement of the organs; that it causes functional disturbance no one dreams of denying; indeed, it has been remarked that no habitual smoker can be truly said to have a day's perfect health.—*Abstract from the Quarterly Journal of Science.*

AIMS AND INSTRUMENTS OF SCIENTIFIC THOUGHT.

By Professor W. KINGDON CLIFFORD,
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II.

I WANT, in the next place, to consider what we mean when we say that the uniformity which we have observed in the course of events is *reasonable* as well as exact.

No doubt the first form of this idea was suggested by the marvellous adaptation of certain natural structures to special functions. The first impression of those who studied comparative anatomy was, that every part of the animal frame was fitted with extraordinary completeness for the work that it had to do. I say extraordinary, because at the time the most familiar examples of this adaptation were manufactures produced by human ingenuity; and the completeness and minuteness of natural adaptations were seen to be far in advance of these. The mechanism of limbs and joints was seen to be adapted, far better than any existing iron-work, to those motions and combinations of motion which were most useful to the particular organism. The beautiful and complicated apparatus of sensation caught up indications from the surrounding medium, sorted them, analyzed them, and transmitted the results to the brain in a manner with which, at the time I am speaking of, no artificial contrivance could compete. Hence the belief grew among physiologists that every structure which they found must have its function and subserve some useful purpose; a belief which was not without its foundation in fact, and which certainly (as Dr. Whewell remarks) has done admirable service in promoting the growth of physiology. Like all beliefs, found successful in one subject, it was carried over into another, of which a notable example is given in the speculations of Count Rumford about the physical properties of water, to which the President has already called your attention. Pure water attains its greatest density at a temperature of about 39½° Fahr.; it expands and becomes lighter whether it is cooled or heated, so as to alter that temperature. Hence it was concluded that water in this state must be at the bottom of the sea, and that by such means the sea was kept from freezing all through; as it was supposed must happen if the greatest density had been that of ice. Here, then, was a substance whose properties were eminently adapted to secure an end essential to the maintenance of life upon the earth. In short, men came to the conclusion that the order of Nature was reasonable in the sense that every thing was adapted to some good end.

Further consideration, however, has led men out of that conclusion in two different ways: First, it was seen that the facts of the case had been wrongly stated. Cases were found of wonderfully complicated structures that served no purpose at all; like the teeth of that whale of which you heard in Section D the other day, or of the Dugong, which has a horny palate covering them all up and used instead of them; like the eyes of the unborn mole, that are never used, though perfect as those of a mouse until the skull-opening closes up, cutting them off from the brain, when they dry up and become incapable of use; like the outsides of your own ears, which are absolutely of no use to you. And when human contrivances were more advanced it became clear that the natural adaptations were subject to criticism. The eye, regarded as an optical instrument of human manufacture, was thus described by Helmholtz—the physiologist who learned physics for the sake of his physiology, and mathematics for the sake of his physics, and is now in the first rank of all three. He said, "If an optician sent me that as an instrument, I should send it back to him with grave reproaches for the carelessness of his work, and demand the return of my money."

The extensions of the doctrine into physics were found to be still more at fault. That remarkable property of pure water, which was to have kept the sea from freezing, does not belong to salt-water, of which the sea itself is composed. It was found, in fact, that the idea of a reasonable adaptation of means to ends, useful as it had been in its proper sphere, could yet not be called universal, or applied to the order of Nature as a whole.

Secondly, this idea has given way because it has been superseded by a higher and more general idea of what is reasonable, which has the advantage of being applicable to a large portion of physical phenomena besides. Both the adaptation and the non-adaptation which occur in organic structures have been *explained*. The scientific thought of Dr. Darwin, of Mr. Herbert Spencer, and of Mr. Wallace, has described that hitherto unknown process of adaptation as consisting of perfectly well-known and familiar processes. There are two kinds of these: the direct processes, in which the physical changes required to produce a structure are worked out by the very actions for which that structure becomes adapted—as the backbone or notocord has been modified from generation to generation, by the bendings which it has undergone; and the indirect processes, included under the head of Natural Selection—the reproduction of children slightly different from their parents, and the survival of those which are best fitted to hold their own in the struggle for existence. Naturalists might give you some idea of the rate at which we are getting explanations of the evolution of all parts of animals and plants—the growth of the skeleton, the nervous system and its mind, of leaf and flower. But what, then, do we mean by *explanation?*

We were considering just now an explanation of a law of gases—the law according to which pressure increases in the same proportion in which volume diminishes. The explanation consisted in supposing that a gas is made up of a vast number of minute particles always flying about and striking against one another, and then showing that the rate of impact of such a crowd of particles on the sides of the vessel containing them would vary exactly as the pressure is found to vary. Suppose the vessel to have parallel sides, and that there is only one particle rushing backward and forward between them; then it is clear that if we bring the sides together to half the distance, the particle will hit each of them twice as often, or the pressure will be doubled. Now, it turns out that this would be just as true for millions of particles as for one, and when they are flying in all directions instead of only in one direction and its opposite; provided only that they interfere with each other's motion. Observe, now: it is a perfectly well-known and familiar thing that a body should strike against an opposing surface and bound off again; and it is a mere every-day occurrence that what has only half so far to go should be back in half the time; but that pressure should be strictly proportional to density is a comparatively strange, unfamiliar phenomenon. The explanation describes the unknown and unfamiliar as being made up of the known and the familiar; and this, it seems to me, is the true meaning of explanation.[1]

Here is another instance: If small pieces of camphor are dropped into water, they will begin to spin round and swim about in a most marvellous way. Mr. Tomlinson gave, I believe, the explanation of this. We must observe, to begin with, that every liquid has a skin which holds it; you can see that to be true in the case of a drop, which looks as if it were held in a bag. But the tension of this skin is greater in some liquids than in others; and it is greater in camphor-and-water than in pure water. When the camphor is dropped into water, it begins to dissolve and get surrounded with camphor-and-water instead of water. If the fragment of camphor were exactly symmetrical, nothing more would happen; the tension would be greater in its immediate neighborhood, but no motion would follow. The camphor, however, is irregular in shape; it dissolves more on one side than the other; and consequently gets pulled about, because the tension of the skin is greater where the camphor is most dissolved. Now, it is probable that this is not nearly so satisfactory an explanation to you as it was to me when I was first told of it; and for this reason: By that time I was already perfectly familiar with the notion of a skin upon the surface of liquids, and I had been taught by means of it to work out problems in capillarity. The explanation was therefore a description of the unknown phenomenon which I did not

[1] This view differs from those of Mr. J. S. Mill and Mr. Herbert Spencer, in requiring every explanation to contain an addition to our knowledge about the thing explained. Both those writers regard subsumption under a general law as a species of explanation. *See* also Ferrier's "Remains," vol. ii., p. 436.

know how to deal with as made up of known phenomena which I did know how to deal with. But to many of you possibly the liquid skin may seem quite as strange and unaccountable as the motion of camphor on water.

And this brings me to consider the source of the pleasure we derive from an explanation. By known and familiar I mean that which we know how to deal with, either by action in the ordinary sense, or by active thought. When, therefore, that which we do not know how to deal with is described as made up of things that we do know how to deal with, we have that sense of increased power which is the basis of all higher pleasures. Of course, we may afterward by association come to take pleasure in explanation for its own sake. Are we, then, to say that the observed order of events is reasonable, in the sense that all of it admits of explanation? That a process may be capable of explanation, it must break up into simpler constituents which are already familiar to us. Now, first, the process may itself be simple, and not break up; secondly, it may break up into elements which are as unfamiliar and impracticable as the original process.

It is an explanation of the moon's motion to say that she is a falling body, only she is going so fast and is so far off that she falls quite round to the other side of the earth, instead of hitting it; and so goes on forever. But it is no explanation to say that a body falls because of gravitation. That means that the motion of the body may be resolved into a motion of every one of its particles toward every one of the particles of the earth, with an acceleration inversely as the square of the distance between them. But this attraction of two particles must always, I think, be less familiar than the original falling body, however early the children of the future begin to read their Newton. Can the attraction itself be explained? Le Sage said that there is an everlasting hail of innumerable small ether-particles from all sides, and that the two material particles shield each other from this, and so get pushed together. This is an explanation; it may or may not be a true one. The attraction may be an ultimate simple fact; or it may be made up of simpler facts utterly unlike any thing that we know at present; and in either of these cases there is no explanation. We have no right to conclude, then, that the order of events is always capable of being explained.

There is yet another way in which it is said that Nature is reasonable; namely, inasmuch as every effect has a cause. What do we mean by this?

In asking this question we have entered upon an appalling task. The word represented by "cause" has sixty-four meanings in Plato, and forty-eight in Aristotle. These were men who liked to know as near as might be what they meant; but how many meanings it has had, in the writings of the myriads of people who have not tried to know what they meant by it, will, I hope, never be counted. It would not only be the height of presumption in me to attempt to fix the meaning of a word which has been used by so grave authority in so many and various senses; but it would seem a thankless task to do that once more which has been done so often at sundry times and in divers manners before. And yet without this we cannot determine what we mean by saying that the order of Nature is reasonable. I shall evade the difficulty by telling you Mr. Grote's opinion.[1] You come to a scarecrow and ask, "What is the cause of this?" You find that a man made it to frighten the birds. You go away and say to yourself: "Every thing resembles this scarecrow. Every thing has a purpose." And from that day the word "cause" means for you what Aristotle meant by "final cause." Or you go into a hair-dresser's shop, and wonder what turns the wheel to which the rotatory brush is attached. On investigating other parts of the premises, you find a man working away at a handle. Then you go away and say: "Every thing is like that wheel. If I investigated enough I should always find a man at a handle." And the man at the handle, or whatever corresponds to him, is henceforth known to you as "cause."

And so generally. When you have made out any sequence of events to your entire satisfaction, so that you know all about it, the laws involved being so familiar that you seem to see how the beginning must have been followed by the end, then you apply that as a simile to all other events whatever, and your idea of cause is determined by it. Only when a case arises, as it always must, to which the simile will not apply, you do not confess to yourself that it was only a simile and need not apply to every thing, but you say, "The cause of that event is a mystery which must remain forever unknown to me." On equally just grounds, the nervous system of my umbrella is a mystery which must remain forever unknown to me. My umbrella has no nervous system; and the event to which your simile did not apply has no cause in your sense of the word. When we say, then, that every effect has a cause, we mean that every event is connected with something in a way that might make somebody call that the cause of it. But I, at least, have never yet seen any single meaning of the word that could be fairly applied to the *whole* order of Nature.

From this remark I cannot even except an attempt recently made by Mr. Bain to give the word a universal meaning, though I desire to speak of that attempt with the greatest respect. Mr. Bain[2] wishes to make the word "cause" hang on in some way to what we call the law of energy; but, though I speak with great diffidence, I do think a careful consideration will show that the introduction of this word "cause" can only bring confusion into a matter which is distinct and clear enough to those who have taken the trouble to understand what energy means. It would be impossible to explain that this evening; but I may mention that "energy" is a technical term out of mathe

[1] Plato, vol. ii. (Phædon). [2] "Inductive Logic," chap. iv.

matical physics, which requires of most men a good deal of careful study to understand it accurately.

Let us pass on to consider, with all the reverence which it demands, another opinion, held by great numbers of the philosophers who have lived in the brightening ages of Europe: the opinion that, at the basis of the natural order, there is something which we can know to be *unreasonable*, to evade the processes of human thought. The opinion is set forth first by Kant, so far as I know, in the form of his famous doctrine of the antinomies or contradictions, a later form[1] of which I will endeavor to explain to you. It is said, then, that space must either be infinite or have a boundary. Now, you cannot conceive infinite space; and you cannot conceive that there should be any end to it. Here, then, are two things, one of which must be true, while each of them is inconceivable; so that our thoughts about space are hedged in, as it were, by a contradiction. Again, it is said that matter must either be infinitely divisible, or must consist of small particles incapable of further division. Now, you cannot conceive a piece of matter, divided into an infinite number of parts, while, on the other hand, you cannot conceive a piece of matter, however small, which absolutely cannot be divided into two pieces; for, however great the forces are which join the parts of it together, you can imagine stronger forces able to tear it in pieces. Here, again, there are two statements, one of which must be true, while each of them is separately inconceivable; so that our thoughts about matter also are hedged in by a contradiction. There are several other cases of the same thing, but I have selected these two as instructive examples. And the conclusion to which philosophers were led by the contemplation of them was, that on every side, when we approach the limits of existence, a contradiction must stare us in the face. The doctrine has been developed and extended by the great successors of Kant; and this unreasonable, or unknowable, which is also called the absolute and the unconditioned, has been set forth in various ways as that which we know to be the true basis of all things. As I said before, I approach this doctrine with all the reverence which should be felt for that which has guided the thoughts of so many of the wisest of mankind. Nevertheless, I shall endeavor to show that, in these cases of supposed contradiction, there is always something which we do not know now, but of which we cannot be sure that we shall be ignorant next year. The doctrine is an attempt to found a positive statement upon this ignorance, which can hardly be regarded as justifiable. Spinoza said, "A free man thinks of nothing so little as of death;" it seems to me we may parallel this maxim in the case of thought, and say, "A wise man only remembers his ignorance in order to destroy it." A boundary is that

[1] That of Mr. Herbert Spencer, "First Principles." I believe Kant himself would have admitted that the antinomies do not exist for the empiricist.

which divides two adjacent portions of space. The question, then, "Has space (in general) a boundary?" involves a contradiction in terms, and is, therefore, unmeaning. But the question, "Does space contain a finite number of cubic miles, or an infinite number?" is a perfectly intelligible and reasonable question which remains to be answered by experiment.[1] The surface of the sea would still contain a finite number of square miles, if there were no land to bound it. Whether or no the space in which we live is of this nature remains to be seen. If its extent is finite, we may quite possibly be able to assign that extent next year; if, on the other hand, it has no end, it is true that the knowledge of that fact would be quite different from any knowledge we at present possess, but we have no right to say that such knowledge is impossible. Either the question will be settled once for all, or the extent of space will be shown to be greater than a quantity which will increase from year to year with the improvement of our sources of knowledge. Either alternative is perfectly conceivable, and there is no contradiction. Observe especially that the supposed contradiction arises from the assumption of theoretical exactness in the laws of geometry. Now, the other case that I mentioned has a very similar origin. The idea of a piece of matter the parts of which are held together by forces, and are capable of being torn asunder by greater forces, is entirely derived from the large pieces of matter which we have to deal with. We do not know whether this idea applies in any sense to the *molecules* of gases even; still less can we apply it to the *atoms* of which they are composed. The word "force" is used of two phenomena: the pressure, which when two bodies are in contact connects the motion of each with the position of the other; and attraction or repulsion; that is to say, a change of velocity in one body depending on the position of some other body which is not in contact with it. We do not know that there is any thing corresponding to either of these phenomena in the case of a molecule. A meaning can, however, be given to the question of the divisibility of matter in this way. We may ask if there is any piece of matter so small that its properties as matter depend upon its remaining all in one piece. This question is reasonable; but we cannot answer it at present, though we are not at all sure that we shall be equally ignorant next year. If there is no such piece of matter, no such limit to the division which shall leave it matter, the knowledge of that fact would be different from any of our present knowledge; but we have no right to say that it is impossible. If, on the other hand, there *is* a limit, it is quite possible that we may have measured it by the time the Association meets at Bradford. Again, when we are told that the infinite extent of space, for example, is something that we cannot conceive at present, we may reply that this is only natural, since our experience has never yet supplied us with the

[1] The very important distinction between *unboundedness* and *infinite extent* is made by Riemann, *loc. cit.*

means of conceiving such things. But, then, we cannot be sure that the facts will not make us learn to conceive them; in which case they will cease to be inconceivable. In fact, the putting of limits to human conception must always involve the assumption that our previous experience is universally valid in a theoretical sense; an assumption which we have already seen reason to reject. Now, you will see that our consideration of this opinion has led us to the true sense of the assertion that the order of Nature is reasonable. If you will allow me to define a reasonable question as one which is asked in terms of ideas justified by previous experience, without itself contradicting that experience, then we may say, as the result of our investigation, that to every reasonable question there is an intelligible answer, which either we or posterity may know.

We have, then, come somehow to the following conclusions: By cientific thought we mean the application of past experience to new circumstances, by means of an observed order of events. By saying that this order of events is exact, we mean that it is exact enough to correct experiments by, but we do not mean that it is theoretically or absolutely exact, because we do not know. The process of inference we found to be in itself an assumption of uniformity, and that, as the known exactness of the uniformity became greater, the stringency of the inference increased. By saying that the order of events is reasonable, we do not mean that every thing has a purpose, or that every thing can be explained, or that every thing has a cause; for neither of these is true. But we mean that to every reasonable question there is an intelligible answer, which either we or posterity may know *by the exercise of scientific thought.*

For I especially wish you not to go away with the idea that the exercise of scientific thought is properly confined to the subjects from which my illustrations have been chiefly drawn to-night. When the Roman jurists applied their experience of Roman citizens to dealings between citizens and aliens, showing by the difference of their actions that they regarded the cicumstances as essentially different, they laid the foundations of that great structure which has guided the social progress of Europe. That procedure was an instance of strictly scientific thought. When a poet finds that he has to move a strange new world which his predecessors have not moved; when, nevertheless, he catches fire from their flashes, arms from their armory, sustentation from their footprints, the procedure by which he applies old experience to new circumstances is nothing greater or less than scientific thought. When the moralist, studying the conditions of society and the ideas of right and wrong which have come down to us from a time when war was the normal condition of man and success in war the only chance of survival, evolves from them the conditions and ideas which must accompany a time of peace, when the comradeship of equals is the condition of national success—the process by which he does this is scientific thought and nothing else. Remember, then, that it is the guide of action; that the truth which it arrives at is not that which we can ideally contemplate without error, but that which we may act upon without fear; and you cannot fail to see that scientific thought is not an accompaniment or condition of human progress, but human progress itself. And for this reason the question what its characters are, of which I have so inadequately endeavored to give you some glimpse, is the question of all questions for the human race. —*Advance-sheets from Macmillan.*

INTRODUCTION TO "THE GREAT PROBLEM."[1]

By HOWARD CROSBY, D. D., LL. D.,

CHANCELLOR OF THE UNIVERSITY OF NEW YORK.

THE royal Psalmist said, "The heavens declare the glory of God, and the firmament showeth his handy work." The modern Huxleys respond: "The heavens declare nothing at all, and the firmament is ultimately but eternal protoplasm." In this happy and hopeful response the materialists are as much traitors to science as enemies to religion. They *ignore all the facts of mind.* This whole department of cognitions is neglected in arranging their premises. The very first canon of science is thus violated, which demands that *all* facts be collated as data. Then, a second fallacy of which they are guilty is, *leaving scientific proof and leaping, by the imagination, to the conclusion that life is merely matter.* They find an ultimate matter (only ultimate, however, owing to the limited power of the microscope), and straightway say, "This is *life*," although it is known to exist without life, and has not a single characteristic of life in it. By such unscientific methods these scientific men, whose names are now so famous, have imposed upon the unlearned and credulous, and made men lose their faith in the eternal truths of God. Darwinism is another form of the same infidelity, working its evil by the same unscientific methods. Darwin leaps to his conclusions against every axiom of science, and Darwinism is, instead of science, mere theory. Science and Religion are at one. They both come from God and lead to God. "The heavens declare the glory of God," and "the statutes of the Lord are right, rejoicing the heart," are accordant strings of the same harp.

We need sensible and learned men to come forward and show the

[1] "The Great Problem: The Higher Ministry of Nature viewed in the Light of Modern Science; and as an Aid to Advanced Christian Philosophy." By John R. Leifchild, A. M., Author of "Our Coal-Fields and our Coal-Pits," "Cornwall; its Mines and Miners," etc., etc., with an Introduction by Howard Crosby, D. D., LL. D., Chancellor of the University of New York. 543 pages. G. P. Putnam & Sons.

world what fools these pseudo-scientists are, and thus break the spell, which is as groundless as the Cock-lane Ghost, but which holds so many all-agape at their fantastic tricks.

Mr. Leifchild's book is popular, and yet sound and thoughtful. Its style is terse and clear. He represents the materialists and pantheists (the extremes are one) with fairness, and exposes the core of their absurdities, showing the higher ministry of Nature in declaring the glory of God, vindicating the equal authority of our intuitions and our senses, and the separateness, yet intimate connection, of mind and matter. It is a book that should find its way to every parlor, where the materialistic poison has been scattered, to straighten and strengthen the weak knees, and give color to the pallid cheek, letting the light upon the frightful spectre, and showing it to be but a man of straw. It is high time that this buffoonery in the name of science were played out. Scientific and religious men must join to put out the intruder, with a brand upon his back. To hold serious talk with him is only to set him up in his assumption. Mr. Leifchild's book exposes him to the world, pulls off the lion's skin, and turns the public fear into laughter. Let the voice of Truth be heard through a thousand such books, and the cant of materialism shrink into silence.

FOUL AIR AND DISEASE OF THE HEART.

By CORNELIUS BLACK, M. D. Lond., M. R. C. P.

IF the question were asked, "Which side of the heart is the more frequently affected by disease?" the answer, in perhaps nine cases out of ten, would be, the left. This answer would not, however, embrace the whole truth. It would be true of the aggregate of cases of cardiac disease without reference to age; but it would be untrue if the occurrence of cardiac disease were referred to the later periods of life. If a man lives to the age of forty years without having suffered from cardiac disease, and, if after that period the heart becomes affected, the mischief will, as a rule, be found to exist on the *right* side. If, on the contrary, cardiac disease should occur before that age, the disease will, almost invariably, be found to exist on the *left* side. Hence, it follows that the right side of the heart is the seat of cardiac disease occurring after middle age—the left side of the heart the seat of cardiac disease occurring before middle age.

As in time, so it is with respect to the nature of the diseases which affect the right and left sides of the heart respectively. Those of the right side are the result of tissue-degeneration, or of mere mechanical influences; those of the left side are almost invariably the product of inflammation. The former are diseases which tend to widen the valvular apertures, and to dilate the right side of the heart; the latter are diseases which tend to contract the valvular apertures, and to increase the size and bulk of the left side of the heart.

Disease of the right side of the heart is essentially passive and secondary in its character; disease of the left side of the heart is essentially active and primary in its character. I speak now of disease when it occurs, not when it has existed for some time. Active inflammation of the left chambers of the heart arises; it progresses to a certain extent; treatment subdues it; the patient recovers; but a certain amount of damage is left behind. Years pass on; the patient during this time appears none the worse for his previous illness; but at length pulmonary symptoms suddenly manifest themselves, and then it is that the physician discovers that the left side of the heart is permanently damaged, and that the present condition of the lungs is traceable to this cause.

In this instance the mischief in the heart inducing this condition of the lungs is not, strictly speaking, active. The first step of the cardiac disease was active; but the second step was chronic. Bit by bit—increment by increment—after the patient's apparent recovery from the primary attack, is the valvular lesion left by such attack added to, not perhaps constantly, but intermittingly, until at length the aggregate increments of addition so hamper, oppress, obstruct, and distort the mitral, or the mitral and aortic valves, that secondary consequences begin to follow.

Why are the affections of the two sides of the heart essentially different in their nature? Why do those of the left side of the heart point to an inflammatory origin; those of the right side of the heart, with but few exceptions, to a non-inflammatory origin? There must be some cause for this difference. What is it? The reason is found in the difference which exists between the constitution of the blood which reaches the left side of the heart from the lungs, and that which reaches the right side of the heart from the general system. The blood reaching the left side of the heart from the lungs has been replenished with all the elements necessary for the growth of the tissues; it has been purified, renovated, and vivified by its oxygenation in the lungs, and it is thus rendered in the highest degree stimulating to the left heart. The blood reaching the right side of the heart from the general system has been deprived, by the requirements of growth, of the chief portion of its nutrient materials; it has been fouled by the *débris* of tissue-waste; it has been further poisoned by its impregnation with carbonic-acid gas: it is therefore a depressant, rather than a healthy excitant, to the right heart. True, it brings with it to the chambers of the right heart the products of the digestion of food; but what are they, either as nutrients or excitants, when they reach that point? They are no more than inert, unusable, passive elements. Not until they have passed to the lungs, and have there received the vivifying influence of oxygen, can they enter into the real composition of the blood, and thus become active, exciting, disposable constituents of it.

"Like begets like" in very many instances. This axiom is true in relation to diseases of the heart. The rich, stimulating blood of the left ventricle urges, feeds, and actively supports any disease which may arise at that point; while the poor, impoverished, fouled, tainted, and attenuated blood which flows through the cavities of the right heart favors disease of a correspondingly low and degenerate character.

So long as the body is rapidly built up and as rapidly pulled down, disease of the left heart maintains an active character; but when the balance between nutrition and waste is destroyed—when nutrition becomes less active, while waste remains the same, or is more active than before—disease of the left heart loses more and more of its active character, and approximates more and more in its nature to disease of the right heart. In many this change begins at the age of forty; in others, not until five or ten years after that period. Thenceforward the tendency to inflammatory disease of the left heart declines—the tendency to degeneration increases. With the gradual declination of the one tendency and the gradual increase of the other, a period is at length reached when active inflammatory disease ceases, as a rule, to affect the left heart. At this juncture the left and right sides of the heart, hitherto dissimilar in their tendencies, are in this respect almost as one. The active tendency of early life has given place to the passive tendency of advancing years—inflammation to degeneration.

Acute rheumatism—a fruitful cause of cardiac disease in the earlier periods of life—is seldom seen beyond the age of fifty. I have, however, attended a case of acute articular rheumatism at the age of seventy-five; but such an instance was an exception to the rule. After fifty, acute rheumatism gives place to a form of rheumatism which slowly produces rigidity of the coats of the blood-vessels, hardens and contracts the tendons, thickens and renders stiff and rigid the ligaments of the joints, hardens and lessens the articular cartilages.

Thus, then, according to a law of Nature, the *ultima linea* of life ends in—degeneration.

Apart from the influence of this law, can any accidental, casual, or avoidable circumstance favor this immutable tendency to degeneration, speaking more particularly in reference to the heart? Yes; many circumstances are daily, hourly, momentarily doing this. Thousands annually perish from heart-disease, whose lives might and would have been prolonged had but proper attention been given to the simple laws of Nature. These laws demand attention to the three great vital functions—the action of the brain and nervous system, respiration, and circulation.

None of these functions must be overworked, as none of them must fall short of their proper duty. Healthy, regular, daily action is their law of life. If the brain and nervous system are overworked, vitality is lowered, the resisting power of the body is diminished, disease is easily produced. If the brain and nervous system are underworked, the generation of nervous power is low and deficient, the vitality of the tissues becomes low in proportion, and disease is easily excited. Overwork exhausts, ruins, kills the body, just as the continued generation of the galvanic current exhausts the acid and wears out the zinc plate. The weakest point of the body has to bear the result of this violation of Nature's laws. If the heart is that point, disease falls upon it, and death before the legitimate term of man's existence is the consequence.

To keep the body in perfect health it must be duly oxygenated. There must be free and ample interchange between the blood in the lungs and the air entering the pulmonary cells. The life-stream must be purified by its elimination of carbonic acid; it must be vivified by the absorption of oxygen. The fulfilment of these conditions demands a full, free, and constant admission of pure air into the lungs. This full, free, and constant admission of pure air cannot be obtained in badly-ventilated houses, crowded buildings, schools as at present constructed, theatres, manufactories, pits, underground railways, and the like.

When the body has reached that age at which natural decay or degeneration has begun, the absence of pure air hastens and increases the degenerative tendency. Where the heart is more prone than other organs to disease, the want of pure air falls with powerful effect upon the tissues of the right heart. Their nutrition is defective by reason of the impurity of the blood with which they are fed, their vital force is lowered, their muscular fibre loses its tonicity, degeneration and debility take the place of active nutrition and power. If in this condition any stress is thrown upon the heart by hurried walking, by lifting, climbing, violent declamation, passional expression, singing, laughing, or by any unusual exercise of the voice, the tricuspid valve gives way, it henceforth fails to close its aperture, and the results of a back-flooding of blood upon the venous system of the body begin to follow. If none of these exciting causes occur, the continued breathing of impure air is followed by constantly-progressing degeneration of the tissues of the valves and muscular structure of the right heart; they become soft and feeble, their atoms shrink; the segments of the tricuspid are at length unable to meet in their attempt to close their aperture; a small chink or slit is left between them; through this the blood finds its way into the auricle above at every contraction of the heart; and soon regurgitation is followed by the secondary consequences produced in the general system—congestion of the liver, stomach, spleen, kidneys, bowels—by hæmorrhoids, general dropsy, and occasionally by cerebral mischief.

I hold that the breathing of impure air is a fruitful source of disease of the right heart occurring after middle age. How many people ignorantly favor its occurrence by confining themselves to closely-shut, non-ventilated, hot, stifling rooms, in which the carbonic acid has accumulated to 2 or 3 per cent. of the air they respire! How many are thus destroyed by being compelled, through the exigencies of life, to pass the greater part of their time in pits and manufactories where ventilation is defective, or in which the air respired is poisoned by noxious fumes and offensive emanations from the materials undergoing the process of manufacture! How many are falling victims to the poisonous influence upon the heart of the atmosphere of an underground railway! What do these facts suggest? How are these evil results to be prevented? The simple answer is—Let the rooms in which you live be effectually ventilated by an incoming current of air filtered from all adventitious impurities, and so divided that no draught shall be felt; and by an outgoing current which shall remove from the apartments the carbonic acid, carbonic oxide, sulphurous-acid gas, sulphuretted hydrogen, and other noxious compounds, as rapidly as they are generated. Apply the same principle to public buildings, theatres, schools, manufactories, pits, and to all places in which people are accustomed to congregate.

As to underground railways, the best plan is to avoid them. True, the time passed in their polluted atmosphere is usually very short; but it is, nevertheless, sufficiently long to paralyze occasionally the heart's action, and always, by its pollution of the blood and by its direct effect upon the nervous system, to favor degeneration of the structures of the heart.

It often occurs to a medical man to visit a patient for the first time, and to find him suffering from a dilated right heart. He may for some short time have been sensible of a change in his breathing on walking rather quickly, or in mounting the stairs, or he may never have felt, or at least recognized, any such sensations. His attention was first arrested by observing that his feet and ankles were swollen, especially at night on going to bed. This sign it is which gives him the first alarm, and which causes him to seek the aid of his physician. An examination of his case detects a dilated right heart, with incompetency of the tricuspid valve. How has this condition of the heart been brought about? There is no history of previous cardiac disease; there has been no illness ushering in the present condition of things; there has never been, nor is there now, any affection of the lungs, and yet the right heart has suffered a lesion fatal to life! The answer is, that every such case has passed the age of forty, that the tissues of the right heart have entered upon the period of degeneration, and that this degeneration has, with very few exceptions, been hastened by the breathing of an impure air, either during the pursuit of the ordinary occupations of life, or in the patient's own dwelling.

When the degeneration of the right heart has progressed to a certain extent, incompetency of the tricuspid valve follows either with or without the aid of an exciting cause. Hence it is easy to understand why dilatation of the right heart and tricuspid incompetency are often found to exist apart from any previous history of cardiac disease.

The third great vital function which influences the degenerative tendency of the heart is that of the circulation of the blood. To preserve the health of the tissues, the blood must not only be pure and rich in the materials of growth, but it must flow with a certain speed through all the blood-vessels. If the speed with which the blood moves is on the side of either *plus* or *minus* of the standard of health, disease will shortly arise. If it is on the side of *plus*, active disease of the heart, where that organ is the one to suffer, will follow. If on the side of *minus*, tissue degeneration will ensue. Active disease will be the consequence before middle age; degeneration after that period.

These facts teach that all violent and long-continued efforts of the body should be avoided. They hurry the heart's action to an inordinate degree, they cause it to throw the blood with great force into the extreme vessels, and, as there is almost always one organ of the body weaker than the others, the vessels of this organ become distended, and, remaining distended, the organ itself becomes diseased. Running, rowing, lifting, jumping, wrestling, severe horse-exercise, cricket, football, are fruitful causes of heart-disease. Those which require the breath to be suspended during their accomplishment are more fruitful causes in this respect than those which require no such suspension of the breathing. Rowing, lifting heavy weights, wrestling, and jumping, do this; and, of these, rowing is the most powerful for evil. At every effort made with the hands and feet, the muscles are strained to their utmost; the chest is violently fixed; no air is admitted into the lungs; blood is thrown by the goaded heart with great force into the pulmonary vessels; they become distended; they at length cannot find space for more blood; the onward current is now driven back upon the right heart; its cavities and the blood-vessels of its walls become in like manner distended; the foundation of disease is laid. Hypertrophy, hæmoptysis, inflammatory affections of the heart and lungs, are the consequences in the young; valvular incompetency, rupture of the valves or of the muscular fibres of the heart, pulmonary apoplexy, and cerebral hæmorrhage, are too frequently the immediate consequences in those of more mature years.

If the flow of blood is *minus* the standard of health, the heart's walls are imperfectly nourished, by reason of a deficient supply of food within a given time; the blood itself, receiving less aëration, is, in consequence, more impure; degeneration of the heart's walls is thus induced, if it does not already exist—hastened, if it is present.

I propose now to consider the influence of an increasng quantity of carbonic acid in the air respired upon the contractility of the muscular fibres of the heart.

I take for my example the newly-hatched trout. During the winters of 1869–'70 and 1870–'71, I hatched some thousands of this fish, many of which I daily submitted to microscopical examination. The result of my investigations, in reference to the action of the heart and to the influence upon it of a decreasing quantity of oxygen and an increasing quantity of carbonic acid in the water in which the fish was confined, shows—

That, on placing the fish in a glass trough containing a quantity of water, the heart is seen, under the microscope, to be affected in the following manner:

In the first few moments of examination the venous blood, collected by the veins from the head, back, and yelk-bag (the first two of which unite to form a bulbous vessel into which the third opens), is seen to be projected with considerable force and rapidity into the upper (auricle) of the two cavities of which the heart is composed, and thence as instantaneously into the lower (ventricle) cavity, which contracts with equal rapidity, and forces the blood into the branchial artery, which conveys it to the gills. The projection of the blood into the auricle, its passage into the ventricle, and its expulsion therefrom, are but the work of an instant. As the blood enters the auricle, both it and the ventricle seem to anticipate the charge of blood; but especially is this the case with the ventricle. Before the blood well touches the valve which guards the entrance from auricle to ventricle, the latter is observed to shorten its longitudinal diameter, to visibly meet, as it were, the coming charge of blood from the auricle, and to force it instantly into the branchial artery. There is no delay whatever of the blood in the auricle or ventricle. It is shot in a straight line from the vena cava through the auricle and the auriculo-ventricular valve, caught by the contracting ventricle, and deflected and forced, without a moment's delay, into the branchial artery.

From these observations it was evident that the contraction of the heart was not excited by the distention of its cavities, but that it was induced by the mere impingement of the blood upon its lining membrane. In contracting, the ventricle was seen to roll about one-third upon its axis, by which a portion of that part of it which was previously out of sight was brought into view. As soon as it had delivered its blood into the branchial artery, it relaxed, and increased again its longitudinal diameter, recoiling from systole with an energy and a rapidity equal to those of its contraction.

In three or four minutes the heart is observed to contract both less quickly and less energetically. A very short time after this the blood can be seen gently pouring into the auricle, and thence into the ventricle, which latter now allows itself to be about one-fourth filled before it contracts. It now expels its blood, and again dilates; but its dilatation, like its contraction, is not so instantaneous as it was when first observed under the miscroscope. In a short time longer the sensibility of the heart is greatly diminished, for the blood is seen to be accumulating in both the auricle and ventricle, but especially in the former, from both of which cavities it is now only partly expelled by the contraction of the heart.

At length, just before death, the blood is seen to flow from the auricle into the ventricle, thence into the branchial artery and along it, the heart being passive during this time, and only now and then at long intervals manifesting a very slight and partial contraction. During the whole of this time the blood is coagulating more and more in the auricle and ventricle, but especially in the former; and, when at length the heart has ceased to beat, the auricle and the vena cava opening into it are fully distended, while the ventricle is only partly distended with black-red blood. In the last moments of life, after the heart has ceased to beat, the branchial artery is seen to be pushing forward its slender current of blood, and to become at length quite empty and transparent.

Here, then, as the oxygen dissolved in the water in which the fish is confined becomes exhausted, and as the carbonic acid increases, the sensibility and contractility of the heart are diminished, and at length entirely destroyed. The negation of oxygen, and the increase of carbonic acid, have culminated in the death of the fish.

Precisely the same effect is produced upon the human heart by an accumulation of carbonic acid in the air respired.

In the ordinary condition of the atmosphere, in which carbonic acid does not exceed one part in a thousand parts of that medium, its effects upon the heart are inappreciable. When, however, the carbonic acid has accumulated to the extent of 1 per cent. of the air respired, it begins to produce a slight feeling of faintness, and some degree of uneasiness across the brow. At 2 per cent. the heart's action is quickened, the sense of faintness is greater, there is slight giddiness, with heaviness and constriction of the head, together with nausea. At 3 per cent. all these symptoms are increased. There are vertigo, fluttering of the heart, nausea and sickness, followed by an overwhelming sense of muscular prostration. At this moment the contractions of the heart become very feeble, the skin relaxes, and is bedewed with a cool, clammy perspiration. These symptoms deepen with the increasing quantity of carbonic acid in the air respired until the utmost limit of toleration is reached, beyond which life can no longer be maintained. At this stage lethargy supervenes; and, at the moment of its occurrence, the heart begins to beat less frequently and much less powerfully than before. This condition is the parallel of that observed in the young trout, when the blood begins to accumulate and to coagulate in the auricle and ventricle, and when the heart's sensibility and contractility are reduced in the greatest degree.

From these effects it is certain that confinement to an atmosphere impregnated with carbonic acid, even to the extent of one per cent. only, quickly deranges the function of the heart, and ultimately deteriorates the tissues themselves of that organ.

The greater the percentage of carbonic acid in the air respired, the more quickly and the more profoundly are these effects produced. The constant breathing of air containing one per cent. only of carbonic acid proves fatal to life; but, if it is respired for a short time only, functional disturbance alone is then and there produced. *It is, however, certain that in this functional disturbance lie the germs of organic mischief, and that frequent repetition of the cause will undoubtedly end in organic disease. Hence the impure atmosphere of the bedrooms of the poor, and, indeed, of many of the middle class, proves a sharp spur to the degenerative tendency manifested by the heart, and especially by the right side of the heart, after the age of forty.* Such bedrooms are generally small in their superficial area, low-pitched, and often lighted by a diminutive window, which at night is kept constantly closed; and having a door which opens to the interior of the house, but which is also closed during the occupation of the rooms. Nay, to prevent the slightest admission of fresh air, the crevices of both window and door are most carefully stopped; and, to render the matter still worse, a fire is not unfrequently kept burning during the winter nights.

What must be the effect produced upon the air of such rooms under the conditions named? I take, for example, an average-sized bedroom in the cottages of the poor—say, a room twelve feet long, ten feet wide, and eight feet high. This gives a cubical space of 960 feet, which is not more than half the cubical space allowed each patient in our best-arranged hospitals. In this room, with its diminutive window and door constantly closed, three, four, and frequently a greater number of persons pass the night of eight or ten hours' duration. No provision has been made for the admission of fresh air—none for the escape of the carbonic acid exhaled during respiration. What little provision did exist in the crevices formed by the badly-fitting door and window has been carefully abrogated by sand-bags, rolls of rags, and stuffing of every description. Thus the air of the room becomes poisoned with carbonic acid, and in this condition it is breathed and rebreathed, to the manifest injury of the heart.

A simple calculation will enable us, if not to determine with exactitude, at least to approximate to the amount of carbonic acid exhaled by each sleeper, and consequently to the degree of vitiation which the air of the apartment undergoes. I fix the number of respirations at its minimum—14 per minute; the quantity of air exhaled at each expiration at 20 cubic inches; the quantity of carbonic acid contained in the expired air at 4 per cent.; and the duration of the night at 8 hours. Hence, $14 \times 20 \times 8 \times 60 = 134{,}400$ cubic inches, or 77.77

cubic feet, of air expired by each sleeper during the night of eight hours. This expired air contains 4 per cent. of carbonic acid. $\therefore 100:77.77::4=3.11$ cubic feet of carbonic acid exhaled by each sleeper during the night. Suppose the number of sleepers occupying the bedroom to be four, this will give $3.11\times 4=12.44$ cubic feet as the quantity of carbonic acid which is exhaled by the four sleepers during the eight hours of night. The room itself contains 960 cubic feet of air, and through this 12.44 cubic feet of carbonic acid would have been diffused by the termination of the night. It therefore follows that, if no fresh air entered the room, and if in consequence the carbonic acid had no means of escape, the air of the apartment would, at the end of the eight hours of night, contain 1.29 per cent. of this gas: a quantity sufficient to produce serious results.

This statement, however, does not represent all the facts of the case. It must be remembered that the oxygen contained in the air of the room would be constantly undergoing reduction by respiration during the night. If the quantity thus consumed were determined from the quantity of carbonic acid exhaled, allowing for the fact that 15 per cent. more oxygen is taken into the blood than is contained in the carbonic acid of the air expired, it will be found that from one-third to one-half of the oxygen originally contained in the air of the room would have been consumed by the end of the night. This reduction in the quantity of oxygen, and the great increase of carbonic acid, would affect the body in two ways: firstly, by a deficiency of oxygen; and, secondly, by an excess of carbonic acid, in the air respired. Hence the reduction of the one and the increase of the other would render the air far more injurious than if only one of these changes in its constitution had taken place.

The actual result is not, however, in strict accordance with this calculation, because fresh air, although in limited quantity, does find its way into the room, and carbonic acid does, to a limited extent, find its way out. These, therefore, would modify the constitution of the air of the room at the close of night; but they would still leave it with an excess of carbonic acid injurious to life.

It is found that when air moderately impregnated with carbonic acid is inspired it greatly impedes the exhalation of more from the lungs; and that the greatest quantity of carbonic acid which exists in prebreathed air never exceeds 10 per cent. It is much to be feared that to this degree of vitiation the air of the bedrooms of the poor and of others not unfrequently rises by the too prevalent system of excluding fresh air, and by the frequent absence of provision for the escape of that which has already passed through the lungs.

Can it then be a matter of surprise that death from diseased heart should so often occur during the night?

In thousands of instances of cardiac disease life is thus sacrificed, where, had but proper ventilation of the bedrooms been observed, the *subjects of such disease might, despite the cardiac mischief, have continued to live for an indefinite time.*

It has frequently been my duty, during a practice of nearly thirty years in the midst of a large community prone by the habits and particular avocations of the people to heart-disease, to investigate cases of "found dead" in bed, and I have often been compelled to refer the immediate cause of death to the effect of carbonic acid liberated by respiration and confined to the apartment, in destroying the sensibility and contractility of the heart, rather than to the direct influence of the diseased heart itself.

I remember that on one occasion I was summoned to a case which had occurred in a bedroom fifteen feet long, twelve feet wide, and eight feet high. In this room, with the door and window closed, no fewer than twenty persons slept night after night! Can any one doubt that the air of such a room would be charged to excess with carbonic acid exhaled by respiration? Those who perished in this manner were beyond the age of forty; and, in every instance examined, the right side of the heart was either primarily affected by tissue-degeneration, or by disease consecutive to mischief in the left side of the heart and lungs.

Often indeed in the dwellings of the middle and higher classes of society the provisions for ventilating both their bedrooms and their day-rooms are miserably inadequate to preserve health. The consequence is, that cardiac disease is promoted to an inconceivable extent. *There is no other disease in which the demand for cold, fresh air is so urgently pressed by the patient as in cardiac disease. There is none in which a constant supply of pure air is more needed—none in which it is more grateful to the patient, or in which it has a more immediately beneficial effect.* At all times and seasons—in the depth of winter—by day and by night—a patient suffering from a paroxysm of cardiac asthma will hurry to the open door or window, and there, with his body hanging half out, will remain, with scarcely any vestments upon him, breathing the cold air until the paroxysm has ceased. Ought not this urgent, this powerful supplication of Nature to teach us the importance of ventilation, and of a full supply of fresh air in the treatment of heart-disease?

I hesitate not to say that free ventilation—the free admission of pure air into the apartment by day and by night—is one of the most important remedial measures which can be adopted in the treatment of this disease.

Where this means is defective, but where, nevertheless, the vitiation of the air of the bedroom does not exceed 1 per cent. of carbonic acid, a sensible effect is produced upon those who have slept within its influence. They complain, on leaving their bed, of weakness; their limbs tremble; they feel somewhat giddy, and their head feels heavy, or it aches. The least effort disturbs the heart's action, which is somewhat quick and feeble; their countenance is pale; the lips are not unfrequently somewhat blue; and the tongue is covered with a thin, whitish, and somewhat slimy fur. The appetite is in abeyance; there is a feeling of nausea; and the first evacuation is generally dark in color.

What is the pathological condition of such patients at this moment? Simply this: The blood contains an excess of carbonic acid, which, circulating with the blood through every organ, disturbs the natural action of every organ, blunting its sensibility, vitiating its particular function, and interfering with those molecular changes which constitute healthy nutrition.

A person thus affected does not usually die. The body, removed to a pure atmosphere, begins at once to excrete the carbonic acid by the lungs, the liver, the skin, the kidneys, and the bowels, and in the course of a few hours the more visible manifestations of its baneful effects have passed away. It, however, often happens that a sense of weariness and muscular debility is felt for days afterward. Night, too, frequently places such subjects in the same condition as before. The same bedroom is occupied; the same inadequate means of ventilation continue; the same accumulation of carbonic acid takes place; and the same effects upon the bodily organs are repeated. Blood charged with an excess of carbonic acid again pervades every tissue of the heart, diminishing its vitality, lowering its sensibility, and assimilating its nutrition to that of the reptilian heart. But the low character of the nutrition of the reptilian heart does not accord with the comparatively quick circulation, rapid nutrition, vital power, and energy of action required by the human heart. The one cannot be substituted for the other. In man the change results in disease where disease does not exist—aggravates disease where it is already present. —*Lancet.*

FORESTS AND FRUIT-GROWING.

By J. STAHL PATTERSON, Esq.

FRUIT has become a necessary of life—a great variety of fruit indeed, and a great deal of it; and this will become more and more the case with the increase of intelligence and thrift. The great abundance of most kinds of fruit for the last two or three years may cause us to feel a security, which is not well grounded, with regard to the conditions of climate necessary to the unfailing production of fruit. Only within a few years past have there been seasons when the fruit-crop was very light, and not at all adequate to the demand. One of the causes of this is the capriciousness of the seasons, and this capri ciousness, I believe, is becoming constantly greater as the country grows older.

An inquiry, then, of much scientific interest, and of great material importance, has reference to what may be the cause of this increasing uncertainty of the fruit crop. In the early settlement of the country, it was easy to grow peaches, even in localities where growing peaches now seldom gladden the eye. In Ohio between the parallels of 40° and 41°, for example, peach-buds were seldom injured by winter or spring frosts, and the crop was abundant almost every year when the country was "new." For the last twenty-five years peaches miss oftener than they hit, and in many parts this has told so fearfully against the enterprise of production that scarcely a peach-tree is now to be seen.

The clearing of the country had made this change. The continued clearing of the country will increase the mischief still more. The growing of peaches and of most other fruits will be driven, as indeed it already has been, to special localities and special soils. It is now for such localities to look out in time and preserve as far as possible the favorable conditions they now have, and if possible to increase them.

More especial reference is here had to that part of our country which lies north of the fortieth parallel, where most of the fruit-localities are to be found in the vicinity of considerable bodies of water.

The water absorbs heat during the summer, which it slowly gives off on the approach of cold weather, warming the atmosphere in its vicinity, and preventing the occurrence of early frosts in the fall along the shore-border from five to ten miles wide. This gives the wood and buds a chance to mature thoroughly, so that they will endure a harder freeze in the winter than wood and buds which were suddenly stopped in the course of maturing by an early frost in the fall. In the spring the waters warm more slowly than the land, and the atmosphere thus chilled along this same shore-belt keeps back vegetation and fruit-buds so as greatly to lessen the danger from late frosts; and what may seem to be a contradiction, but is nevertheless true, spring frosts are usually lighter within than they are outside this shore-belt.

These several advantages from the proximity of a considerable body of water are well understood. There is another, however, that may be of some value. During the heated term of summer there is always a cool breeze from the water which modifies the temperature of the hottest part of the day along this otherwise favored border of shore-land, and may act beneficially in various ways: first, by promoting a more active circulation of air among the leaves and young branches, thereby favoring the healthy action of the organic surfaces—hence, greater immunity from blight and mildew in this region; secondly, by affording protection against the injury to which growing fruit is liable from excessive heat; thirdly, by maintaining a greater uniformity of heat between night and day. The experiments of Köppen have shown that change of temperature alone is deleterious to vegetable growth; and we may, perhaps, justly infer that uniformity of temperature, when it lies at or near that degree which is most favorable to healthy vegetable activity, is a desirable point in a fruit-growing climate for the even, early, and better maturing of fruit.[1]

The influence of forests on rainfall is still an unsettled question. It is a very general impression that forests, in some way, promote the fall of rain when it would not occur if the same region was bare of trees. A great array of authorities may be quoted in favor of this view. It is believed that Spain, parts of France, Switzerland, and the Tyrol, Northern Africa, Persia and Palestine, Egypt and India, the islands Malta and Mauritius, the Cape Verd Islands, and most of the West Indies, have either been turned into deserts or greatly injured by the destruction of their forests, and the blight and droughts which have followed. It is alleged, too, that the planting of forests has in some instances, as in Scotland, Egypt, and St. Helena, caused a more abundant rainfall. But these alleged results, though supported by great names in science, are disputed. Forests may affect rainfall for any thing positively known, but the evidence that they do so is not such as science can accept.[2] But, however this may be, they have doubtless much to do with the benefit which vegetation receives from the rain that does fall.

In a country quite destitute of timber the surface would dry off much more quickly, in consequence of the free sweep afforded to the winds. The water from rains would also pass over the surface more freely into the brooks, and be thus lost to vegetation. The spongy surface of the forest absorbs a larger proportion of rain than the open fields, and thus retains it in the soil as a source from which the neigh-

[1] Both De Vries and Sachs ascertained that every kind of plant has its special degree of temperature at which it makes most growth in a given time; but, while Köppen recognized this, his investigations have made an addition to our knowledge of the subject, his point being that the plant grows more when kept at a uniform temperature than if it had varied between extremes of which this temperature is the mean, thus showing that variation of temperature acts as a check on growth.

According to Karsten, great and sudden changes injure the health and hardiness of plants; while De Vries comes to a directly opposite conclusion. This, however, does not affect Köppen's result, which has reference to rapidity of growth. Moreover, even if great daily variation of temperature should not affect the health of plants, it might, nevertheless, be not wholly harmless to the tenderer fruits.

The preceding paragraphs have been suggested by the kinship between forests and lakes in their influence on climate and fruit-growing.

[2] Since writing the above, we have happened to fall upon several statements in favor of the influence of forests on rainfall, some of them from respectable scientific sources, Proctor, Bryant, Colver, etc. I learn, however, that Prof. Henry, of the Smithsonian Institution, has recently reported that observations for the last twenty years in this country show no appreciable influence of forests on the amount of rainfall. This should carry much more weight with it than the mere fashion of opinion about forests causing rain.

boring streams receive a continual supply, while its evaporation from the surface and its transpiration through the leaves of the trees afford moisture to the atmosphere.

The moisture thus imparted to the atmosphere mitigates the severity of a drought in various ways: First, by lessening evaporation from the surface, as this is accelerated by a dry atmosphere, and retarded by a moist one; secondly, by affording to the soil a greater proportion of moisture for condensation, when the surface cools at night. Thirdly, by affording moisture for direct absorption by the leaves. This is a disputed point among men of science; but the late researches of Cailletet promise a reconciliation of the conflicting views, as usual, by showing that both were wrong and both right. He found that, when a plant was abundantly supplied with moisture in the soil, the leaves never absorb; but that they do absorb whenever the soil is deficient in moisture, and the leaves begin to droop.

Hence, there might be evidence of drought in a country without forests, while there were no such evidences in a country sufficiently guarded by forests, though the amount of rain had been the same in both.

These considerations are not altogether without value in regard to fruit-growing. It is true that grapes do best in rather a dry climate; but most kinds of fruit require considerable moisture, especially at the time of transplanting, and also when the fruit is maturing. In affording some mitigation of the extreme effects of dry weather, forests may be regarded as having a beneficial influence on the growing of most fruits.

Of far greater concern to the fruit-interests of any locality is the influence of woodland on temperature. On this subject there is quite a general unanimity of opinion. Certain forms of the evidence are so familiar that the conviction produced is general. Every one, who has travelled through woodlands and open fields during cold weather, has readily perceived how much warmer was the atmosphere of the wood than that of the field. It is said that engineers on our railroads find that it requires less fuel to keep up steam in passing through a long stretch of woodland (Marsh). But the warming influence of the forest has been subjected to more rigid tests than these. Boussingault proved that, within several parallels of the equator on either side, the temperature of cleared land is about two degrees higher than that which is covered with forest. But we are more directly concerned with results in our temperate climate.

The researches of Becquerel, Krutsch, and Berger, had appeared to prove, first, that a wooded region would have a cooler summer and a warmer winter than a region almost destitute of woods; and, secondly, that during the daytime the temperature of the atmosphere in the forest would always be lower, and during the night always higher, than in the open field; the difference between the diurnal maximum and minimum of the forest being less than that of the field; in other words, the diurnal temperature is more uniform.

But this is a matter involving such complicated and varying conditions, that absolute propositions are open to question, however true they may be with proper qualifications. Rivoli has very recently done much to make our knowledge of this subject definite. His observations were carefully made, under circumstances which eliminated, as much as possible, all disturbing conditions; there being no body of water near, the country level, and the wind having a fair sweep in all directions. We will state the results of his investigations as briefly as possible.

Influence of Forests on Winter Temperature.—In the winter-time, the simplest relations of the forest to temperature prevail. During this season of the year, when the wind passes into the north and becomes colder, the forest warms it; when it passes into the south and becomes warmer, the forest cools it. During winter the forest plays the *rôle* of a bad conductor, and acts as an equalizer of temperature.

Influence of Forests on Summer Temperature.—In summer the case is not so simple, owing to evaporation from the surface, transpiration through the leaves, and radiation from them. At this season of the year the atmosphere in the forest is usually warmer during the nights and colder during the day than in the open field. The night is warmer in consequence of the obstruction which the mass of foliage presents to radiation from the surface beneath it; the day is cooler in consequence of the transpiration of vapor from the leaves, and the obstruction interposed between the surface and the direct rays of the sun. In the summer, as well as in the winter, the forest usually acts as an equalizer of the temperature of the atmosphere.

While, however, this is usually the case, there are exceptions. During nights when it is calm, radiation from the leaves of the trees may cool particles of air, which, descending toward the surface, form just before daybreak a stratum of the atmosphere below, which is colder than if the region had been destitute of trees. It is within the experience of most cultivators of the soil that frosts sometimes strike hardest near a wood.

To the fact that under certain circumstances a forest may cause frost in the fields near by, we may add the qualification that this can only occur in the case of white frosts, and that whenever there is motion of the atmosphere, and the wind a cold one, the influence of the forest is always protective. An orchard sheltered by a wood may escape unhurt, while another in the same neighborhood not so protected may suffer the loss of its entire crop. This is believed to be not a very uncommon occurrence in the case of peaches.

If the fruit-growing interest of the country were to state its account with the forest, we should suppose it to be something like the following:

The Count against Forests.—1. Unfavorable to the free circulation of the atmosphere in summer-time; in this respect the influence of the forest is directly the opposite to that of an adjacent body of water. 2. Imparting moisture to the atmosphere, whereby, under certain conditions of the weather, the heat may become too great for the good of growing fruit. 3. Causing an occasional late frost in the spring. 4. Affording a harbor for birds and birds'-nests. This is no small consideration in some localities, where birds have to be slaughtered by the ten thousand to save certain kinds of fruit, as cherries, blackberries, and Delaware grapes. I speak advisedly, being well aware of the sentimentalism against which I offend. Some kinds of birds are, of course, only innocent and useful. I make no charge against them (nor against the forest which protects them). Let them live and sing! But, that birds which prey so remorselessly on fruits destroy insects enough to pay for the fruit they waste and consume, is very improbable, and we let the count stand against the trees and bushes that shelter them.

The Count in favor of Forests.—1. Usually equalizing the temperature between night and day during the summer-season—uniformity of temperature being a condition which is favorable to vegetable development. 2. Equalizing the effects of rainfall by storing up the waters to be given off gradually to the streams and the atmosphere, thus favoring the development of most kinds of fruit. 3. Imparting moisture to the atmosphere by transpiration through the leaves, and thus profiting the fields in various ways during a drought. This moisture may also contribute to the warmth of the atmosphere when warmth is beneficial. 4. Intercepting the sweep of the winds, and thereby lessening the mechanical injury to plants and trees, and weakening the coöperation for mischief of wind and cold. As a screen for protection against the wind, trees are not without appreciation, and it is generally understood that, even if they imparted no warmth to a cold wind passing through them, the mechanical resistance they afford prevents it from taking the warmth so readily out of vines, trees, and the soil. 5. Cooling the warm winds of winter and spring, thereby keeping back vegetation out of the way of late spring frosts. 6. Warming the cold winds in winter. The last three on the list being by far the most important; and by their coöperation they might very easily, and often do, make the difference, at a critical time, of a crop or no crop, as this often depends on a degree or two of temperature.

It will be readily perceived that all the better influences of wooded lands are of very much the same character as the influence of a body of water. It is when these two classes of conditions meet in the same locality that general fruit-growing has its best chances of success.

What proportion of woodland should remain in the interest of protection for agricultural and horticultural purposes, might be difficult to ascertain. Different localities would no doubt require a different proportion. Rentzsch (quoted by Marsh) estimates that for the interior of Germany about 23 per cent., and along the coast 20 per cent., is necessary for the needed protection. The case hardly admits of such precision; more would no doubt be better, and in a dry climate like ours, more than anywhere else.

So rapidly is the destruction of timber going on in this country that many localities originally covered with forest have not so great a proportion as this remaining, and other localities are in a fair way soon to be in the same condition. This is becoming, or at least should become, a real cause of apprehension to those who have the welfare of the farming interest, and especially of the fruit-growing interest, at heart. This continuous destruction of timber must eventually result in injury to the market value of lands in certain neighborhoods, especially lands for fruit-growing purposes.

The remnants of forests in the States have another enemy as inexorable and remorseless as the woodman's axe. Many forest-trees, like the wild Indian, do not seem to flourish in the midst of civilization. They first show signs of decay at the top. This takes place after the underbrush has been cleared away and the surface has lost that perfect mulch of decayed leaves which belongs to native forests. The trees are now liable to suffer from extremes of drought as never before. This change is equal to a change of habitat, and the consequence to some varieties of trees is loss of health and vitality.

According to the experiments of Prof. Pfaff made on an oak-tree, the amount of moisture lost by transpiration during the summer-season was more than eight times the quantity of rainfall on the same area for the same time. Dr. Hahn, who thinks this estimate quite too high, says, nevertheless, that "Herr Pfaff's results show us what an enormous quantity of water is required by isolated trees in a comparatively dry and free (*bewegten*) atmosphere, and how much they need the protection which they afford to each other in their combined capacity as a forest." Whenever the balance and integrity of the original forest is broken, the supply of water during droughts not being equal to the demand of trees now suffering the double disadvantage of needing more moisture and less of it available than before, death begins in the topmost branches, that part of the tree which is most exposed to the conditions of active transpiration and farthest removed from the source of moisture.

What should we do about this blight? Save the timber by using it before it is injured, and plant enough to make up for the loss.

For the application of the facts as now ascertained, let us take the southern shore of Lake Erie, which is a good fruit-region lying midway between the Eastern and Western cities, and affording to both part of their supply of fruit. Fruit does not do so well here now as it did in the early settlement of the country. Cut off the timber which still remains, and the injury to fruit-growing would be still greater; and so far as this result would have an effect, it would be to depreciate the market value of land. What this region especially needs is a protection of woodland against the cold westerly and southwesterly winds to coöperate with the benign influence of the lake in other regards. The more forest to the south of this belt of shore-land the better. The more frequently blocks and belts of woodland intervene throughout its entire extent for immediate local shelter and a general screen against westerly winds, the better for the farming and fruit-growing interests of this region.

But, so long as it pays an immediate profit to cut down the forest, it will be done. It is not within the province of legislation to stop it. There is no hope from voluntary concert of action. A certain percentage of timbered lands might be exempted from taxation; but this innovation, though talked of, is slow in coming about.[1] To a certain extent tree-destruction should be offset by tree-planting. The planter might not receive his profits so quickly as the destroyer, but nevertheless, wherever timber is likely soon to beome scarce, and that is almost everywhere, profits would be sure to accrue from direct sales as well as from the value thus added to the land generally—and, besides the profits in dollars and cents, that accruing from the consciousness of having done a beneficent action.

There are a great many purposes for which timber, and timber only can be used; and for these purposes it should be religiously conserved. I once heard a gentleman say, "I don't worship my timber;" he sacrificed it to gain, in a perfectly legitimate manner it is true. Still the writer must say that he has a sincere respect for the "worship of timber;" it is not a bad kind of religion, so far as it goes.

Immense quantities of timber are slaughtered every year for fuel, and this, too, in a country where there is more coal than anywhere else in the world. There is but one way to stop this branch of the destroying process, and that is by increasing railroad facilities so as to make our coal-fields accessible to every part of the country. Cheap coal will save the timber. When no longer consumed in the millions of household fires in city and country, or in furnaces for the driving power of locomotives and mills, great will be the saving of timber for the necessary purposes for which timber must be used, and for the protection of our cultivated fields and gardens.

The burning of Chicago must make an immediate draft on timbered lands for certain purposes of building for which timber is still largely used. But this great fire, in proving the absolute necessity of building cities of brick, stone, and iron, will operate eventually to the saving of timber and the longer continuance of the protection which our northern

[1] Only Missouri, Nebraska, and Illinois, have legislative enactments to encourage the planting of timber. New York, Massachusetts, and California, do something in the same direction through their agricultural societies.

forests afford against northern winds to the great agricultural districts which lie to the south of them.

And here I cannot but refer to a most short-sighted policy which our Government has been pursuing in giving a factitious value to lumber made from our own timber, by a so-called protective tax on foreign lumber. While this has operated directly against the building interests of our own people, it, at the same time, has led to the more rapid destruction of our own forests; and, in thus giving protection to the capital employed in lumbering, it is removing the protection which our forests afford to the American agriculturist, thus damaging the people at large in a twofold manner. This must be the case just so far as the forests belonging to the United States afford greater protection to our cultivated fields than is afforded by the forests of Canada. We do not realize the benign influence which our forests to the west and east of the great lakes exercise upon the climate and agriculture of the country. Imagine them all removed; the cold winds from the northwest and northeast, having unobstructed sweep, would reach us with greater force, and, passing over a bleak and treeless region, they would come to us absolutely colder. Our Government, by its protective policy, has been doing something to bring about this undesirable result. It is high time that a wiser policy should prevail, and that the Government should protect by taking its hands off.[1] (It is gratifying to record that, since the above was written, the duty on lumber has been greatly reduced.)

There is no need of attributing more to forests than is their due. There are storms against which they afford no protection—avalanches of cold which rush down upon the country, killing fruit-buds, and even vines, shrubs, and trees. But these are exceptional. It is in the case of somewhat milder cold-storms that forests save, when without them there would be ruin. The great fact of the increasing uncertainty of fruit and agricultural crops with the continued clearing of the country, is a fact so patent, and of import so significant, that it alone is sufficient to prove the great value of forests for protection, and to put us on guard against their wanton destruction.

[1] According to an estimate in the Report of the Department of Agriculture for 1870, all the pine-timber in the region between the Mississippi on the west and Lakes Superior and Michigan on the north and east, will, at the present rate of consumption, disappear within the next twelve years, while the hard wood will last only about twelve years longer. Lumbermen do not take all, but what they leave is consumed by the fires which generally follow. About 330,000 acres are denuded annually in this region. This is only a part, perhaps, about half the annual consumption of timber in the northwestern section of our country. To compensate for this loss only about 150,000 acres are annually planted in timber throughout the entire West.

This destruction of timber is general. Even fruit-localities are not spared, as the writer has had abundant opportunity to witness, where the demand for railroad ties at high prices has created almost a *furor* for coining money out of the great oaks, regardless of consequences to climate and culture.

The alarm about the destruction of timber in this country is only too well founded.

A NEW THEORY OF VOLCANOES.

THERE are few subjects less satisfactorily treated in scientific treatises than that which Humboldt calls the Reaction of the Earth's Interior. We find, not merely in the configuration of the earth's crust, but in actual and very remarkable phenomena, evidence of subterranean forces of great activity, and the problems suggested seem in no sense impracticable, yet no theory of the earth's volcanic energy has yet gained general acceptance. While the astronomer tells us of the constitution of orbs millions of times farther away than our own sun, the geologist has hitherto been unable to give an account of the forces which agitate the crust of the orb on which we live.

A theory has just been put forward respecting volcanic energy, however, by the eminent seismologist Mallet, which promises not merely to take the place of all others, but to gain a degree of acceptance which has not been accorded to any theory previously enunciated. It is, in principle, exceedingly simple, though many of the details (into which we do not propose to enter) involve questions of considerable difficulty.

Let us, in the first place, consider briefly the various explanations which had been already advanced. There was first the chemical theory of volcanic energy, the favorite theory of Sir Humphry Davy. It is possible to produce on a small scale nearly all the phenomena due to subterranean activity, by simply bringing together certain substances, and leaving them to undergo the chemical changes due to their association. As a familiar instance of explosive action thus occasioned, we need only mention the results experienced when any one, unfamiliar with the methods of treating lime, endeavors over-hastily to "slake" or "slack" it with water. Indeed, one of the strong points of the chemical theory consisted in the circumstance that volcanoes only occur where water can reach the subterranean regions—or as Mallet expresses it, that "without water there is no volcano." But the theory is disposed of by the fact, now generally admitted, that the chemical energies of our earth's materials were almost wholly exhausted before the surface was consolidated.

Another inviting theory is that according to which the earth is regarded as a mere shell of solid matter surrounding a molten nucleus. There is every reason to believe that the whole interior of the earth is in a state of intense heat; and if the increase of heat with depth (as shown in our mines) is supposed to continue uniformly, we find that at very moderate depths a degree of heat must prevail sufficient to liquefy any known solids under ordinary conditions. But the conditions under which matter exists a few miles only below the surface of the earth are not ordinary; the pressure enormously exceeds any which our physicists can obtain experimentally. The ordinary distinction between solids and liquids cannot exist at that enormous pressure; a mass of cold steel could be as plastic as any of the glutinous liquids, while the structural change which a solid undergoes in the process of liquefying could not take place under such pressure even at an enormously high temperature. It is now generally admitted that, if the earth really has a molten nucleus, the solid crust must, nevertheless, be far too thick to be in any way disturbed by changes affecting the liquid matter beneath.

Yet another theory has found advocates. The mathematician Hopkins, whose analysis of the molten-nucleus theory was mainly effective in rendering that theory untenable, suggested that there may be isolated subterranean lakes of fiery matter, and that these may be the true seat of volcanic energy. But such lakes could not maintain their heat for ages, if surrounded (as the theory requires) by cooler solid matter, especially as the theory also requires that water should have access to them. It will be observed also that none of the theories just described affords any direct account of those various features of the earth's surface—mountain-ranges, table-lands, volcanic regions, and so on—which are undoubtedly due to the action of subterranean forces. The theory advanced by Mr. Mallet is open to none of these objections. It seems, indeed, competent to explain all the facts which have hitherto appeared most perplexing.

It is recognized by physicists that our earth is gradually parting with its heat. As it cools it contracts. Now, if this process of contraction took place uniformly, no subterranean action would result. But, if the interior contracts more quickly than the crust, the latter must in some way or other force its way down to the retreating nucleus. Mr. Mallet shows that the hotter internal portion must contract faster than the relatively cool crust; and then he shows that the shrinkage of the crust is competent to occasion all the known phenomena of volcanic action. In the distant ages when the earth was still fashioning, the shrinkage produced the *irregularities of level* which we recognize in the elevation of the land and the depression of the ocean-bed. Then came the period when, as the crust shrank, it formed *corrugations;* in other words, when the foldings and elevations of the somewhat thickened crust gave rise to the mountain-ranges of the earth. Lastly, as the globe gradually lost its extremely high temperature, the continuance of the same process of shrinkage led no longer to the formation of ridges and table-lands, but to local crushing down and dislocation. This process is still going on, and Mr. Mallet not only recognizes here the origin of earthquakes, and of the changes of level now in progress, but the true cause of volcanic heat. The modern theory of heat as a form of motion here comes into play. As the solid crust closes in upon the shrinking nucleus, the work expended in crushing down and dislocating the parts of the crust is transformed into heat, by which, at the places where the process goes on with greatest energy, "the material of the rock so crushed and of that adjacent to it are heated even to fusion. The access of water to such points determines volcanic eruption."

Now, all this is not mere theorizing. Mr. Mallet does not come before the scientific world with an ingenious speculation, which may or may not be confirmed by observation and experiment. He has measured and weighed the forces of which he speaks. He is able to tell precisely what proportion of the actual energy which must be developed as the earth contracts is necessary for the production of observed volcanic phenomena. It is probable that nine-tenths of those who have read these lines would be disposed to think that the contraction of the earth must be far too slow to produce effects so stupendous as those which we recognize in the volcano and the earthquake. But Mr. Mallet is able to show, by calculations which cannot be disputed, that less than one-fourth of the heat at present annually lost by the earth is sufficient to account for the total annual volcanic action, according to the best data at present in our possession.

This would clearly not be the place to follow out Mr. Mallet's admirable theory into all its details. We must content ourselves with pointing out how excellently it accounts for certain peculiarities of the earth's surface-configuration. Few that have studied carefully-drawn charts of the chief mountain-ranges can have failed to notice that the arrangement of these ranges does not accord with the idea of upheaval through the action of internal forces. But it will be at once recognized that the aspect of the mountain-ranges accords exactly with what would be expected to result from such a process of contraction as Mr. Mallet has indicated. The shrivelled skin of an apple affords no inapt representation of the corrugated surface of our earth, and, according to the new theory, the shrivelling of such a skin is precisely analogous to the processes at work upon the earth when mountain-ranges were being formed. Again, there are few students of geology who have not found a source of perplexity in the foldings and overlappings of strata in mountainous regions. No forces of upheaval seem competent to produce this arrangement. But by the new theory this feature of the earth's surface is at once explained; indeed, no other arrangement could be looked for.

It is worthy of notice that Mr. Mallet's theory of volcanic energy is completely opposed to ordinary ideas respecting earthquakes and volcanoes. We have been accustomed vaguely to regard these phenomena as due to the eruptive outbursting power of the earth's interior; we shall now have to consider them as due to the subsidence and shrinkage of the earth's exterior. Mountains have not been upheaved, but valleys have sunk down. And in another respect the new theory tends to modify views which have been generally entertained in recent times. Our most eminent geologists have taught that the earth's internal forces may be as active now as in the epochs when the mountain-ranges were formed. But Mr. Mallet's theory tends to show that the volcanic energy of the earth is a declining force. Its chief action had already been exerted when mountains began to be formed; what remains now is but the minutest fraction of the volcanic energy of the mountain-forming era; and each year, as the earth parts with more and more of its internal heat, the sources of her subterranean energy are more and more exhausted. The thought once entertained by astronomers, that the earth might explode like a bomb, her scattered fragments producing a ring of bodies resembling the zone of asteriods, seems further than ever from probability; if ever there was any danger of such a catastrophe, the danger has long since passed away.—*Spectator.*

GREAT FIRES AND RAIN-STORMS.

BY JOHN TROWBRIDGE,

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THE belief that great fires are followed invariably by rain-storms is wide-spread, and the great fires of the present year in America, it is claimed, afford no exception to the law. The attitude of scientific men in regard to so-called popular fallacies and superstitions is not, in general, a praiseworthy one. A belief needs often only to be wide-spread among the people at large to be denounced. Science is but another word for truth, and even popular traditions deserve to be examined with care. The difficulties, however, in the way of an investigation of the effects of fires in producing rain-storms are manifold. Our knowledge of the science of meteorology is, at the best, very imperfect; and we have no series of observations from which we can draw trustworthy conclusions. A careful search into the narratives of great fires and into the accounts of great naval and land fights gives nothing which a scientific man would accept for a moment. One who is ready and determined to believe, it is true, will find in history many curious and apparent corroborations of the truth of his belief. Thus in Pepys's "Diary" there is a quaint and circumstantial account of the great fire in London. In speaking of the progress of the fire, he says: "So as we were forced to begin to pack up our own goods, and prepare for their removal; and did by moonshine (*it being brave dry and moonshine and warm weather*) carry much of my goods into the garden;" and in another place: "But Lord! what a sad sight it was by *moonlight* to see the whole city almost on fire that you might see it plain at Woolwich, as if you were by it." In still another place, in speaking of the poor sufferers made homeless by the fire: "A great blessing it is to them that it is fair weather for them to keep abroad night and day." He thus concludes: "*Sunday.*—So to my office, there to write down my journall, and take leave of my brother, whom I send back this afternoon, though raining; *which it hath not done a good while before.*"

After reading this, we turn to the account of the burning of Moscow. But this occurred in September, and the equinoctial gales were blowing fiercely at the time. If we look into the history of land and sea fights, we find many striking and apparent confirmations of the truth of the popular belief. Froude concludes his description of the fight at Flores, 1591, as follows: "Nor did the matter end without a sequel awful as itself." Sea-battles have been often followed by storms, and without a miracle; but with a miracle, as the Spaniards and the English alike believed, or without one, as we moderns would prefer believing. "There ensued on this action a tempest so terrible as was never seen or heard the like before." The human mind is undoubtedly prone to connect great calamities together, and to believe that the one following depended in some mysterious way upon the one preceding.

We turn now to the great fire at Chicago. It was telegraphed to London, England, that "this fire was chiefly checked on the third or fourth day by the heavy and continuous down-pour of rain, which, it is conjectured, was partly due to the great atmospheric disturbances which such an extensive fire would cause, especially when we are told that the season just previous to the outbreak of the fire had been particularly dry." In an article published in the "Journal of the Franklin Institute," July, 1872, by Prof. I. A. Lapham, assistant to the Chief-Signal Officer U. S. A., entitled "The Great Fires of 1871 in the North-west," we find the following in regard to the burning of Chicago: "During all this time—twenty-four hours of continuous conflagration upon the largest scale—no rain was seen to fall, nor did any rain fall until four o'clock the next morning; and this was not a very considerable 'down-pour,' but only a gentle rain, that extended over a large district of country, differing in no respect from the usual rains. The quantity, as reported by meteorological observers at various points, was only a few hundredths of an inch. It was not until four days afterward that any thing like a heavy rain occurred. It is therefore quite certain that this case cannot be referred to as an example of the production of rain by a great fire. Must we therefore conclude," says Prof. Lapham, "that fires do not produce rain, and that Prof. Espy was mistaken in his theory on that subject? By consulting his reports (Fourth Report, 1857, p. 29), it will be found that he only claimed that fires would produce rain under favorable circumstances of high dew-point, and a calm atmosphere. Both of these important conditions were wanting at Chicago, where the air was almost entirely destitute of moisture, and the wind was blowing a gale. To produce rain, the air must ascend until it becomes cool enough to condense the moisture, which then falls in the form of rain. But here the heated air could not ascend very far, being forced off in nearly an horizontal direction by the great power of the wind. The case therefore neither confirms nor disproves the Espian theory, and we may still believe the well-authenticated cases where, under favorable circumstances of very moist air and absence of wind, rain has been produced by large fires." Prof. Lapham also remarks, "The telegraph-wires indicated no unusual disturbance of the electrical condition of the atmosphere." Upon reading this last remark, the question occurs to us, Can there not be a change in the electrical state of the atmosphere which, although too small to manifest itself upon telegraph-wires, may occasion storms?

Some experiments made by the writer in the physical laboratory of Harvard College, on the influence of flames upon the electrical state of the air, may throw some light upon this subject. Two pieces of apparatus were used, one of them "the new quadrant electrometer" of Sir William Thomson, and the other a "water-dropper," also an invention of that distinguished philosopher. The electrometer is a very complicated piece of apparatus. Let me describe it in as clear a manner as possible. I do not know that I shall succeed in conveying to the uninitiated any idea of that instrument, for it has many parts. I shall endeavor merely to explain its principles roughly. Conceive of a light aluminum needle, suspended by two single cocoon threads in the centre of a glass jar, which is filled to nearly one-sixth of its capacity with strong sulphuric acid. A very fine platinum thread drops from the aluminum needle and dips in the acid. Let us see what we have now. An aluminum needle suspended in mid-air by two filaments of silk very near each other, and so fine that they can hardly be perceived by the naked eye. Further, this needle has an extremely fine metallic wire running down from it and terminating in a little weight, also of the metal platinum, which is immersed in the sulphuric acid. Thus we see that the needle is very free to swing in a horizontal plane, and it will be readily perceived that, if there were but one filament of silk supporting it, it might swing round a complete circumference, or indeed make many revolutions under the influence of a strong repellant or attractive force; the two filaments by their torsion allow the needle to swing only to a certain distance, and compel it to return to its original position when the force is removed. One can readily conceive of this by suspending a bar in an horizontal position by two vertical ropes, and then endeavoring to turn it in an horizontal plane.

Let us now charge the aluminum needle with positive electricity. To do this, we shall conduct into the sulphuric acid by means of a metallic wire a slight positive charge, and the acid, being a good conductor, will convey this charge by the extremely fine metallic wire to the aluminum needle suspended above the acid in mid-air. Now, if we present a substance charged with negative electricity to the needle, it will, as is well known, be speedily attracted; and if the substance presented has a positive charge it will be repelled: the unlike charges attracting and the like repelling each other. Thus, we see that we have a very delicate test for the character of the electricity in the body which we bring into the neighborhood of the needle. But, the needle being only about two inches in length, slight movements in it can hardly be detected. How is this to be remedied? We are going to deal with delicate impulses, and it is necessary to have some means of observing them. Standing at this window, through which the sun streams brightly, with a little mirror, we can, as any school-boy knows, throw the image of the sun in almost any direction that we please. Now it rests upon the brick wall across the street, a hundred feet or more distant from us. Let us turn the glass slightly: see how small a movement suffices to make the sun's image on the wall dart over at least twenty feet! Why can we not attach a little mirror, which shall not weigh more than a feather, just above our needle, and let it reflect, instead of the sun, a little point of light from a kerosene-lamp upon yonder wall which is four feet from it? We have done so. We allow the light of the lamp to stream through a small opening in a screen of blackened paper, and to fall upon the mirror. Upon presenting this metallic plate, which has been charged with positive electricity, the spot of light darts along the scale pasted on the wall; it has gone over nearly six inches of the scale, while the motion of the needle and the mirror was hardly perceptible. We have now an extremely delicate test for the presence of electricity—so delicate that even the small charge ever present in our bodies is sufficient when we approach the instrument to make the spot of light dart to and fro. It is only necessary now to have some convenient means of presenting the body to be examined to the needle; for it will be seen that all movements of the air in its neighborhood must be avoided. To accomplish this end, we surround the needle with four plates of brass, which are carefully separated from the needle. They are in the form of sectors of a circle and lie in an horizontal plane, the suspension fibres of the needle going through a round hole in the centre of the circle of which the sectors form a part. These sectors are separated from each other at first; the opposite pairs can, however, be connected at will. It is not necessary to dwell upon their peculiar construction: their object is to prevent the charge, led to them by these copper wires, running to any part of the room, and thereby to influence the needle. It will be seen that this instrument, of which we have explained only the principal features, is wonderfully delicate, and far superior to the old electrometers which showed electrical attraction and repulsion by the divergence of two suspended gold leaves.

It remains now to describe the "water-dropper." This consists merely of a tin vessel carefully insulated at the base, with a long glass tube projecting from an orifice near the bottom. The water runs through this tube and issues in a fine stream from its end, breaking into drops about fourteen inches below it. A collecting-plate connected with one of the brass plates which we have described in the electrometer stands under this stream of water. Now the drops of water in their fall upon the plate remove by their impact the charge which the plate has by itself—for all bodies have a greater or less electrical condition, and the plate then takes the electrical condition of the air in which it is immersed.

Let us place our water-dropper on the window-sill with its tube projecting into the open air; and, having placed the collecting-plate so that the drops of water may strike upon it, let us notice our little spot of light. It is a clear day in early summer; there are no clouds to be seen, save a rift away on the horizon in the west. The spot of light moves gradually over the scale, indicating that there is a slight positive charge of electricity in the atmosphere. Now it is stationary, and we are about to record the reading of the scale, when the spot of light gives a quick jump and then returns to nearly its original position. Perhaps some movement of ours has deranged the instrument. We look at it carefully, and return to our position of observation. A low rumble, as if of distant thunder, is heard. We do not mind this at first; presently the spot of light darts again along the scale, and again returns to its original position. We stand in silence, waiting for further developments. Now, we hear again a rumble, and a low muttering, as if of thunder in the west. Can this movement of the spot of light have any connection with the distant lightning? At least five minutes must have elapsed between the time of the movement of the spot of light and the moment when the thunder was heard. Again the spot moves, again follows a low peal of thunder; again and again the same phenomenon is observed. There can be no doubt of it: the electrical discharges of the approaching storm, yet miles away, are registered by this little instrument in our laboratory. Now the storm approaches nearer. We hear the wind in the trees; a few drops fall upon the tinned roof; the lightning darts hither and thither, and the spot of light leaps responsively to it.

Such, then, is the delicacy of our instrument. By allowing the spot of light to fall upon sensitive paper, which moves along by clock-work, we shall have all of its motions recorded by photography. This registration has been accomplished by Sir William Thomson, to whom we owe so many beautiful electrical instruments. It would be well if our Signal Service should make contemporaneous observations in different parts of the country by means of these instruments. Such observations could not fail to throw light upon the connection of electrical storms with rain-storms, and extend our knowledge of meteorology.

Let us now, having proved our instruments, approach the question of the influence of flames upon the electrical state of the atmosphere. Our observations must be made in the laboratory, and are necessarily of a somewhat general character from the nature of the subject. It is a cold, clear day in early winter, with the wind blowing freshly from the northwest. We know by various indications that the air is highly electrified. The wind blows too freshly to place our water-dropper out-of-doors; accordingly, it is placed upon a table in the laboratory, and we notice the indication of the instrument. The air is indeed highly charged—the spot of light is thrown to a greater distance upon the scale than we have often noticed. Let us record the reading; it is as much as the positive pole of twelve Daniell cells gives. Now, lighting our Bunsen gas-burner, and placing it near our water-dropper, let us observe the spot of light; it does not change its position materially at first.

Now, after the lapse of a few minutes, it falls to a lower position upon the scale, now it goes down to zero. Now it mounts again, but in a contrary direction to its first indication, showing a slight negative charge in the air, which before was strongly charged positively. Can this be due to the presence of the flame? And, if it is due to the flame, are not great fires capable of influencing the electrical state of the atmosphere, to a greater or less extent? Such are the questions which force themselves upon us. We must, in the first place, examine our flame. Soldering a platinum wire to the copper connecting wire, and dispensing with the water-dropper, we examine the outer and inner cone of the flame. At all points in the luminous portion of the flame an indication of negative electricity is obtained; at all points in the immediate neighborhood of the flame, but exterior to it, there are signs of a positive charge in the heated air. The inner cone of partly-consumed gas is neutral, or slightly negative.

The flame, therefore, is negative, and it tends by its presence to reduce the positive charge of electricity which generally characterizes the air of fine weather to zero, or to change it to a feebly negative charge. We learn from various writers upon meteorology that the normal electricity of the atmosphere is positive. Herschel in his work on Meteorology says, p. 125: "Out of 10,500 observations made at the Kew Observatory in 1845–'47, 10,176 showed positive, and only 364 negative electricity—the latter being almost always accompanied with heavy rain." Sir William Thomson, in the proceedings of the Literary and Philosophical Society of Manchester, March, 1862, relates some experiments which tend to show that clearing-up weather is preceded, and in many cases foretold, by a change in the atmosphere from a negative to a positive charge of electricity.

We can, therefore, conclude with some probability of truth that great fires, by changing the electrical state of the atmosphere, have an influence upon the production of rain. The state of our knowledge, however, in regard to the part that electricity plays in atmospheric changes, is very meagre. The question of the truth of the popular belief that great fires are followed by rain still remains unanswered; and we can only hope that we have thrown a little more light upon it by our research.

PROFESSOR TYNDALL'S TOPICS.

THAT the expectation of pleasure and profit from the course of lectures which Prof. Tyndall has prepared for delivery in this country is not likely to be disappointed, will appear from the following careful analysis of his theme, Light and Heat, as he has arranged it for six nights:

He begins in a prefatory way, and dwells upon the introduction of the experimental method into Science—speaks of the ardor of investigators and of their rewards. He seeks to show that most of them wrought for the sake of *knowledge*, and with no practical end in view, though their discoveries travelled to the most astonishing practical applications. After dwelling on the importance of original inquiry, he takes up the real subject of the lectures. The instruments are explained, and the principles upon which they depend. He points out the proximate cause and action of the electric light which is to be used in the illustrations. The laws of reflection are demonstrated, and one or two striking practical applications adduced. Then he goes on to refraction. These elementary subjects are really touched upon in order to enable him, in a subsequent lecture, to reveal the workings of Newton's mind when he theorized upon the subject of light. Refraction is followed by an inquiry into the constitution of light, its analysis and synthesis. This occupies the first lecture.

In the second lecture the demonstrated constitution of light is applied to the doctrine of colors. He goes very thoroughly and plainly into this matter, making perfectly evident the causes on which ordinary colors depend; winding up by the experimental proof that yellow and blue light, when mixed together, produce *white* and not green. Having exhausted the ordinary spectrum, he describes the difference between the emissions from solids and their vapors. Metallic vapors are produced and shown with their characteristic colors. Their light is then analyzed, and it is shown to be distinctive of the substance from which it comes. Spectrum analysis is dwelt upon, and copiously illustrated.

In his third lecture, Tyndall deals with solar light, dwelling upon the distinction between the bright lines of the metallic vapors, and the dark lines of Frauenhofer. The reciprocity of radiation and absorption is demonstrated, and it is shown experimentally that an incandescent vapor absorbs the light which it emits. This leads up to the theory of the physical constitution of the sun. Then he goes on to show the extension of the spectrum beyond its visible range, performing with quartz prisms and lenses Stokes's experiments on Fluorescence, and the rendering visible of invisible rays. Then the other side of the spectrum is handled; its extension as *heat* beyond the limits of light is demonstrated. Numerous experiments on the *total* heating power of the rays from the electric light are made; fusion and combustion being thus effected. Here he hopes to perform the famous Florentine experiment of the ignition of a diamond in oxygen, using, however, a purely terrestrial source of radiant heat. He also hopes to produce combustion by rays concentrated by a lens of *ice*. The heat-rays are then filtered from the light-rays, and it is shown that all the foregoing effects are produced by rays totally beyond the range of vision; fusion, combustion, and explosion, being produced at foci perfectly dark, and, as far as the air is concerned, perfectly *cold*. It is also proved that these dark rays perform the work of evaporation in the tropical ocean, and the work of fusion upon the Alpine ice and snows. The rays, moreover, are shown to be competent to raise platinum to a white heat, so that by its intervention you may extract from the dark rays all the colors of the spectrum. This brings him to the end of the third lecture.

In the fourth lecture he shows the irresistible tendency of the human mind to seek for governing principles which rule facts and correct them, rendering them, so to say, organic. He dwells upon the exercise of the theorizing faculty, taking Newton as an example. He tries to show how naturally his optical theory grew out of his previous knowledge. The doctrine of colors is now extended by the introduction of the colors of thin plates, of striated surfaces, etc., and he unravels the subtle additions which Newton made in his theory, in order to fit it to these new facts. The theory of emission is then contrasted with the theory of undulation. The latter is rendered familiar to the mind by preliminary considerations regarding water-waves, and by experiments regarding sound. He dwells upon the labors of Thomas Young, and the effect of Brougham's attacks in the *Edinburgh Review*. This will be his most difficult lecture, but he has wrought hard to make it clear, and it is essential to the comprehension of the subsequent ones.

In the fifth lecture Tyndall enters upon the phenomenon of crystallization, and seeks to give an intelligible explanation of crystalline architecture. The process of crystallization is experimentally illustrated. This is done with a view to the action of crystals upon light. In the first experiments he deals with crystals solely with reference to the polarization of light. This is explained and illustrated by numerous experiments. Double refraction and the state of the two halves of the divided beam are dwelt upon. Then come the chromatic phenomena of polarized light. Basing himself upon the principles explained in the fourth lecture, he hopes to make these effects comprehensible by all intelligent persons. The effects of mechanical strains and pressures in producing a *quasi* crystalline structure are exhibited. Then the similar phenomena of unannealed glass. He hopes to show these effects in a very splendid fashion. They will more than fill the fifth lecture.

The sixth lecture is devoted to the further illustration of the action of crystals upon light; uniaxal and biaxal crystals, circular polarization, and the chromatic effects produced by rock-crystals; the conferring of double refractory power by sonorous vibrations; and the magnetization of light. Although the syllabus is short, it covers a good deal.

We have sketched the course of six lectures. The materials touched upon are ample to fill the six to overflowing, allowing an hour and a half for each lecture. A seventh very striking lecture might be given, he says, on the identity of light and heat—every experiment made in the optical lecture being shown capable of repetition with pure lightless radiant heat, the thermo-electric pile and galvanometer being substituted for the eye. He has made an arrangement for the projection of the galvometer-dial upon a screen, which renders it visible to any number of people.

As he worked at the subject, the desire grew upon him to do it more and more thoroughly, and to spare no expense as regards apparatus. He has accordingly purchased between three and four hundred pounds sterling worth of new instruments; and has gone over all the experiments, so as to render every thing sure, and in a manner worthy of the subject and of the occasion.—*United States Railroad and Mining Register.*

THE COCOA-NUT PALM, AND ITS USES.

By C. R. LOW.

COASTING along Ceylon and the Malabar littoral, the voyager will notice the tall palm-trees, which appear as if growing in the sea, and will learn, on inquiry, that they are of the variety *Cocos nucifera*, or the loving cocoa-nut tree.

Though the sight of these never-ending groves may at length pall upon the eye of the traveller, yet he will do wisely if at eventide, while the ship is becalmed, he should take the "jolly" boat and land on the silent beach. In a few minutes he will stand in a "grove of palms," and must be of a somewhat stolid temperament if he does not feel something like a new sensation, as he looks aloft and listens to the rustle of the first breath of the sea-breeze, as it gently waves the graceful fronds or leaves overhead. Those who have been in the East will, as they read these lines, recall the sound, and with it, perhaps, may be brought to mind many pleasant days and the faces of old friends who sleep beneath the southern cross. Those who have not strolled under the welcome shade afforded by the fern-like canopy, will remember Thomson's lines:

"Sheltered amid the orchards of the sun,
Where high palmettos lift their graceful shade,
Give me to drain the cocoa's milky bowl,
And from the palm to drain its freshing wine."

There are many varieties of the palm. Among them the *Caryota urens* is the most ornamental, with its long, pendulous clusters of dark-red, succulent, acrid berries. The pith of this tree yields a species of sago, and the sap is commonly employed in the Deccan as yeast for raising or fomenting bread. There is also the travellers' palm, or crab-tree, from which a watery juice is extracted, and which, crowning the summits of hills, forms a picturesque object on the landscape, with its broad, fan-shaped leaves. The date-trees of India and Ceylon neither possess the loftiness nor the beauty of foliage of those growing in such luxuriance on the banks of the Shatt-al-Arab, in Mesopotamia, and indeed seldom bear fruit. The areca-palm, which is cultivated in most parts of India, and is indigenous on the Malabar coast, furnishes the "betel-nut," which, mixed with "paun," forms a composition which the Hindoos are in the constant habit of chewing.

There are five well-marked varieties of the cocoa-nut.[1] The Tembili, of which there are different descriptions, is a very well-formed, handsome nut, of oval form and bright-orange tint. The Buddhist priests of Southern India and Ceylon generally contrive to keep a store of the choicest kinds of the Tembili in their temples as offerings to the passer-by, who is expected to make a return. The Nawasi is slightly heart-shaped, of lighter color than the preceding, and bears an edible husk. On stripping off the outer rind, the inner skin turns to a pale-red color, and is fit for use. There is a third variety of nut, somewhat small and round, and in color much resembling the Tembili. Then there is the common cocoa-nut, so well known to every urchin; and, lastly, we have the double (*Ladoicea Seychellorum*), which, as its name implies, is a product of the Seychelles, a group of islands in the Indian Ocean.

In old times the most marvellous medicinal virtues were attributed to nuts of this description, and they were considered unfailing antidotes to all kinds of poison. As their origin was veiled in obscurity—those obtained being either caught-up floatings at sea or on the coasts of the Maldive Islands, where they were thrown up by the tides and currents—the most extravagant sums were asked and obtained for them. Thus it is recorded that the Emperor Rudolph II. offered 4,000 florins for one which chanced to be for sale, but, the bidding being considered insufficient, the precious nut passed into other hands. It is even said that a merchant-ship, with her freight and stores complete, has been bartered in exchange for one.

The natives believed that the trees producing these nuts grew at the bottom of the sea, and were enchanted palms, which vanished the instant the adventurous diver attempted to reach them. Death was

[1] "The Cocoa-nut Palm," by W. B. Lord, R. A.

awarded to any one who, having found one of these nuts on the shore, failed to make it over to his sovereign. The kernel was the part supposed to possess miraculous medicinal qualities, and with it were mixed such anomalous ingredients as pounded antlers of deer, ebony-raspings, and red-coral dust.

At the present day, when these cocoa-nuts are exported from the Seychelles Islands, cups made from the shells are mounted by the wealthy natives of India with gold and precious stones; the religious mendicants of Ceylon also set a high value on the shells, and use them as alms-boxes to attract the contributions of the faithful.

The palm bearing the common cocoa-nut attains, in situations favorable to its growth, a height of from 60 to 80 feet, but rarely exceeds a diameter, at the base, of from one to two feet. The roughness of the bark is caused by the progressive falling off of the fronds, as the tree shoots upward. But this roughness and the crookedness of the tree (for a straight palm is rare indeed) are compensated by the beauty of the foliage of the crown. "Here," says Mr. Lord, "the graceful, fern-like leaves may be seen in every stage of development—the lower tiers drooping, those above spreading out feather-like, while the centre stands up plume-like in all its beauty." The nuts grow in clusters, and the number on one tree varies from 40 to 200 in different stages of development. The "spathes," which are thrown up among the young leaves of the cocoa-palm, and on which grow the blossoms, are often nearly four feet in length and six inches in circumference. In favorable seasons these spathes or plumes of flowers are shot forth every four or five weeks, and as the blossoms drop off the young nuts are formed, affording a store of food and drink all the year round. When the sap of the palm is sought for the manufacture of toddy, or some other products, the young fronds, together with the flower-spathe, are bound together with ligatures, in order to prevent the development of the blossoms; a puncture is then made at the foot of the spathe with a toddy-knife, and numerous taps administered to the part adjoining the cut, with the handle, to set the sap flowing; a chatty, or earthen pot, is then suspended in a suitable position to receive the cool, sweet juice of the tree.

To ascend the lofty palm various methods are employed, and often has the writer watched the agile natives swarming up with rapidity by inserting the great-toe into a series of notches cut into the bark. Another method is by casting a band round both tree and toddy-drawer, who then plants the soles of the feet against the trunk, and literally walks up, "hand over fist." They also traverse the space between the top of the trees on coir-ropes, thrown across from one to the other. Early in the morning, before the sun is up, the toddy-drawer with monkey-like agility ascends the tree, lowers down his well-filled pot, which is received by a companion, who replaces it by an empty one. From one to three quarts is the general result of one night's drawing; but the trees thus treated become barren, and yield no fruit. Immediately after collection the toddy is sweet and deliciously cool, but in the course of a few hours this is changed for an agreeable acidity. It forms a refreshing drink in this state, but in twenty-four hours becomes quite sour. Toddy, when fermented, is made into arrack, a liquor which, being cheap and fiery, is greatly consumed by the poorer class of Europeans at Bombay, and is the bane of our soldiers and sailors in the presidency town.

Vinegar is made by allowing the toddy to stand for about a month in earthen jars fitted with covers. The liquid is then carefully strained, and replaced in the jars, in which is thrown a little red pepper, a small piece of the fruit of the gamboge-tree, and a pod of the horseradish, which in the East attains the dimensions of a tree. In about five weeks vinegar of a most excellent quality is the result. Not only spirits and vinegar are made from the juice, but the material known as jaffery, or native sugar, is produced before fermentation by boiling the sap to a syrup with quicklime, when it is roughly crystallized. Large quantities of this are exported, and used for sweetmeats, in the manufacture of which in great variety the natives of India are consummate adepts.

The cocoa-nut is consumed in a greater variety of ways than even the sap, and not a portion of it, or of the palm on which it grows, is without its special use. Besides the refreshing drink extracted from the young undeveloped nut, which is also made into a dye, the pulp inside the soft crust is considered a delicacy, and is used in the preparation of various dishes. The kernel, when ripe, is also treated in a variety of ways for food, and forms an important ingredient of curry. Cocoa-nut oil is also extracted from the ripe fruit by the natives with their primitive contrivances, in which bullocks are the motive power. When under European manipulation, iron machinery driven by steam expresses about 2½ gallons from 100 nuts. Besides its more practical and prosaic virtues of supplying food and clothing, the poets of the East have from time immemorial assigned as one of the attributes of the cocoa-nut palm-tree that it "loves to hear the sound of footsteps and pleasant voices."

In moderately favorable situations, says a writer, this species of the palm commences bearing fruit at from ten to thirteen years of age, and remains at full maturity for between sixty and eighty years, producing, on an average, about 100 nuts annually. The tree then begins to deteriorate and fall off in its yield, continuing in this declining condition for about twenty years, when it ceases bearing altogether, and dies. It is curious that while in this moribund state the famous "porcupine-wood" of commerce is obtained from its trunk; so that even in death the cocoa-nut palm is man's faithful friend, and ministers to his wants.

Many are the uses to which the tree is put while in maturity. The thatch covering the houses is made with the prepared mid-ribs of its leaves, and secured with cord twisted from the cocoa-fibre, from which also nets and fishing-lines are made. The plaited strips of the leaf supply material for baskets in which the freshly-gathered nuts are stored. Cocoa-cloth is an article of manufacture. Torches are made by twisting together a sufficient number of dry leaflets, the end of the mid-rib serving as the handle; from these leaflets, when split, mats are woven. As to the fibrous husk of the nut known as coir, its utility is without limit. Besides floor-cloths and mats, which are generally employed in this country for offices, and from their strength of texture are unrivalled, the coir is manufactured into rope, and is extensively used on board ship; and in the "country" trading-ships of India it entirely supersedes manila and hemp, as being equally strong and durable, and infinitely cheaper.

Pipes, bottles, and drinking-vessels for native use, oftentimes polished and handsomely-mounted, are made of cocoa-nuts, from which the white meat is extracted, without injuring the shell, by pouring out the milk, filling it with salt, and burying it in the hot sand until the kernel is decomposed, when it is removed from one of the three holes in the "monkey's" face. Thus countless are the benefits conferred on man by the palm, forming, as it does, one of the most useful of all the gifts of Providence. The South-Sea Islanders, we are informed by those who have been among them, make books out of the leaf-strips similar to the papyrus of the ancient Egyptians. Canoes are built of the pliable planks, which, when grooved and bored, are stitched together with coir-twine, are propelled by cocoa-wood paddles, masted with a slender young palm, and rigged with coir-cordage, which carries a mat-sail; thus, ready for sea, freighted with a cargo of nuts, oil, lamp-black, vinegar, sugar, and arrack (all the produce of the palm), and finally stored with nut-food for the voyage, the sole remaining requisite to make a successful commercial venture, but one that man cannot command, is a propitious breeze.—*Food Journal.*

HUMANITY AND INSANITY.

FROM THE FRENCH OF MAXIME DU CAMP.

IN studying the history of insanity, we are surprised to find that the same mild treatment now universally adopted was very clearly prescribed by the chief professors of medical science in the beginning of our era. Thus, Aretæus the Cappadocian recommends the use only of the supplest cords, to restrain violent maniacs, "for," says he, "to resort to any cruel measures of restraint will increase rather than allay the over-excitement." Galen was the first to maintain that all disorders of the mental faculties are produced by a lesion of the organs of thought, which are situate in the brain. Yet we are not to imagine that in Galen's day the art of healing was faultless; indeed, so far is this from being the case, that we find his contemporaries making large use of philters, charms, and magical formulæ. In the seventh century Paulus of Ægina reasserted the principles maintained by Galen and by Aretæus; but with him the line of rational medical tradition comes to a close, and henceforth, for centuries, it would seem as if the doctors shared in the disorder which they assumed to cure. The madman was now no longer regarded as a sick patient, nor even as a human being. He was treated as a wild-beast—half brute, half demon; soon his disorder was called "satanic possession," and he himself burned at the stake.

The middle ages were a period of upheaval, when every thing was swallowed up in the bottomless abyss of scholasticism and demonology, and medicine became a routine of superstitious practices.[1] Such and such a plant was considered beneficial, if gathered at the new moon; but deadly poison, if at the moon's wane. Science, art, and literature, went down in the storm, and wars, battles, pestilence, and famine, were the order of the day. As God was invoked in vain, men turned to Satan. The belief in the devil was universal, and the world became a hell. Now both science and experience show tl at the prevailing notions of a given period are very rapidly taken up by the insane, and by them distorted into grotesque shapes, with a uniformity resembling the symptoms of epidemic disorders. This phenomenon is of daily occurrence. Thus, accordingly as France is ruled by a king, an emperor, or a president, those insane persons who imagine themselves to be somebody, claim the rank of president, emperor, or king, as the case may be. Just now, respectable women patients at the Salpêtrière, Ste.-Anne, Vaucluse, and Ville-Évard asylums solemnly assure the physicians in charge that they are *pétroleuses*; while men of unquestionable patriotism will tell you that they guided the Prussians up the heights of Sedan. The phenomenon therefore of diabolic possession in the middle ages is perfectly natural. The calamities attendant on continual wars had so enervated the people, that they were fit subjects for all manner of mental disorder; and this, taking form from the prevailing ideas of the times, found expression in demoniacal possession.

[1] Borden, who lived in the seventeenth century, and was a man of keen intelligence, tells us of a monk he knew, who practised bloodletting to an unlimited extent. After three bleedings, he would add a fourth, for the reason that there are four seasons, four quarters of the globe, and four cardinal points. After the fourth he took a fifth, because there are five fingers on the hand. To the fifth he would add a sixth, for did not God create the world in six days? But the number must be made seven, there being seven days in the week, and seven sages of Greece. An eighth bleeding had to follow, eight being a round number; and a ninth, because *numero Deus impare gaudet*—God loves odd numbers.

During the middle ages the devil was everywhere—*ubique dæmon.* There was one religious sect whose adepts were ever spitting, hawking, and blowing the nose, with a view to expel the devils they had swallowed. A trace of this still remains in some localities, where one who sneezes is saluted with "God bless you!" Such beliefs were universal. Thus a certain prior of a convent had around him constantly a guard of two hundred men, who hewed the air with their swords, so as to cut to pieces the demons who were assailing him. Demons were even cited to appear before ecclesiastical tribunals.—A curious and a pitiful epoch, when the possessed and their exorcists were madmen alike!

This view of insanity was favored by the philosophical, or rather the theological ideas of the time. According to these, man was of a twofold nature. On the one hand was *the flesh*, mere matter; on the other, *the soul*, a direct emanation from Deity, passing through this vale of tears, on its way to the ineffable glory of heaven. The body is but the soul's dwelling-place—a temple or a den, accordingly as its invisible inhabitant is the servant of God or of Satan. Therefore, when the soul is diseased, the treatment must regard the soul alone, which is governed by laws of its own, and is merely in juxtaposition with the body for a moment. No doubt the ideal of purity thus held up was sublime; yet the result of it was the upsetting of the body's equilibrium; and this reacted on the mind. But this theory led to still more serious consequences; for it was admitted into science, and checked the progress of the medical art. When in 1828 Broussais attacked it, he was accused of blasphemy, and of "sapping the foundations" of society. Now, however, we know that the faculties of the mind are not independent of the conditions of the body. Take a slight dose of sulphate of quinine, and you lose, for the time being, the faculty of recollection; swallow a little hashish, and you are transiently insane.

In 1453 Edelin, a priest and doctor of the Sorbonne, preached against the cruelty of putting to death poor creatures who were the dupes of their own diseased imaginations. On being cited to defend himself before a tribunal, he became suddenly insane, and was immured for life, that is, shut up between four walls, without food, drink, or light. In the sixteenth century Europe literally blazed with the fires lighted to punish witches and sorcerers, who were simply madmen. Luther had a visit from the devil. Pico della Mirandola tells of Savonarola's visions, and Melanchthon holds converse with spirits. Even Ambroise Paré, the Hippocrates of modern times, believed in possession, in compacts with the devil, and the like. The same is to be said of Fernel, famous for his calculation of the earth's dimensions, and of Bodin, the great jurisconsult. These great men, with all their sagacity, with all their learning, would seem never to have heard of the monk Bacon's dictum: "We cannot determine by speculation or by imagination what Nature will do, or what endure; all that must be made out by experiment." When illustrious *savants* like these were firm believers in demonism, it need not cause us any surprise to see eight hundred sorcerers burnt at the stake within sixteen years in Lorraine alone, or five hundred at Geneva in three months.

The first effective blow was aimed at this superstition by Wier, a physician of Cleves, who was the true founder of mental pathology. Knowing well the temper of his time, he moved with extreme caution. He classes demons in sundry categories, and reckons their number by millions. Having thus given an exhibition of his orthodoxy, he next throws all the blame on the devil. It is he, and not the witch or the sorcerer, that is to be punished. As *possession* is simply a form of disease, the possessed should rather be treated medically than burned at the stake. Wier brings facts to show that the phenomena of possession are all explainable without supposing any diabolic interference. His was the period of the invention of printing, of the discovery of America, of the Protestant Reformation—the age of Galileo and of Kepler. It might have been supposed that the sixteenth century would have seen the end of demonism in Europe. But no; the princesses of the house of Medici brought in their train to France a horde of astrologers, necromancers, disciples of Locusta, fortune-tellers, etc. Three famous cases of possession marked the beginning of the seventeenth century: that at Labourd in 1609; that of the Ursulines at Aix in 1611; and of the Ursulines at Loudun, from 1632 to 1639.

The phenomenon of insensibility to pain is one of not very rare occurrence. This insensibility may be confined to a single member, or some particular locality, or it may extend to the whole body. During the middle ages all sorcerers were supposed to bear the mark of the devil, viz., the spot touched by the fiend when taking possession of his subject. This spot was insensible to pain, and was discovered by prodding the unfortunate culprit with a long needle, here and there, all over the body until it was found.

So general was the prevalence, among the inmates of convents, of a peculiar form of hysteria, that it got the name of *possession des nonnains* (*nonnain*, nun). Its pathology is clear: melancholia attended by hallucinations, illusions of the sense of touch, and an irresistible desire of suicide. Take the remarkable case of the nuns of Saint-Louis de Louviers (1642), which engaged the attention of the Parliament of Rouen. The principal heroine of this sad history was Madeline Bavent, who, on being shut up in a dungeon, spent four hours in endeavoring to put an end to her life, by driving a large nail into her bowels, and turning it round and round. She was clearly the subject of hystero-melancholia, but her judges decided that she was possessed of a devil. But at length the belief in demonism was forced to give way before the gradual advance of science, and in 1672 Colbert induced Louis XIV. to sign the famous ordinance forbidding the

Parliament any longer to prosecute sorcerers. But this was not until over twenty thousand individuals had perished at the stake simply for having been insane.

Thus ended what we may call the thaumaturgic era of insanity, and now follows the era of repression. There were as yet no hospitals to receive the insane, who were confined in convents or in prisons, according to the violence of their disorder. They were fettered, beaten, suffered to wallow in straw, exhibited to sight-seers, to gratify idle curiosity, or to afford amusement. This treatment was far from being such as medical science requires; but, still, it at least was a great improvement on the stake, and was less calculated than the exorcisms of the previous period to over-excite the patient. A last effort was made by the clergy and the Parliaments in 1713 to recover the powers of which they had been deprived by the ordinance of Louis XIV., but they were unsuccessful; and, consequently, when the Jansenist miracles and *diableries* became the talk of Paris, the government was content with simple measures of police repression. Finally, in 1768, the Parliaments declared that *possession* is a disease. Cagliostro was afforded every facility for summoning up the devil and putting him *en rapport* with the Cardinal Rohan; and Mesmer might now assemble at his famous banquet all the nervous subjects in Paris, without any hindrance on the part of king, clergy, or police.

Science meanwhile was not idle. While justice was growing more lenient toward the insane, the study of the principles to be applied in the treatment of insanity engaged the earnest attention of all the great physicians of Switzerland, England, Holland, Germany, Italy, and France, and the various phenomena of mental pathology were carefully described by Plater, Willis, Boerhaave, Fleming, Fracassini, Morgagni, Boissier de Sauvages, Lieutard, Lorry, and others. As regards the question of treatment, however, these learned writers nearly all fell into error, because they started out with false premises. In their time the famous theory of *humorism* held undivided sway, and according to this all disease came from the *humors*, the blood, lymph, bile, etc.; and a person was diseased to a greater or less degree, according to the higher or lower degree of crudity or of coction in which his humors were found. Hence there were two universal remedies, which were expected to answer every malady: purging and blood-letting. Violent insanity had its seat in the blood; melancholy madness, in the bile; exalted mania, in the spleen. Baglivi, who died in 1707, introduced into medicine the doctrine of *solidism*, which attributes the cause of disease to the solid parts of the body. Baglivi's writings were translated into French by Pinel, who was himself a *reformer* in the best sense of that word, and who introduced the mild treatment of the insane in modern times. In 1791 he published his "Medico-philosophical Treatise on Insanity," and 1792 was appointed physician-in-chief of the Bicêtre Asylum.

We can imagine what Bicêtre must have been when Pinel took charge—a jail, house of correction, penitentiary, and hospital, all in one; and its inmates—assassins, debauchees, sick patients, paupers, idiots—lived in fearful promiscuousness; it was, in fact, a moral cess-pool. The insane, as being no better than wild-beasts, were kept separate, shut up in pens six feet square, to which light and air were admitted only through a small opening in the door. There was a bed of loose straw, renewed every month. The patient had a chain around the waist, besides being manacled and fettered. He received neither care nor medical treatment, but was left to exhaust himself in his paroxysms, affording amusement to curious visitors, who flocked to witness the strange antics of the madmen. Pinel had the invaluable assistance, in carrying out his reforms, of a humble hospital attendant, who had himself by practical experience arrived at Pinel's own conclusions years before. "When the insane patients become too violent, what do you do?" asked Pinel. "I take off their chains, they then become quiet." Pinel ordered the irons to be struck off all the patients. Among them was an old soldier of the guards, a man of herculean strength, and a violent lunatic. The physician had his irons taken off, and then bade him remove the chains off all the other patients. The old soldier's gratitude was such that he remained for the rest of his life attached to the personal service of Pinel. As Colbert, in persuading Louis XIV. to publish his famous ordinance, had brought the thaumaturgic[1] era to a close, so Pinel put an end to the era of repression. After a protracted contest, victory declared in favor of common-sense and humanity. Esquirol followed after Pinel, and showed that the physician who would treat mental disorders, must study the various symptoms; and this he can do only by daily contact with the insane. Ferrus discovered the importance of giving to the insane employment of some kind, as a means of restoring them to a healthy condition of mind. While thus, in France, science was engaged in establishing the moral bases of the disease, Roller was founding a model establishment in Germany, on the principle of surrounding the patient with all those influences which could bring his thoughts back into their normal courses. His long experience went to show the advantage of employing opium and its derivatives in the treatment of mental disorders. These are the founders of the science of Mental Alienation: others have developed their premises and added to their teachings, but to Pinel, Esquirol, Ferrus, and Roller, the human race owes a debt of everlasting gratitude for having first opened the way.—*Abridged from the Revue des Deux Mondes.*

[1] *Thaumaturgic*, working miracles, exciting wonder.

DRIFTING OF THE STARS.

By RICHARD A. PROCTOR, B. A.,

HON. SECRETARY OF THE ROYAL ASTRONOMICAL SOCIETY.

FROM time to time, during the last three years, I have brought before the readers of this magazine the various arguments and considerations on which I have based certain new views respecting the constitution of the sidereal universe. In so doing I have had occasion to deal chiefly with facts already known, though not hitherto viewed in that particular light in which I sought to place them. Indeed, it is an essential part of my general argument that much that is contained in observations already made has been escaping us. In the eagerness of astronomers to ascertain new facts, they have been neglecting the interpretation of facts already ascertained.

But I have long felt that it would greatly tend to advance the new views which I have advocated, if some process of research, pursued by one of those astronomers of our day who possess the requisite means and leisure for prolonged inquiries, should confirm in a clear and decisive way some definite point of my new theories. Thus, if new observational evidence should be found in favor of my theory that the nebulæ are not external to our galaxy, or if new evidence should be obtained to show that the stars are aggregated in certain regions within our system and segregated from others; or, again, if my theory of star-drift should be confirmed by new and striking evidence, I felt that a greater measure of confidence in my analysis of former evidence would thenceforward be accorded. I had no occasion, indeed, to complain of cavil or opposition; in fact, a degree of attention had been given to the new opinions I advocated which was certainly much greater than I had looked for. But there must always be such an inertia in the general weight of opinion in favor of accepted views, that only a steady reiteration of reasoning during a long period, or else some striking and impressive discovery, can cause the weight of opinion to tend in the contrary direction.

I cannot but regard myself as most fortunate in finding the first confirmation of my views (1) coming from one of the most eminent astronomers and physicists of the day, (2) bearing upon one of the most definite and positive of my vaticinations, and (3) relating to one of the most interesting subjects in the whole range of recent astronomical research.

It will be in the remembrance of many readers of this magazine that, nearly four years ago, Dr. Huggins succeeded in showing that the bright star Sirius is travelling at an enormously rapid rate away from us. In other words, besides that rapid thwart-motion which is shifting the place of this star upon the heavens, the star has a rapid motion of recession. In the paper called "Are there any Fixed Stars?" in the *Popular Science Review* for October, 1868, the nature of the means by which this discovery was effected was fully described and explained. It may be permitted to me to mention, also, that while Dr. Huggins's researches were still unannounced (or rather incomplete) I was so far fortunate as to indicate the possibility of employing the very method of research which Dr. Huggins was then engaged (unknown to me) in applying to Sirius. I propose here briefly to describe and explain the method, referring the reader, who desires fuller information on these preliminary points, to the paper of October, 1868, mentioned above. I am the more desirous of doing this, because I find the principle of the method not readily grasped, and that I conceive the explanation I am about to offer may remove certain difficulties not uncommonly experienced.

Conceive that a person, standing on the edge of a steadily-flowing stream, throws corks into it at regular intervals—say one cork per second. These would float down the stream, remaining always separated by a constant distance. Thus, if the stream were flowing three feet per second, the corks would be a yard apart (supposing, for convenience of illustration, that each cork was thrown with exactly the same force and in exactly the same direction). Now, if a person a mile or so down the stream saw these corks thus floating past, he could infer that they had been thrown in at regular intervals; and, moreover, if he knew the rate of the stream, and that the corks were thrown in by a person standing at the river's edge, he would know that the interval between the throwing of successive corks was one second. But, *vice versa*, if he knew the rate of the stream, and that the corks were thrown in at intervals of one second, he could infer that the person throwing them was standing still. For let us consider what would happen, if the cork-thrower sauntered up-stream or down-stream while throwing corks at intervals of one second. Suppose he moved up-stream at the rate of a foot per second; then, when he has thrown one cork, he moves a foot up-stream before he throws the next; and the first cork has floated three feet down-stream; hence the second cork falls four feet behind the first. Thus the common distance between the corks is now four feet instead of three feet. Next, suppose he saunters down-stream at the rate of a foot per second; then, when he has thrown one cork, he moves a foot down-stream before he throws the next; and the first cork has floated three feet down-stream; hence the second cork falls only two feet behind the first. Thus the common distance between the corks is now two feet instead of three feet. It is clear, then, that the person standing a mile or so down-stream, if he knows that the stream is flowing three feet per second, and that his friend up-stream is throwing one cork in per second, can be quite sure that his friend is standing still if the corks come past with a common interval of three feet between them. Moreover, he can be equally sure that his friend is sauntering up-stream, if the corks come past with a common interval exceeding three feet; and that he is sauntering down-stream, if the common interval is less than three feet. And, if, by some process of measuring, he can find out exactly *how much* greater or how much less than three feet the interval is, he can tell exactly how fast his friend is sauntering up-stream or down-stream. It would not matter how far down-stream the observer might be, so long as the stream's rate of flow remained unchanged; nor, indeed, would it matter, even though the stream flowed at a different rate past the observer than past the cork-thrower, so long as neither of these two rates was liable to alteration.

Now, we may compare the emission of light-waves by a luminous object to the throwing of corks in our illustrative case. The rate of flow for light-waves is indeed infinitely faster than that of any river, being no less than 185,000 miles per second. The successive light-waves are set in motion at infinitely shorter time-intervals, since for extreme red light there are no less than 458,000,000,000,000 undulations per second, and for extreme violet no less than 727,000,000,000,000; but these specific differences do not affect the exactness of the illustration. It is obvious that all that is necessary to make the parallel complete is that the flow of light-waves shall reach the observer at a constant rate (which is the actual case), and that he shall know, in the case of any particular and distinguishable kind of light, what is the rate at which the wave-action is successively excited, and be able to compare with this known rate the rate at which they successively reach him. If they come in quicker succession than from a luminous body at rest, he will know that the source of light is approaching, as certainly as our observer down-stream would know that his friend was sauntering toward him if the corks came two feet apart instead of three feet. If, on the contrary, the light-waves of a particular kind come in slower succession than from a body at rest, the observer will know that the source of light is receding, precisely as the river-side observer would know that his friend was travelling away from him if the corks came past him four feet apart instead of three.

Now, the stellar spectroscopist *can* distinguish, among the light-waves of varied length which reach him, those which have a particular normal length. He analyzes star-light with his spectroscope, and gets from it a rainbow-tinted streak crossed by dark lines. These dark lines belong to definite parts of the spectrum; that is, to such and such parts of its red, or orange, or yellow, or green, or blue, or indigo, or violet portion. Thus they correspond to light having a particular wave-length. And *many* of these lines in stellar spectra are identifiable with the lines due to known elements. For instance, in the spectrum of Sirius there are four strong dark lines corresponding to the known bright lines of the spectrum of hydrogen. Thus the wave-length corresponding to any one of these dark lines is perfectly well known to the spectroscopist from what he has already learned by examining the bright lines of hydrogen. Now, if Sirius were receding very rapidly, the wave-length corresponding to one of these lines would be lengthened; it would correspond, in fact, to a part of the spectrum nearer the red end, or the region of longer light-waves, and thus the dark line would be shifted toward the red end of the spectrum; whereas, on the contrary, if Sirius were very rapidly approaching, the dark line would be shifted toward the violet end of the spectrum. All that would be necessary would be that the rate of approach or recession should bear an appreciable proportion to the rate at which light travels, or 185,000 miles per second. For, reverting to our cork-thrower, it is clear that, if he travelled up-stream or down-stream at a rate exceedingly minute compared with the stream's rate of flow, it would be impossible for the observer down-stream to be aware of the cork-thrower's motion in either direction, unless, indeed, he had some very exact means of measuring the interval between the successive corks.

Now, the spectrum of a star can be made longer or shorter, according to the dispersive power employed. The longer it is, the fainter its light will be; but, so long as the dark lines can be seen, the longer the spectrum is, the greater is the shift due to steller recession or approach; and, therefore, the more readily may such recession or approach be detected. But, with the instrument used by Dr. Huggins four years ago, it was hopeless, save in the case of the brilliant Sirius (giving more than five times as much light as any other star visible in our northern heavens), to look for any displacement due to a lower rate of recession than some hundred miles per second (little more than the two-thousandth part of the velocity of light). What was to be done, then, was to provide a much more powerful telescope, so that the stellar spectra would bear a considerably greater degree of dispersion. With admirable promptitude, the Royal Society devoted a large sum of money to the construction of such an instrument, to be lent to Dr. Huggins for the prosecution of his researches into stellar motions of approach and recession. This telescope, with an aperture of fifteen inches, and a light-gathering power somewhat exceeding that usual with that aperture, was accordingly completed, and provided with the necessary spectroscopic appliances. Many months have not passed since all the arrangements were complete.

In the mean time, I had arrived at certain inferences respecting the proper motion of the stars, on which Dr. Huggins's researches by the new method seemed likely to throw an important light.

More than three years ago, I had expressed my conviction that, whenever the recorded proper motions of the stars were subject to a careful examination, they would confirm the theory I had enunciated, that the stars are arranged in definite aggregations of various forms—star-groups, star-streams, star-reticulations, star-nodules, and so on.

Making leisure, in the summer of 1869, for entering upon such an examination, I was led to several results, which not only confirmed the above-mentioned theory, but suggested relations which I had not hitherto thought of. Some of these results are discussed in the article called "Are there any Fixed Stars?" already referred to; others are presented in an article called "Star-drift," in the *Student* for October, 1870. The special results on which Dr. Huggins's recent discoveries throw light, were first publicly announced in a paper read before the Royal Society, on January 20, 1870.

I had constructed a chart in which the proper motions of about 1,200 stars were *pictured*. To each star a minute arrow was affixed, the length of the arrow indicating the rate at which the star is moving on the celestial vault, while the direction in which the arrow pointed shows the direction of the star's apparent motion. This being done, it was possible to study the proper motions much more agreeably and satisfactorily than when they were simply presented in catalogues. And certain features, hitherto unrecognized, at once became apparent. Among these was the peculiarity which I have denominated "Star-drift;" the fact, namely, that certain groups of stars are travelling in a common direction.[1] This was indicated, in certain cases, in too significant a manner to be regarded as due merely to chance distribution in these stellar motions; and I was able to select certain instances in which I asserted that the drift was unmistakable and real.

Among these instances was one of a very remarkable kind. The "seven stars" of Ursa Major—the Septentriones of the ancients—are known to all. For convenience of reference, let us suppose these seven divided as when the group is compared to a wagon and horses. Thus, there are four wagon-wheels and three horses. Now, if we take the wagon-wheels in sequence round their quadrilateral (beginning with one of the pair farthest from the horses), so as to finish with the one which lies nearest to the horses, these are named by astronomers, in that order, Alpha, Beta, Gamma, and Delta, of the Great Bear. Thus, Alpha and Beta are the well-known pointers (Alpha nearest the pole), and Delta is the faintest star of the Septentrion set. The three horses are called in order Epsilon, Zeta, and Eta; Epsilon being nearest to Delta. Now, when the proper motions of these seven stars had been mapped, I found that, whereas Alpha and Eta are now moving much as they would if the sun's motion were alone in question, the other five are all moving at one and the same rate (on the star-sphere, that is) in almost the exactly opposite direction. Moreover, a small star close by

[1] I include this among "features hitherto unrecognized," though Michell had already noted the fact that the stars are arranged into systems. "We may conclude," he said, "that the stars are really collected together in clusters in some places, where they form a kind of systems; while in others there are few or none of them, to whatever cause this may be owing, whether to their mutual gravitation or to some other law or appointment of the Creator."

Zeta (the middle horse), a star known to the Arabian astronomers as the "Test," because to see this star was held a proof of good eyesight, is moving in the same direction and at the same rate as Zeta and the rest of this set. And besides this star (which has also been called Jack by the middle horse), Zeta has a telescopic companion which also accompanies him in his motion on the celestial sphere.

After a careful consideration of these circumstances, and an analysis of the probabilities in favor of and against the theory that the concurrence of apparent motion was merely accidental, I came to the conclusion that the five large stars and the two smaller ones form a true drifting set. I found, on a moderate computation, that the odds were upward of half a million to one against the concurrence being accidental; and, since I had recognized other instances of concurrence not less striking, I felt that it was morally certain that these stars belong to one star-family.

The reader will perhaps not be surprised to learn, however, that before publishing this conclusion I submitted it (in July, 1869) to one who was, of all men, the best able to pronounce upon its significance —the late Sir John Herschel. I have the letter (dated August 1, 1869), which he sent in reply, before me as I write. The part relating to my discovery runs as follows: "The considerations you adduce relative to the proper motions of the stars are exceedingly curious and interesting. Of late years catalogues have gone into much detail, and with such accuracy that these motions are of course much better known to us than some twenty or thirty years ago. The community of proper motion over large regions (of which you give a picture in Gemini and Cancer) is most remarkable, and the coincidence of proper motion in Beta, Gamma, Delta, Epsilon, and Zeta Ursæ Majoris, most striking. Your promised paper on this subject cannot fail to be highly interesting."[1]

In a letter written on May 11, 1870, and referring not to another letter of mine, but to my "Other Worlds," Sir John Herschel remarked, "The cases of star-drift such as that in Ursa Major are very striking, and richly merit further careful examination."

My first public expression of opinion respecting the star-drift in Ursa Major was conveyed in the following terms: "If these five stars indeed form a system (and I can see no other reasonable explanation

[1] He proceeds as follows (the passage is removed from the main text, as relating to a different branch of the subject): "I cannot say that I am at all surprised at its being found that the average proper motions of stars of small magnitudes are not less than those of large, considering (as I have always done) that the range of individual magnitude (i. e., lustre) must be so enormous that multitudes of *very* minute stars may in fact be our very near neighbors." Compare my paper on "The Sun's Journey through Space," above referred to, which paper also deals with the point touched on in the next sentence of Sir John Herschel's letter: "Your remark on the conclusion I have been led to draw, relative to the small effect of the correction due to the sun's proper motion, will require to be very carefully considered, and I shall of course give it every attention."

of so singular a community of motion), the mind is lost in contemplating the immensity of the periods which the revolutions of the components of the system must occupy. Mädler had already assigned to the revolution of Alcor around Mizar (Zeta Ursæ) a period of more than 7,000 years. But, if these-stars, which appear so close to the naked eye, have a period of such length, what must be the cyclic periods of stars which cover a range of several degrees upon the heavens?" (From Zeta to Beta is a distance on the heavens of about 19°.) "The peculiarities of the apparent proper motions of the stars," I added, "lend a new interest to the researches which Dr. Huggins is preparing to make into the stellar proper motions of recess and approach."

But a few months later, in a lecture delivered at the Royal Institution, I pointed out more definitely what result I expected from Dr. Huggins's researches. "Before long," I said, "it is likely that the theory of star-drift will be subjected to a crucial test, since spectroscopic analysis affords the means of determining the stellar motions of recess and approach. The task is a very difficult one, but astronomers have full confidence that in the able hands of Dr. Huggins it will be successfully accomplished. I await the result with full confidence that it will confirm my views."

It will be manifest that if the five large stars in Ursa are really travelling in the same direction, then, when Dr. Huggins applied the new method of research, he would find that, so far as motion in the line of sight was concerned, these stars were either all receding or all approaching at the same rate, or else that they were all alike in showing no signs of any motion, either of recess oı approach.

But in the mean time there was another kind of evidence which the spectroscope might give, and on which I formed some expectations. If these stars form a single system, it seemed likely that they would all be found to be constituted alike—in other words, that their spectra would be similar. Not, indeed, that associated stars always display such similarity. Indeed, the primary star of a binary system not unfrequently exhibits a spectrum unlike that of the small companion. But the five large stars in Ursa, being obviously primary members of the scheme they form, might be expected to resemble each other in general constitution. Moreover, since the stars not included in the set—viz., Alpha and Eta—might be regarded as probably very much nearer or very much farther away, it was to be expected (though not so confidently) that these two stars would have spectra unlike the spectrum common (on the supposition) to the five stars.

Now, Secchi announced that the stars of the Great Bear, with the exception of Alpha, have spectra belonging to the same type as the spectrum of the bright stars Sirius, Vega, Altair, Regulus, and Rigel. This result was in very pleasing accordance with the anticipations I had formed, except that I should rather have expected to find that the star Eta had a spectrum unlike that of the remaining five stars of the

Septentriones. Moreover, as the stars belonging to this particular type are certainly in many cases, and probably in all, very large orbs[1] (referring here to real magnitude, not to apparent brilliancy), the inference seemed fairly deducible that the drifting five stars are not nearer than Alpha, and therefore (since we have seen that it is unlikely that *all* the Septentriones lie at nearly the same distance) the inference would be that the drifting stars lie much farther away than the rest.

It remained, however, that the crucial test of motion-measurement should be applied.

In the middle of May last I received a letter from Dr. Huggins announcing that *the five* are *all receding* from the earth. In all, the hydrogen line called F is "strong and broad." In the spectrum of Alpha the line F is "not very strong" (so faint, indeed, Dr. Huggins afterward informed me, that he preferred to determine the star's motion by one of the lines due to magnesium in the star's atmosphere). He found that Alpha is *approaching*. As to Eta, Dr. Huggins remarked that the line at F is "not so strong or so broad" as in the spectrum of "the five." He was uncertain as to the direction of motion, and mentioned that "the star was to be observed again." He subsequently found that this star is receding. But, whereas all the five are receding at the enormous rate of thirty miles per second, Eta's recession was so much smaller that, as we have seen, Dr. Huggins was unable to satisfy himself at a single observation that the star was receding at all.

It will be seen that my anticipations were more than fulfilled. The community of recessional motion was accompanied by evidence which might very well have been wanting—viz., by the discovery that neither Eta nor Alpha shared in the motion. Moreover, the physical association between the five stars was yet further evidenced by the close resemblance found to exist between the spectra of the five stars. Dr. Huggins remarked in his letter: "My expectation had nothing to do with the above results. At the moment, I thought Alpha was included in the group, and was therefore a little disappointed when I found Beta going the opposite way."

We have at length, then, evidence, which admits of no question—so obviously conclusive is it—to show not only that star-drift is a reality, but that subordinate systems exist within the sidereal system. We moreover recognize an unquestionable instance of a characteristic peculiarity of structure in a certain part of the heavens. For, though star-drift exists elsewhere, yet every instance of star-drift is quite distinct in character—the drift in Cancer unlike that in Ursa, and both these drifts unlike the drifts in Taurus, and equally unlike the drift in Aries or Leo. Much more, indeed, is contained in the fact now placed

[1] Sirius demonstrably gives out much more light than our sun, and according to the best determinations of his distance he must (if his surface is of equal intrinsic lustre) be from 2,000 to 8,000 times larger than the sun. Vega, Altair, and Rigel, are also certainly larger and may be very much larger than our sun.

beyond question, than appears on the surface. Rightly understood, it exhibits the sidereal system itself as a scheme utterly unlike what has hitherto been imagined. The vastness of extent, the variety of structure, the complexity of detail, and the amazing vitality, on which I have long insisted, are all implied in that single and, as it were, local feature which I had set as a crucial test of my theories. I cannot but feel a strong hope, then, that those researches which my theories suggest, and which I have advocated during the last few years, will now be undertaken by willing observers. The system of star-gauging, which the Herschels did little more than illustrate (as Sir W. Herschel himself admitted), should be applied with telescopes of different power to the whole heavens,[1] not to a few telescopic fields. Processes of charting, and especially of equal surface charting, should be multiplied. Fresh determinations of proper motions should be systematically undertaken. All the evidence, in fine, which we have, should be carefully examined, and no efforts should be spared by which new evidence may be acquired. Only when this has been done will the true nature of the galaxy be adequately recognized, its true vastness gauged, its variety and complexity understood, its vitality rendered manifest. To obtain, indeed, an absolutely just estimate of these matters, may not be in man's power to compass; but he can hope to obtain a true relative interpretation of the mysteries of the stellar system. If any astronomer be disposed to question the utility or value of such researches, let him remember that Sir W. Herschel, the greatest of all astronomers, set "a knowledge of the constitution of the heavens" as "the ultimate object of his observations."—*Popular Science Review.*

HOW WAS HERCULANEUM DESTROYED?

BY M. BEULÉ, OF THE FRENCH INSTITUTE.

TRANSLATED FROM THE REVUE DES DEUX MONDES.

HISTORY points out marked differences between Herculaneum and Pompeii. The first, settled by the Greeks, was devoted to intellectual culture and refined leisure; the latter, of Oscan origin, concerned itself solely about commerce; one was inhabited by Romans of fortune, and loaded with favors; the other endured the hostility of Rome, and often incurred her chastisement. There is reason to believe that Herculaneum gave a model for many details of civilization to Pompeii, and we may safely assert that Pompeii taught Herculaneum nothing. Besides, the earthquake which was so fatal to

[1] This is a work in which telescopes of every order of power would be useful. The observations, also, would be very easily made and would *tell* amazingly.

Pompeii in the year 63, under Nero, did Herculaneum no injury; so that there a part of the buildings anterior to the empire, and houses of earlier style, which implies purer taste, must have been preserved. This conclusion is strengthened at the present day by the beauty of those objects collected at Herculaneum, and will be settled beyond question whenever the city itself shall be restored to light.

What was the fate of Herculaneum during the eruption of A. D. 79? What special phenomena were displayed on that side of Vesuvius? What causes buried a flourishing city in an instant out of sight of the inhabited world? It has been proved that Pompeii suffered an interment so incomplete that after a few days its inhabitants could recognize their dwellings, could encamp above and clear them out; Herculaneum, on the contrary, was buried so deep that the next day it was impossible to trace a vestige of it. The ready answer to all these questions usually is: "Lava worked all the ruin. Herculaneum was swallowed up under eighty feet of lava. If works of art, bronzes and pictures have been miraculously preserved, it was due to the impenetrable shield of lava, yielding only to a cutting tool, that protected them from the ravages of time." The explanation is tempting. Fancy pictures waves of fire rolling upon the city, rising like the tidal swell, surging in through doors and windows, sweeping around and moulding every thing, then slowly cooling, and preserving for posterity treasures that labor must unveil, repaid by their recovery in unharmed beauty.

This is really the opinion that all Europe holds, and even at Naples almost all visitors of Herculaneum declare that they have touched the lava with their own hands; and, in books written on the Vesuvian cities, more than one traveller affirms as positively that the difficulty of cutting the lava presents the chief obstacle to the disinterment of Herculaneum. How can one venture to meet such convictions by asserting that water, not fire, overwhelmed Herculaneum; that it was not a torrent of glowing lava, but a flood of mud and wet ashes that filled the city? How uproot a prepossession so deep that the works of geologists and *savants* have failed to shake it? Dufrénoy proved that water alone swept over Herculaneum heaps of scoria and pumice crumbled from La Somma; Dyer, Overbeck, Ernst Breton, and others, have affirmed in various languages, to no purpose, that nothing but ashes, wet to paste and hardened by pressure, covered over Herculaneum: no one heeded them, and the blame continues to be thrown on the lava, which makes excavation so costly and laborious.

But every one knows the nature and effects of lava. Lava is an incandescent mass, of so high temperature as to absorb and melt all fusible bodies; forced out from the fissures of the crater by irresistible expansive power, this mass rolls on in a fiery river, burning up every thing in its path; cooling slowly, it grows as hard as porphyry or adamant. Now, I appeal to the recollection of all who have ascended

Vesuvius during those lava-flows that succeed an eruption, and continue for weeks or months even. What happens to-day, if studied with a little good sense and reflection, can enlighten us on what must have happened eighteen centuries ago. For instance, we have seen how slow lava-currents, remote from the vent of escape and cooled by contact with the ground and air, flowing around country-houses, level and consume them, with a sudden flaming up of roofs and floors. How could the stuccoes and the marble statues of Herculaneum remain unharmed, in their original color, free from crack or splinter, if they had been enveloped in lava? We have seen metals by mere contact melt and vanish in that viscous paste, which glows like fused iron or glass gushing from a furnace. How, then, do we find in Herculaneum articles of silver, bronze statues, leaden vases, with their shapes, their relief, their ornaments and polish uninjured? The bronzes of Herculaneum are even better preserved than those of Pompeii, being distinguished by their freshness of surface, their lustre, and dark and even tone, while the Pompeian bronzes have been attacked by sulphurous fumes, and eaten on the surface, and have taken on an agreeable ultra-marine blue tint, like that of sulphate of copper.

Other facts of the same kind are quite as puzzling. The guides amuse strangers with an experiment; breaking off a bit of lava with an iron-pointed stick, they let it cool on the ground, and stamp a penny on it, to get an impression of the coin. If the trial is made too quickly, the copper melts, and the coin, instead of leaving its image, disappears and mingles with the rest of the lava. How, then, do we find at Herculaneum so many ancient silver or copper coins, not merely undestroyed, but not even changed, by those waves of lava which attain a concentrated heat beyond all measurement? We know, too, that the ancients used colors with a mineral base in decorating their buildings; they will stand dampness from the earth, but the touch of fire changes their nature; the partial fires that have left traces in Pompeii have in some places altered the blue to gray, and the red to yellow, and Neapolitan artists in our time well understand the very simple method of producing what is called burnt-yellow, by exposing minium to the action of fire. How, then, do the houses uncovered at Herculaneum present such exquisite colors? How is it that the ultra-marine blue and the vermilion-red, covering whole walls, keep a freshness and smoothness that contact with a burning substance must necessarily have destroyed? Then, too, on Vesuvius I have seen trees just touched by the lava-flow take fire like matches, throw out a blazing jet, and fall at once, as if struck with lightning. Why have the beams and floors and sills of Herculaneum, instead of crumbling into ashes, slowly decayed in their places in the bosom of the earth, leaving no holes nor fractures? Why are they found blackened like oak-timbers that have been sunk in the mud for ages, like the piers of bridges and the piles of old docks at Carthage, and the wood brought down by the Jordan and thrown out by the Dead Sea, saturated in it with chloride of sodium? How is it that every thing proves their decomposition to come only from the effects of time? How has the wood kept its character and color in those parts pierced by spikes and nails, in other words, protected from dampness by iron rust? How do we find manuscripts written on the soft fibres of papyrus-reed, when lava must infallibly have consumed them, and dispersed their ashes like those of a sheet of paper thrown on burning coals? Why has this kind lava, in like manner, respected fruits, nuts, almonds, linen, silk, lamp-wicks found in hundreds, and so many very combustible articles which have merely turned black, when they usually vanish, without the least trace, in the feeblest flame?

This refutation by absurdity might be urged with multiplied arguments. Indeed, very slight reflection suffices to show that fire could not have played any part in the destruction of Herculaneum, and that if lava, the most terrible destroying agent next to lightning, had made its way into the city, we should scarcely recognize a few blackened stones, smashed bricks, and calcined marbles. But, to say all in a word, I state that on a late tour I examined the ground of Herculaneum, in the parts made accessible by excavation, with particular care. I could not find a square inch of lava! Every thing is ashes, nothing but ashes, and these ashes have been hardened by three agents—water, pressure, and time. It is exactly this hardness, which is not to be conceived of as very great, that has deceived visitors, particularly in the underground galleries dug out in exploring the theatre. The descent is by stairways damp with exudations from the streets of Portici; overhead is heard the rolling of vehicles; we pass through tunnels polished with rubbing; we see on the smoky arches the smudge of torches, collecting for centuries; we shudder at the appalling gloom, and seem buried in the bowels of the earth. In a word, the passage impresses the imagination as strange and awful, and we reassure ourselves perforce with the thought that these galleries are hewn in lava, and beyond danger of caving in; but a scratch of the nail on this supposed lava betrays the fact that it is friable and yielding, being only hardened ashes. In one of these tunnels, which are pretty regularly cut out, the guides show the print of a human face. We wonder at the unchanging solidity of a substance which once so finely moulded the objects it surrounded. Still, if you try to cut with a knife, not into the impression itself, but into the parts next it, you are amazed to find that nothing is easier, and that it is all mere solidified ashes.

One street of Herculaneum, in the outskirts, on the side nearest the sea, has been regularly excavated, and several houses cleared out—that called the house of the skeleton, the house of Argus, some shops, a slave-prison, and others—all is in the open air, and one can walk as in the streets of Pompeii. The space thus disentombed is from 3,000 to 4,000 square yards, a large-enough area for observations of the kind we are pursuing. Now no fragments of lava, not a vestige of it, are to be found there, nor any trace of injury caused by lava. On the contrary, on examining the perpendicular surfaces surrounding this four-sided space, every thing is ashes; 30 or 36 feet deep of ashes; only at the upper part a few bits of coal are seen, ejections from the volcano, layers corresponding with the modern eruptions, and separated by layers of vegetable earth which have had time to be deposited between the several eruptions. Look at the fragments of stuff dug out of one of those caverns—examine them—you will still find nothing in them but ashes, broken up by the pick as readily as clay or pumice.

But it may be asked, How could ashes which are light as dust, and with no coherence, gain hardness enough to take durable impressions, to form supporting arches, and to bear so delusive a look of solidity as to be taken for lava? The ready answer is found in the example of Pompeii, and the casts found in the cellars of Diomed's house; but similar and even more striking cases may help us to understand such power of adhesion. In the valleys of Monte Cavo there are ledges of *peperino*, formed by the filling up of volcanic ashes mingled with water. This compost grew so dense that the Romans used it for building-material. The Catacombs of Rome, which are nothing else than a volcanic tufa, that is, sand and pulverized fragments, compressed by time and their own weight, are in like manner friable, easy to cut, easier to rub down, and yet galleries are dug in them, arches, ceilings, stairways, numberless tombs, and as many as five stories of excavations, beneath each other! Nor must it be forgotten that pumice, which furnishes so excellent a water-lime, was taken originally from Pozzuola, near Vesuvius, and is nothing more than a ferruginous clay, once subjected to high volcanic temperature, and ejected in a shower of ashes. I recall, too, the great altar at Olympia, described by the traveller Pausanias, which was formed entirely from the ashes of the victims sacrificed to Jupiter. After every sacrifice the priests moistened the ashes with water from the Alpheus, smeared the altar with them, and so enlarged it gradually until, during ten centuries, the structure gained 125 feet in circuit, and 22 in height. Indeed, any one who has seen water flung into a fireplace may judge of the toughness of ashes when mixed with liquids; much more must the volcanic ashes of the Roman Campagna, of Naples and Santorin be suited for making cements.

For the rest, should this explanation only half satisfy the reader, there are the facts, and not to be denied. I defy any careful observer, examining the parts of Herculaneum hitherto brought to light, to discover any thing else in them than ashes. It may be that, on the surface of the existing soil of Portici, which has been raised at least 60 feet, marks of lava-flows are traceable which belong to modern eruptions, especially toward Resina. Neither can I affirm that, in some unexplored quarter of Herculaneum, the presence of lava may not some day be ascertained; but, as the present question is only about what we know, that is, the parts of the city which are visible, or examined already, I repeat that not the hundredth part of a square yard of lava can be found at Herculaneum, and that ashes are the only thing there is there.

The problem to be solved is, how so huge a mass of ashes was ever piled up above the unfortunate city, and, since water played so fearful a part in the catastrophe, whence that enormous quantity of water came. It is clear, in the first place, that these ashes were thrown out by the volcano. Judging from the character of the region, and from the vents formed at the mouth of the crater, the pumice-stones were all hurled toward Pompeii and Stabiæ, while the ashes drifted toward Herculaneum. Perhaps some allowance must be made for the wind which separated these substances, and the convulsions which ejected them irregularly. Then we must recollect that every very violent eruption is attended by steam produced by the sudden contact of fire with underground sheets of water. The origin of these sheets of water and the effect of their sudden gush into the furnace of eruption have been already explained. These vapors, exceeding the power of calculation in their volume and expansive force, condense at once on contact with the atmosphere; they cool, and fall again in torrents of rain. If M. Fougiré could demonstrate that in 1865, during an eruption by no means extraordinary, there fell on the mountain, in 24 hours, 22,000 cubic metres of water, the number must be multiplied by five, or even by ten, to represent that explosion of Vesuvius, A. D. 79, whose fury has never been equalled. Without adopting the hypothesis of mud-discharges from the crater, or citing the example of the volcanoes in Java, which eject mire instead of water-spouts, we may affirm that such volumes of water, mingling with the ashes and pulverized substances thrown out by other vents, suddenly produced a liquid compost, either in the air or on the ground they fell upon. The Neapolitans are familiar with a phenomenon of this sort, occurring more than once, though under limited conditions. They call it "muddy lava," and their use of the substantive would be correct if they always added the adjective, in saying that Herculaneum was buried under lava. Herculaneum, in fact, was buried by muddy lava, or, in simpler terms, by torrents of mud.

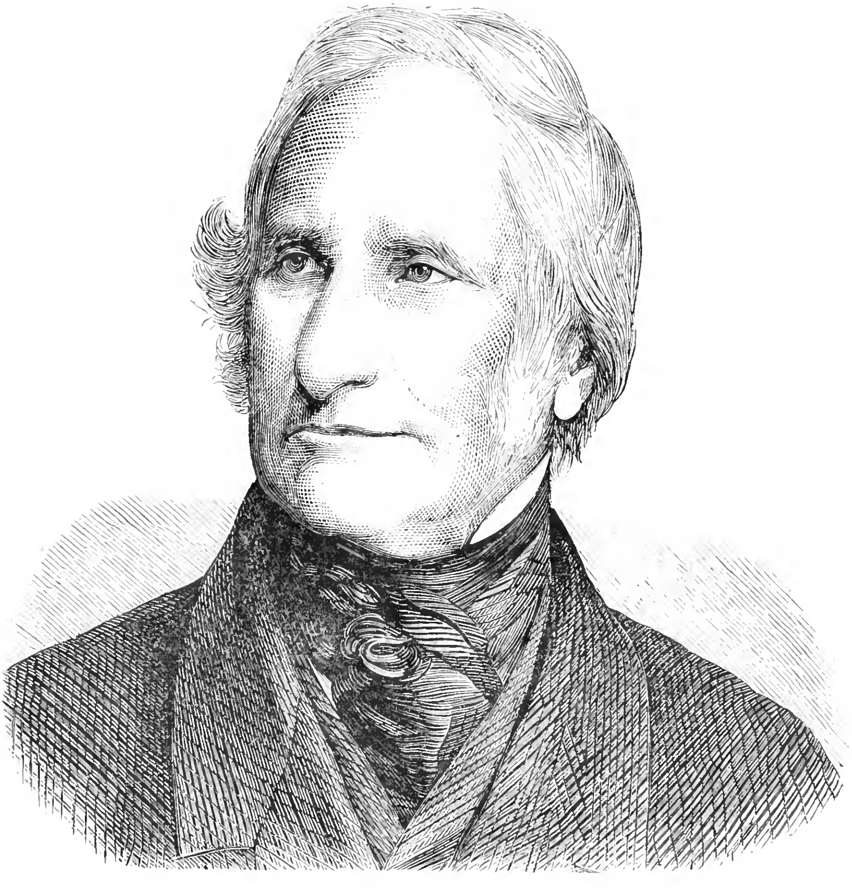
Moreover, these sudden rains, or, rather, deluges, pouring down from the sky at each outburst of steam, swept along all the ashes that had fallen on the slopes of the mountain, and carried them down upon the plain; an ash-avalanche rolled over Herculaneum. At the same time, the rivers, which ran to the right and left of the city, ceased to flow down to the sea. It has been explained how the coast was elevated, and Pliny's ships kept off, by sudden new shoals preventing access to the port of Resina. The effect of this lifting was to raise the mouths of the two rivers, and throw back their waters on the city, and this overflow added its share of mud, ashes, and vegetable matter. Nor must we omit the canals filled up, the sewers choked, the aqueducts shattered by the earthquake, and pouring their contents into the valley. By degrees, as the mud settled in the streets, the courts, rooms, and dwellings, the level of the water rose, new deposits gathered; the ashes falling in dense masses from the sky, grew saturated, and increased the rising heaps. Thus, in a few days, perhaps a few hours, a flourishing city was swallowed up, under an average thickness of sixty feet of mud. Those of the inhabitants who did not take flight at once, were drowned. In vain they climbed to the upper stories, then to the terraces and roofs—they perished at last, leaving the impressions of their bodies in the fluid ashes.

When the waters had drained away, nothing was to be seen but a grayish hillock, seamed on the surface by the streamlets which had been the last to dry up. Nothing rose above the surface, neither temple-façades, nor theatre-walls, nor tops of the loftiest buildings. Under a shell which would harden and thicken every day, Herculaneum was buried far otherwise than Pompeii had been. It was not fifteen feet of pumice stones that filled the ground floors and first stories of the houses up to the windows; it was 70 or 80 feet of compact matter that hid even the site of the city. The inhabitants who escaped must afterward have returned, as the Pompeians did; but, less fortunate, they could not revisit their homes, buried beneath their reach in unknown depths, without a trace to indicate them. Signs of excavation are thought to have been detected outside the city, above the rich villa in which the moderns have recovered 1,756 rolls of papyrus, but the owners did not dig deep enough, and their attempt was fruitless, as is proved by the art treasures discovered a century ago, which they would not have failed to carry away. It is likely that the chief impediment to digging, next to the depth, was the moisture of an alluvial deposit, in which any work soon became impossible.

But after sixteen centuries the moisture had evaporated, and the muddy lava at this day is compact and resistant enough to permit excavations in all directions throughout it. The surface has been restored to cultivation and covered with houses; Portici and Resina are populous and flourishing towns. New eruptions wrapped Herculaneum in a thicker pall, and it seemed forever blotted out from the world, until, in 1684, a baker, in digging a well, came upon ancient ruins—those of the theatre—and brought the buried city again to light.

SKETCH OF GENERAL SIR EDWARD SABINE.

WE furnish our readers this month with an excellent likeness of the venerable President of the Royal Society, England, who will have a permanent and distinguished place in the history of science through his researches on terrestrial magnetism, of which he may be regarded as the pioneer explorer. He is of Irish ex-



GENERAL SIR EDWARD SABINE.

President of the Royal Society.

traction, though descended from an ancient Italian family, and was born in October, 1788. He entered the army, and became second-lieutenant at the age of fifteen, captain at twenty-five, colonel at sixty-three, major-general in 1859, at the age of seventy-one, and was created Knight-Commander of the Order of the Bath, in 1869, at the age of eighty-one. During the war with the United States he took part in the campaign of 1814, on the Niagara frontier, when he commanded the batteries at the siege of Fort Erie. He first became known to the public by the part which he took in the Arctic Explorations in 1818–'19. He here made a series of magnetic observations of great value, an account of which was published in two papers, which he communicated to the Royal Society on his return. These and other papers, printed in the Philosophical Transactions, demonstrated several new and important facts relative to the variations of the magnetic needle, and it was the results of the observations in these northern voyages which gave the first great impulse to the systematic study of the phenomena of terrestrial magnetism. The strong desire of continuing the investigation of this and other branches of experimental physics, prompted him to undertake a series of voyages to places between the equator and the north-pole, making at each point observations on the length of the seconds-pendulum, and on the dip and intensity of the magnetic needle. The fruits of these labors were of high importance, and were published, along with other information, in 1825, and from this period his history is that of a studious investigator into the laws of and phenomena of Nature. In 1827 he was chosen secretary of the Royal Society, which office he filled until 1830. In 1836 he communicated to the British Association at Bristol his observations on the declination and intensity of the magnetic force in Scotland, and to the same Association he delivered at Liverpool a report on the variations of magnetic intensity at different parts of the earth's surface. His labors have led to the discovery of the laws of "magnetic storms," of the connection between certain magnetic phenomena and the changes of the solar spots (already referred to), and of the magnetic action of the sun and moon on the earth. General Sabine deserves almost the sole credit of extending the body of known facts in magnetic science, by the establishment of magnetic observatories in all parts of the world, and the collation of the enormous mass of facts thus acquired. He has contributed, to various scientific societies, numerous papers which display great powers of research. He edited Mrs. Sabine's translation of Humboldt's "Cosmos," published in 1849–'58.

Colonel Sabine was elected Fellow of the Royal Society in 1818, and President of the British Association for the Advancement of Science, at its Belfast meeting, in 1852. He succeeded Sir Benjamin Brodie, as President of the Royal Society, in 1861, and continues to discharge the duties of this office, at the advanced age of eighty-four.

EDITOR'S TABLE.

SOCIOLOGICAL SCIENCE IN ITS LATER STATEMENTS.

THAT man, as an individual, exemplifies the action of law in the various parts of his nature, and is hence the subject of science, everybody now understands: but that men collectively, or in social relations, are governed by natural laws which are capable of scientific investigation, is only beginning to be seen and admitted. If there are natural laws which determine the social state, it is certainly of the highest importance that they should be known. Legislation, philanthropy, and all projects of social amelioration and reform, must be but futile and quackish expedients, so long as men are ignorant of the natural forces, and orderly method, by which human society has been originated and is regulated. Social phenomena have their laws like all other phenomena, and it is the sole business of science to elucidate and declare them. Science has no schemes to propose, no reforms to carry out. Whether society is bad or good, rude or cultivated, getting better or getting worse, developing or perishing, it is all the same: science simply takes note of the facts, and draws from them the general principles to which social changes conform, and the systematic statement of which constitutes true social science.

It is from this point of view that the subject has been approached by Herbert Spencer, who is now acknowledged to be the foremost living expositor of pure scientific sociology. Some confusion has arisen in the public mind in regard to the various works bearing upon this subject which he has undertaken, and for the benefit of those interested we propose to explain his method of dealing with it, as this may prove instructive in relation to the character of the inquiry itself.

Mr. Spencer was attracted to social studies in his youth. His first publication was a pamphlet on the proper sphere and functions of political government, and his first book was a treatise on society, known as "Social Statics." It was a work of great originality and power of statement, and its fundamental idea was that of his present philosophical system, the idea of evolution; but it was only imperfectly worked out, and the effect upon Mr. Spencer's mind of preparing the volume was to convince him that the whole question of the natural laws of society would have to be taken up in a more thorough and comprehensive way, before the requirements of science could be satisfied. As society is made up of men, its deepest laws must be derived from the natures of men. The first thing to be done, therefore, was to inquire what there is in the constitution of human nature which must be known, before social effects can be understood. Man's nature is twofold, vital and psychical; and all social phenomena are phenomena of life and thought, which determine human actions. The laws of life give rise to the science of Biology; the laws of thought and feeling, which depend upon life, give rise to the science of Psychology; and a knowledge of these subjects forms the indispensable basis of Sociology. So clear and close is this dependence, and so comprehensive and complex the investigation, that Mr. Spencer soon saw he must give his life to it, if it was to be adequately done. He accordingly laid out his plan of work in 1859, and commenced its execution in 1860, allowing twenty years for its completion. His first volume was preliminary, and contained an exposition of his method, under the title of "First Principles." Then followed two volumes of the "Principles of Biology," which was succeeded by two volumes of the "Principles of Psychology." This work is just finished, and takes him half through his undertaking. He has now before him the subject of Sociology, which he proposes to treat in three volumes of the "Principles of Sociology," to be commenced this winter. His Philosophical Series will be completed by two additional volumes of the "Principles of Morality," as deduced from the whole system of facts and principles established in the preceding works.

At this stage of his enterprise, Mr. Spencer encounters certain difficulties which have to be met by what we may call side-undertakings—works which have an important bearing upon the subject of Sociology, but are not properly parts of his philosophical system. The articles that are appearing in The Popular Science Monthly, and which, when completed, will form a volume of the International Scientific Series, are designed to explain the nature, scope, and claims of Social Science. Such are the general doubt and misapprehension regarding this subject, that Mr. Spencer was induced to pause for a little at this stage of his labors, and present some considerations of the method and subject-matter of Sociology which are greatly needed by the public, and which do not properly fall within the course of his regular exposition. It is important to make this explanation, as the papers we have published have been supposed, by some, to be a part of his long-expected "Principles of Sociology."

Another of the difficulties of his undertaking was foreseen by Mr. Spencer several years ago, and has led to a separate work, which, though indispensable to the main plan, is nevertheless of independent value, and of great public importance. As the scientific character of his philosophy is fundamentally inductive, the first work in each department is the collection of data on which inductions are to rest. The data of Biology are accessible in treatises on Natural History, where they can be obtained in a digested and authentic form, while any defects may be supplied by special investigations. The data of Psychology are also available in scientific works upon that subject, and the conditions for extending and verifying them can be commanded anywhere. But, as respects its data, Sociology is very different from these sciences. Dealing with the phenomena manifested by diverse races and communities of men; dealing with the development of society, which is a problem of history; dealing with those facts of the social state which illustrate its natural laws; and dealing, moreover, by a scientific method, with a great subject which has hitherto been regarded as not amenable to that method, the difficulty of gathering the indispensable and pertinent facts for such an inquiry was formidable. History has occupied itself with quite other things than the record of such facts. Travellers fill their pages with chaffy gossip and egotistical narrative, and give but little attention to the social facts which it is most desirable to know. Their observations are careless, and their statements loose and often untrustworthy. Nobody has taken pains to collect and sift from the vast mass of historical rubbish and the bulky litter of travellers the few and scattered statements which throw light upon the laws of social life. Before there can be a science of Sociology presenting the generalizations of social phenomena, there must first be an accumulation and a classification of its data. What these are it is important to understand, and, in a remarkable passage of a review article published by Mr. Spencer in 1859,[1] he thus states them:

That which constitutes History, properly so called, is in great part omitted from works on the subject. Only of late years have historians commenced giving us, in any considerable quantity, the truly valuable information. As in past ages the king was every thing and the people nothing, so, in past histories, the doings of the king fill the entire picture, to which the national life forms but an obscure background. While only now, when the welfare of nations rather than of rulers is becoming the dominant idea, are historians beginning to occupy themselves with the phenomena of social progress. The thing it really concerns us to know is, the natural history of society. We want all facts which help us to understand how a nation has grown and organized itself. Among these, let us of course have an account of its government; with as little as may be of gossip about the men who officered it, and as much as possible about the structure, principles, methods, prejudices, corruptions, etc., which it exhibited: and let this account include not only the nature and actions of the central government, but also those of local governments, down to their minutest ramifications. Let us of course also have a parallel description of the ecclesiastical government—its organization, its conduct, its power, its relations to the State; and, accompanying this, the ceremonial, creed, and religious ideas—not only those nominally believed, but those really believed and acted upon. Let us at the same time be informed of the control exercised by class over class, as displayed in social observances—in titles, salutations, and forms of address. Let us know, too, what were all the other customs which regulated the popular life out-of-doors and in-doors, including those concerning the relations of the sexes, and the relations of parents to children. The superstitions, also, from the more important myths down to the charms in common use, should be indicated. Next should come a delineation of the industrial system: showing to what extent the division of labor was carried; how trades were regulated, whether by caste, guilds, or otherwise; what was the connection between employers and employed; what were the agencies for distributing commodities; what were the means of communication; what was the circulating medium. Accompanying all which should be given an account of the industrial arts technically considered: stating the processes in use, and the quality of the products. Further, the intellectual condition of the nation in its various grades should be depicted; not only with respect to the kind and amount of education, but with respect to the progress made in science, and the prevailing manner of thinking. The degree of æsthetic culture, as displayed in architecture, sculpture, painting, dress, music, poetry, and fiction, should be described. Nor should there be omitted a sketch of the daily lives of the people—their food, their homes, and their amusements. And, lastly, to connect the whole, should be exhibited the morals, theoretical and practical, of all classes, as indicated in their laws, habits, proverbs, deeds. These facts, given with as much brevity as consists with clearness and accuracy, should be so grouped and arranged that they may be comprehended in their *ensemble*, and contemplated as mutually-dependent parts of one great whole. The aim should be so to present them that men may readily trace the *consensus* subsisting among them, with the view of learning what social phenomena coexist with what others. And then the corresponding delineations of succeeding ages should be so managed as to show how each belief, institution, custom, and arrangement, was modified, and how the *consensus* of preceding structures and functions was developed into the *consensus* of succeeding ones. Such alone is the kind of information, respecting past times, which can be of service to the citizen for the regulation of his conduct. The only history that is of practical value is, what may be called Descriptive Sociology. And the highest office which the historian can discharge is that of so narrating the lives of nations as to furnish materials for a Comparative Sociology, and for the subsequent determination of the ultimate laws to which social phenomena conform.

In this statement of the missing elements of history, Mr. Spencer has outlined just that body of facts which are indispensable as the foundation of a valid social philosophy; and he foresaw that, before any such philosophy can be constructed, these facts must be systematically and exhaustively supplied. The labor of their careful collection could not fail to be enormous, and its expense, together with their

[1] "What Knowledge is most worth" (*Westminster Review*).

publication, heavy; yet it was essential to the completeness of his system and of immense importance to the progress of knowledge, and Mr. Spencer did not for a moment hesitate to undertake it. He first devised a system of tables suited to present the whole scheme of social facts, displayed by any community, in such a manner that these facts can be compared with each other at a glance, while the social elements of different communities can also be brought into comparison with the greatest facility. These Sociological Tables are marvels of analytic skill, simplicity, and comprehensiveness; and the command they give over the results of investigation is commensurate with the greatness of the subject to which they apply.

Having fixed upon a method of presentation, Mr. Spencer divided the communities of mankind into three great groups: the existing savage races of Asia, Africa, and America; the existing civilized races of Western Europe; and the extinct civilizations of Egypt, Palestine, Greece, Rome, and Peru. Five years ago he engaged an able scholar—a graduate of the University of Edinburgh—to devote himself to the study of the savage races, and gather from all the most reliable sources the facts relating to their social state. The Tables are then gradually filled in, and each one becomes a summary, we might almost say a map, of the social condition of the community to which it is devoted. The first volume of the Sociological Tables will embrace descriptions of some seventy or eighty of the principal savage tribes, and will be accompanied by an octavo volume of extracts from the authorities consulted, and on which the summary of the Tables rests. This portion of the undertaking is now nearly completed. Another able scholar—also an Edinburgh graduate—has been for some years engaged upon the existing civilizations, the results of which will be published in a second volume of Tables and the second accompanying volume of authorities, and this work is also well advanced. A German historical student has also taken up the extinct civilizations, and will prepare the third volume upon this division of the subject. We shall thus have the full realization of what Mr. Spencer pointed out many years ago, in the above-quoted extract, as a great desideratum, and which will create the new and important science of Descriptive Sociology. It is hardly necessary to say that such a work will stand upon its own merits, and have a general usefulness that will no way depend upon Mr. Spencer's philosophical doctrines.

A CORRECTION.

Mr. Editor.—In one of the late numbers of your periodical, I observe that you say, in casually alluding to my Chicago Address, that I treat the doctrine which classes mental and physical forces in the same category as being "heretical." There is but one sense in which the word "heretical" can be properly understood, or even understood at all—and that is, the sense of opposition to the prevailing religious belief. Understanding the word in this sense, there can be no difference of opinion whatever, among any of the parties to this discussion, as to the "heresy" involved in the doctrine in question. The doctrine is as much heretical in your view, and in Mr. Herbert Spencer's, as it is in mine.

But, the inference which the reader is left necessarily to draw from your remark is, that I attempted to controvert the doctrine, *on the ground* that it is heretical—a thing which I did not do at all. I did not even, if I remember aright, take the trouble to remark that the doctrine *is* an heretical doctrine, that being a thing so obvious that it may be allowed to "go without saying." My actual argument was that, in assuming the equivalency and convertibility of mental and physical forces, we are unavoidably led to conclusions which contradict (not *religious dogmas*, of which I said not a word, but) well-established principles of Physics themselves.

Your reference to my Address was so casual and slight, that it may hardly seem sufficient to justify this seriousness of remonstrance, but, slight as it was, it placed me wholly wrong before the readers of the MONTHLY, the greater number of whom have probably not seen my Address.

I am, very respectfully,

F. A. P. BARNARD.

COLUMBIA COLLEGE, *October* 9, 1872.

LITERARY NOTICES.

A HANDBOOK OF CHEMICAL TECHNOLOGY, by RUDOLF WAGNER, Ph. D., Professor of Chemical Technology at the University of Wurtzburg. Translated and edited from the eighth German edition, with Extensive Additions, by WM. CROOKES, F. R. S.

TECHNOLOGY is the term now generally applied to the applications of the principles of science to the arts of industry. The earth in its matter and its forces is a treasury of material for the service of humanity. These materials furnish the aliment by which our bodies are daily nourished, the textures with which we are clad, the buildings that shelter us, and the innumerable objects of use and pleasure that minister to the service of civilized man. The transformations of matter constitute the great business of mankind in all stages of its development. In the lowest stage they are few in number, crude and imperfect in form, and wasteful both of material and of power applied. Nothing is understood, and blind groping leads to scanty and uncertain results. For every particle of matter is bound in the meshes of inexorable law, and the sole condition on which refractory Nature can be conquered and put to use, is that of knowledge. Science creates this knowledge, and thus becomes the guide of industry. The office of science in directing the operations of labor is now the great fact of civilization, and it is daily becoming of more importance to all classes of the community. Processes are daily becoming more expeditious and more perfect; the uses of things are more extended; new objects of value are created; waste-products are utilized; and the economy of effort in production vastly augmented. There is still great deficiency of scientific knowledge on the part of artisans; but large manufacturing establishments have their scientific directors and advisers, while the movement for extended technical education is participated in by all the leading nations of the world.

Technology, though always grounded in science and starting from it, is not in itself a science like astronomy or mechanics, that is, a body of inductive truths applying to specific divisions of natural phenomena, nor is it mainly concerned with true scientific work which is the elucidation of the laws of phenomena. It begins where science leaves off, or rather at the highest point which it has attained, and turns scientific results to practical account. Nevertheless, technology is by no means passive in the research after new truths. Its office being to carry out, or to verify, on a comprehensive scale, the results of pure scientific investigation, it cannot fail to react powerfully upon the work of original investigation. It is constantly putting questions, wanting further explanations, and demanding more light; and by thus forcing tangible problems upon the scientist, under pressure of great interests involved, it both stimulates research and furnishes the experimenter with what he most wants—a definite subject to be worked out. The peril of the technologist of falling into routine, and following blind rules, is thus constantly checked and more or less counteracted by the influence of his own difficulties, and the need of frequent appeal to those whose business it is to explain them.

The raw materials of Nature, which require transformation before they can be available for human use, take two routes to this destination. They either go by the mechanical way, or by the path of chemistry, and so we have two kinds of technology —mechanical and chemical. Mechanical technology deals with the outward changes of natural products, or alterations of form only, as, for example, the joiner and carpenter working in wood; the making of iron rails, sheath-metal, and wire; the casting of iron, zinc, and alloys of copper, into various objects; the spinning and weaving of various fibres, flax, cotton, jute, to become materials of greater value; also the manufacturing of paper from rags, of horn into combs, and of bristles into brushes—all these operations belong to this section.

Chemical technology, on the other hand, as Dr. Wagner observes, "deals with the operations by which the raw material is not only changed in its form, but especially as regards its nature; such, for instance, is the case with the extraction of metals from their ores; the conversion of lead into white-lead and sugar of lead (acetate of lead); the conversion of sulphate of baryta into chloride of barium and baryta white (permanent or Chinese white); the conversion of cryolite into sulphate of alumina, alum, and soda; the conversion of rock-salt into sulphate and carbonate of soda; the conversion of carnollite and kainite into chloride and bromide of potassium, sulphate and carbonate of potassa; the conversion of copper into verdigris and sulphate of copper; the manufacture of paraffin, and paraffin or crystal oils from peat, Boghead coal, and lignite; the preparation of kelp and iodine from sea-weeds; the manufacture of stearine-candles (stearic acid properly) and soap from oils and fats; the preparation of sugar and alcohol from starch· the conversion of alcohol into vinegar; the brewing of beer from barley and hops; the manufacture of pig-iron into malleable iron (puddling process), and the conversion of malleable iron into steel; the production of gas, coke, and tar from coals; the extraction from the tar of such substances as benzol, carbolic acid, aniline, anthracen, asphalte, naphthaline; the preparation of tar-colors, as rosaniline, aniline blue, Manchester yellow, Magdala red, alizarine, iodine green, picric acid, etc."

These illustrations of the scope and character of chemical technology give also an idea of the quality and range of Dr. Wagner's book. For twenty years he has held an eminent position in Germany as an authority upon technology, and his voluminous annual reports upon the subject have been the standards of reference in regard to its progress. The first edition of the present hand-book was published in 1850; and the eighth edition, which appeared last year, is now translated, and is the first that appears in English. The volume is a compact cyclopædia of the most recent and accurate knowledge on a wide range of practical subjects, and will be of great value to the industrial and manufacturing interests of the country.

The Great Problem: The Higher Ministry of Nature viewed in the Light of Modern Science and as an Aid to Advanced Christian Philosophy. By John R. Leifchild, A. M., author of "Our Coal-Fields and our Coal-Pits," "Cornwall: Its Mines and Miners," etc., etc. With an introduction by Howard Crosby, D. D., LL. D., Chancellor of the University of New York. 543 pages. George P. Putnam & Sons.

Mr. Leifchild's book, entitled "The Higher Ministry of Nature," has been republished by the Putnams, who have appropriately prefixed to it the title "The Great Problem." The general aim of the author, who is a semi-preacher and semi-geologist of London, is to show that the higher teachings of Nature confirm true religious faith instead of subverting it; but he feels it incumbent upon him to go into all the controverted questions of the time in theology, metaphysics, and science, and is equally ready in the treatment of theism, pantheism, the unknowable, Spinozism, Darwinism, evolution, morals, the correlation of forces, protoplasm, and other knotty matters too numerous to mention.

The American volume comes well commended to the public. A gentleman high in the honors of scholarship, and the responsibilities of education, and who presides over our metropolitan university, has prepared a compact and telling introduction to Mr. Leifchild's volume, in which he assures us that it is a work that strips off disguises and goes to the core of things. His decisive views are put in a narrow compass, so that we are happily enabled to give them complete to the readers of the Monthly. If any should happen to think that the volume lacks point and incisiveness, they will find this quality eminently supplied in the chancellor's brief prologue. When, however, he calls for a thousand such books, we think he under-estimates the potency of a smaller number, for certainly, before a score had made their appearance, "The Modern Huxleys," whose skins are so ruthlessly stripped off, would call upon their eternal protoplasmic firmament to fall upon them and hide them forever from the calamities to come.

The author of the performance before us is of a most conservative temper, and refrains from altering even by a hair's-breadth any of the questions he has undertaken to discuss. All the conflicts, confusions, and obscurities of the subject, are faithfully reflected in his pages. For the alleged stripping off of disguises and plucking out the core of things, we have sought in vain, our impression being that this is exactly what the author has avoided. The assiduity with which he leaves things as he finds them is remarkable, and this trait gives a special value to his treatment of the subject. What is denounced by many people, Mr. Leifchild denounces, and what is indorsed by many other people, Mr. Leifchild indorses, and, if it happen to be the same thing, that is none of *his* business. Mr. Lyell's views of species are quoted, and then it is naively stated that Mr. Lyell has abandoned them—with Mr. Lyell be all the responsibility. His book may therefore be taken as having some value in indicating the various drifts of public opinion. Mr. Herbert Spencer is freely denounced by certain parties as the prince of materialists and the arch-enemy of all religion, because he is the leading exponent of the doctrine of evolution, and Mr. Leifchild joins in the condemnation, and quotes President Porter, of Yale, exultingly as the great "Spencer-crusher." But there are others who maintain that the doctrine of evolution is not necessarily atheistic, or materialistic, or destructive of religion, and with these also Mr. Leifchild is in equal accord. Lest the readers of Chancellor Crosby's introduction should be puzzled at this statement, and perhaps a little skeptical about it, we quote the following passages from "The Great Problem:"

"The earnest and increased study of Nature in our day leads us to much broader views of Divine action than have been formerly entertained; and to these views natural science conducts us without really leading us away from the Deity. Just as we now discover more and more geographically, so we discern more and more theologically. The earth is far larger to us than to Herodotus; Columbus was a far better geographer than the Grecian; but the discovery of America did not annul the existence of England or Spain. The discovery of new stars does not extinguish the old stars, does not darken one beam of their light. In like manner, the discovery of Natural and Sexual Selection, or rather the application of them, does not limit the action of the Creator" (p. 256). "The unity of Evolution, as comprehended by the Cosmos, is aptly described by Mr. Spencer, who shows the higher generalization of our knowledge concerning Evolution to be—so far as we know the constitution of the world—one unceasing and all-perfecting system, advancing everywhere and in all. After elaborately working out his own theory, Mr. Spencer suggestively intimates that the laws of Evolution, contemplated as holding true of each order of existence separately, hold true when we contemplate the several orders of existences as forming together one natural whole. While we think of Evolution as divided into Astronomic, Biologic, Psychologic, Sociologic, etc., it may seem to a certain extent a coincidence that the same law of metamorphosis holds throughout all its divisions. But when we recognize these divisions as mere conventional groupings made to facilitate the arrangement and acquisition of knowledge—when we regard the different existences with which they deal as component parts of one Cosmos—we see at once that there are not several kinds of Evolution having certain traits in common, but one Evolution going on everywhere after the same manner. While any whole is evolving, there is always going on an Evolution of the parts into which it divides itself. This holds true of the totality of things as made up of parts within parts, from the greatest down to the smallest. We know that, while a physically cohering aggregate like the human body is getting larger, and taking on its general shape, each of its organs is doing the same; that, while each organ is growing and becoming unlike others, there is going on a differentiation and integration of its component tissues and vessels; and that even the components of these components are severally increasing and passing into more definitely heterogeneous structures. But we have not duly remarked that, setting out with the human body as a minute part, and ascending from it to the greater parts, this simultaneity of transformation is equally manifest; that, while each individual is developing, the society of which he is an insignificant unit is developing too; that, while the aggregate mass forming a society is becoming more definitely heterogeneous, so likewise is that total aggregate, the Earth, of which the society is an inappreciable portion; that, while the Earth, which in bulk is not a millionth of the solar system, progresses toward its concentrated and complex structure, the solar system similarly progresses; and that even its transformations are but those of a scarcely appreciable portion of our sidereal system, which has at the same time been going through parallel changes" (p. 260). "The more I can understand of the manner of Evolution, the more am I impressed with its unity of purpose, even in full view of its multiplicity of parts, and manifoldness of stages. From increase of such knowledge I rise into higher perceptions. I see rhythm in every motion on the earth, rhythm therefore in combined motions, a wonderful rhythm pervading the Cosmos" (p. 259). "What can we say of Evolution? if we treat it reverently, and not atheistically, we can only say that it presupposes an evolver, and that such an evolver must be Divine" (p. 257). "The manner of his unfolding is the true and limited province of physical inquiry; yet a noble province it is, rich in results, fair with flowers by the wayside, and abundant in promise for future ages. Men are observers of natural development; whether or not included in it; they watch its progress in other existences with deep interest. Every advance in it is fitted to impress the beholder with admiration, and to direct him not only to the advance itself, but to convert him from a mere interpreter of stage after stage into an obedient servant and reverent worshipper of the grand Evolver."

The Ancient Stone Implements, Weapons, and Ornaments, of Great Britain, by John Evans, F. S. A., Honorary Secretary of the Geological and Numismatic Societies of London, etc., etc.

The author of this work is the highest authority in England—perhaps the highest in the world—upon the subject of which it treats. A gentleman of extensive means and a laborious student, he has taken up that great division of Prehistoric Archæology which deals with the vestiges of man in the age of stone, and in the present volume we have the matured and comprehensive results of his inquiries. He has concentrated his main attention upon England, and given an exhaustive presentation of the evidence that has now been gathered, regarding the primitive state of the inhabitants of that island, when their implements of war and peace were chiefly constructed of flint. The volume is a valuable contribution to the obscure but interesting question of the antiquity of man, and the primeval conditions of his life. Mr. Evans is not a partisan, or a propagandist of any extreme views upon this subject, but deals with it simply as a scientific question, to be elucidated by the painstaking accumulation of the relics of antiquity which yet remain, and which are becoming more varied and abundant with increasing search and observation. He has figured in his pages about 800 objects—arrow-heads, daggers, knives, axes, hammers, adzes, picks, chisels, gouges, drills, scrapers, whetstones, stone-vessels, buttons, rings, necklaces, bracelets, and various other things—stating their locality and under what circumstances they were found. Great care has been taken with the illustrations, Mr. Evans having spared no expense in procuring the best artistic talent in order to secure the highest accuracy of representation. The book is valuable for the fidelity of its preparation, both in a scientific and artistic point of view, and, as it contains most of the information at present available with regard to the class of antiquities of which it treats, it will at once take eminent rank among treatises upon this branch of the natural history of man.

A Manual of Microscopic Mounting, with Notes on the Collection and Examination of Objects. By John H. Martin. Philadelphia: Lindsay & Blakiston, 1872.

The necessity of the microscope to the naturalist and physician, and its wide employment as a means of recreation and study by the non-professional, have created a demand for something that shall serve as a guide in the delicate operations connected with its use. So far as the management of the instrument itself is concerned, this has been supplied in various treatises; but, with the exception of incidental directions, widely scattered, and therefore not readily accessible, we do not remember to have seen any thing recent that would help the student in the preparation and mounting of specimens. Yet this is by far the most difficult part of microscopic work, and, after the management of the instrument has been learned, the beginner not unfrequently breaks down, or becomes sorely discouraged in his attempts to prepare and mount his objects. But, if he fails to master this department, all opportunity for original research is precluded, and he is compelled to rely on the use of purchased slides, which, often got up merely "to sell," are not always to be depended on. His need is a set of clear and explicit directions in regard to all the important details of this part of the work, and this the book before us appears well designed to fill.

Beginning with the illustrated descriptions of all the necessary apparatus, and minute directions for its use, there follow very complete explanations of the various methods of mounting, with careful directions how to proceed in each; and after this the manner of preparing specimens for the purpose of mounting is very fully treated. How to collect, label, and temporarily preserve all sorts of objects intended for mounting is next considered; and then we come to the seventh and last chapter, which gives instructions how to proceed in the examination of organic and inorganic substances, with tests for adulterations—a branch of microscopic work of much practical importance.

The book closes with an appendix, containing some seventy-five receipts for preparations useful to the microscopist, and a short explanation of how to convert and correct microscopic measurements. It is also provided with a good index.

Thoughts for the Times. Sermons by the Rev. H. R. Haweis, M. A., Incumbent of St. James's, Westmoreland Street, Marylebone, London, Author of "Music and Morals," etc.

We have read Mr. Haweis's "Thoughts for the Times" with much interest, and believe it is destined to make a deep and wholesome impression upon many minds. Books of sermons are getting to be very different things from what they were formerly, and this is one of the improved kind—a book of broad, liberal, and decisive views, applied to practical questions. It is a work of the type of "Robertson's Sermons," fresh and breezy with the stir of living thought, strong in criticism, and thoroughly hospitable to modern ideas. Mr. Haweis does justice to those whom sermonizers generally delight to denounce, and in his search for truth he does not neglect its latest forms. Instead of sounding the alarm-bell, and proclaiming the peril of religion at every step in the onward course of Science, he denies the antagonism, and is in no dread that faith will be destroyed by any discoveries that can be made concerning the order of Nature. While the whole book is pervaded by independent thought, and by a devotional and reverent spirit, the sermons upon the "Idea of God" and the "Law of Progress" are especially significant and instructive.

A Compendious Manual of Qualitative Chemical Analysis, by Charles W. Eliot and Frank H. Storer. Revised, with the Coöperation of the Authors, by Wm. Ripley Nichols. New York; D. Van Nostrand, Publisher, 1872.

No field of literature has been more cultivated, and yet with so little apparent success, as that of elementary text-books, and particularly is this the case in the department of science and technics. Every new effort in this direction is therefore fully deserving of all the encouragement which can conscientiously be extended to it. And we are sure that the little book on Qualitative Chemical Analysis by Messrs. Eliot and Storer deserves as full a measure of recommendation as the success of its first edition implies. It is a book especially adapted to the necessities of the beginner in this branch of chemical technics, and will leave him, if not inclined to pursue the subject into the higher details of analytical practice, with sufficient knowledge of the subject for the man of culture, or, if so inclined, will fit him to erect the edifice of his chemical education on a firm foundation of elementary knowledge.

The Gardener's Monthly.—The amateur in need of practical directions as to the laying out and tending of a garden, and the choice of plants, shrubs, etc., cannot do better than to subscribe for this exceedingly valuable little monthly. He will there always find, in the "Monthly Hints," just the information he is likely to want, coming precisely in season for him; while in the department of "Communications" he will have detailed in brief the experience of some of the most successful amateur and professional gardeners in the country. A glance at the headings of the various departments of this magazine will perhaps best show the ground it is intended to cover. Besides the two already mentioned, we have the following: Editorial, Scraps and Queries, Book Notices, New and Rare Plants, Fruits, etc., Foreign Correspondence, Horticultural Notes. Mr. Thomas Meehan is the editor; and, this said, there is no need of further commendation of the magazine. $2.00 per annum. Philadelphia: Published by Charles H. Marot, 814 Chestnut Street.

THE BEE-KEEPER'S MAGAZINE (H. A. King & Co., 14 Murray street, N. Y.), the initial number of which is out, presents a very creditable appearance, and will no doubt be favorably received by the special public to which it is addressed. It has a very interesting table of contents, and a handsome chromo frontispiece, "A Group of Honey Plants."

BOOKS RECEIVED.

Annual Report of the Director of the Meteorological Observatory, Central Park, New York, 1871.

Reports on the Observations of Encke's Comet during its Return in 1871. By Asaph Hall and William Harkness. Washington: Government Printing-Office, 1872.

The Health and Wealth of the City of Wheeling, etc. By James E. Reeves, M. D. Baltimore, 1871.

MISCELLANY.

Facts relating to Niagara.—We have received a letter stating that the article on Niagara Falls, which was published in the September MONTHLY, contains various inaccuracies, the following being the most important. The author of the article states that a barrier fifteen feet high, stretching across the plateau at the head of the rapids, would throw the water back on Lake Erie. Our correspondent objects that this barrier would have five feet of water flowing over it. The critic further states that the writer of the article blunders about the source of Gill Creek, in such a way as to require its waters to rise 350 feet before they could discharge into Niagara River; and, finally, the author of the article affirms that the falls, in cutting their way southward, have lost 35 feet in height each mile, which, in 6½ miles, the distance to Lewiston, would amount to 227 feet, while our correspondent affirms that this loss of height is but 99 feet.

The Monas Prodigiosa.—In our common household experience we may often observe the sudden appearance of a phenomenon, which, as is remarked by a writer in the *Danziger Zeitung*, is of great interest, both from the historical and the scientific point of view. The writer says that housewives in Dantzic must have noticed blood-red spots making their appearance on farinaceous articles of food, when laid aside for a little while. This phenomenon has been often observed in that city lately, and is attributable to the presence in the food of a microscopic animalcule in the lowest stage of organic development, and consisting of a single mucous sac; though the botanist would perhaps class it among plants. It is probable that house-flies transfer from place to place these animalcules, which adhere to their feet, and thus occasion in provisions those apparent spots of blood which cause housewives so much annoyance. These animalcules acted an important and tragic part in the history of the middle ages, producing the phenomenon of *bleeding hosts* which repeatedly gave the signal for fearful persecutions of the Jews. It will be remembered that in those ages of fanaticism the Jews were often accused of stabbing the consecrated Host, and causing it to bleed, and on this charge over 300 Jews were at one time put to death in Basle, during the fourteenth century. Bolsena, a town in the late Pontifical States, was once the scene of a great miracle, produced by these animalcules. Down to the present day they exhibit at Bolsena, as a famous relic, the robe worn by a certain priest who, in the act of consecrating the eucharistic elements, entertained a doubt as to transubstantiation, when suddenly he perceived on his alb (white robe) drops of blood, which had previously been concealed by the plaits of the garment. He hastened to hide the stain, but in the excited state of his imagination only saw the appearances of bleeding hosts multiplying. This wonderful occurrence (as it was then esteemed) gave occasion to the establishment of the festival of Corpus Christi by Pope Urban IV., and is the subject of Raffaelle's beautiful *Miracolo di Bolsena*, which he painted in the year 1512. The well-known *savant*, Ehrenberg of Berlin, was the first to attempt an explanation of the occurrence, by assigning natural causes for it. A Berlinese lady, having shown to him some potatoes boiled in their skins, and then laid aside for the space of one day, with a deep-red color appearing where the skins had burst, he discovered the existence, at the broken places, of a microscopic animalcule $\frac{1}{3000}$ to $\frac{1}{8000}$th of a line in diameter, which he recognized as the cause of the phenomenon. In memory of the marvels wrought by the creature in past times, he gave it the name of *Monas prodigiosa*—the miraculous monad.

"The City of the Future."—There is a tendency among the more comfortable classes to make cities merely places to work in, but to abandon them for the country as soon as business is over for the day. Mr. O. B. Bunce, in Appletons' Journal, opposes this movement, and claims for city-life superiority over country-life, in almost every respect. He proposes to utilize the pure air above our heads, by erecting buildings of many stories, with steam-elevators and every modern convenience. This would bring the entire population within easy reach of the theatre, lecture- and concert-hall, art-gallery, museum, etc. In short, the writer makes out a strong case for the city, as regards intellectual life. Then come physical health and comfort. It is an error to suppose that the city is less salubrious than the country; a walk up Broadway is sufficient to prove this. Dyspepsia, rheumatism, and diseases arising from damp houses and undrained lands, are more common in the country. The city, too, is not subject to the plague of mosquitoes. The writer would have city people employ all the resources of science, to evolve from their surroundings all the health and comfort, all the enjoyment and intellectual life, which the town can afford.

An Aged Carp.—The following remarkable story concerning the age of a carp recently killed at Chantilly, while fighting with a pike, is told by the Paris *Gaulois:* "It was the oldest carp in the world, being 475 years of age, and belonged to M. C——, the proprietor of a fine property at Chantilly. It was an historical carp, a carp which was born at the Comte de Cosse's, in the time of François I.; it had passed through various fortunes, having had no less than thirty-two masters. M. G—— purchased it a year since for 1,300 francs. The name of the carp was Gabrielle, and it measured nearly $29\frac{3}{4}$ inches round, and $38\frac{2}{3}$ inches in length."

The Potato-Disease. — According to recent statements in the English papers, one of the most serious of the multiplied ills from which England is now suffering is the almost total failure of this year's potato-crop, due to the attack of a parisitic fungus peculiar to plants belonging to the same natural order as the potato. This affection, which is known as the *potato-disease*, or more commonly *rust*, was first observed in Germany in 1842, where it assumed a serious character. In 1844 it broke out in Canada, and did a great amount of damage. In the following year it was first noticed in England, and in 1846 prevailed all over Europe, but was most destructive in Ireland, where it gave rise to the celebrated Irish famine. The mycelium of this fungus eats into and completely destroys the tissue of the leaf and stem, and, when once its ravages have commenced, there is little hope of arresting them. From the leaves and stem the disease frequently extends to the tubers, where it sometimes lies dormant for months, so that, after being stored, apparently sound in autumn, they become affected in the following spring. When the disease appears in the growing plant, brown spots are first seen on the margins of the leaves, corrugating them as they spread. Very rapid extension of the disease, and decay of the leaves and stalks, often ensue. *Botrytis infestans* is the name applied to the fungus, and it is on the under surface of the leaf that it is generally found; it abounds also in the diseased tubers, which, when cut, produce an abundant crop from the fresh surface, and it sometimes vegetates even from the natural skins. The *resting spores* of the fungus may lie dormant through the winter, germinating the next season; and hence, though the eyes of a diseased tuber appear healthy, to plant them would be the certain means of spreading the disease. The same fungus has been found in the berries of the tomato when diseased, and on the leaves of other plants of the natural order *Solanaceæ*, but never on any plant not of that order.

The influences which favor the development of *Botrytis* are not well understood. It is most prevalent, however, in cloudy, moist summers, and all authorities agree that it makes its first decided appearance during thundery weather. The exceptional amount of electrical disturbance which extended over almost the whole of England, during July last, appears to have been most unfavorable to the potato-crop, but in a portion of the county of Devon, where thunder-storms are remarkably rare, the potatoes are said to be comparatively free from the disease. The most destructive outbreaks of the blight have been observed to recur at intervals of about twelve years. In 1846, as before mentioned, the disease was general in Europe, and in some places, as in Ireland, it swept away the entire crop. From 1859 to 1861 it again did a great amount of damage; and now, in 1872, it is more destructive than at any time since 1846. The London *Times* states that the loss to the country from the destruction of the present crop will exceed twenty millions sterling, and very pertinently asks: "What are we doing, or what have we done, to obviate the recurrence of a disease which is always impending? Probably all we can remember is, that there is always a talk of the potato-rot, and that some years it has been worse than others. We can only say that this is a disgraceful confession. There is no matter in which science could interfere with more advantage; and we seem to have all the conditions of the subject under control." *Nature*, in an article upon the subject, admits the force of these remarks, and, pointing out the reasons why neither individuals nor societies should be expected to undertake the work, urges that the government appoint a commission to investigate the origin, course and remedies for the potato-disease.

"Little objection can be anticipated to the course we advocate, on the ground of the money value at stake in the question. We are at the present time spending a large sum of money and employing the highest talent in the country in the settlement of a claim for a few millions; to save the country several times as much per annum cannot be objected to as a matter unworthy the attention of our rulers. And yet, because the one infliction will fall upon us in the form of an additional twopence to our income-tax for a single year, the other in the form of a much heavier addition to our butchers' and greengrocers' bills for many years in succession, we are content in the latter case to grumble and bear it, without making any serious efforts to relieve ourselves from it. Science is often charged with being 'unpractical;' indeed, in the minds of perhaps the majority of people, there is a kind of hazy feeling of a necessary antagonism between what is scientific and what is practical. It is time for science to redeem herself from this imputation, and no better opportunity could be found than in discovering a remedy for the potato-disease."

Action of Plaster on Soils.—Though generally employed by farmers as a fertilizer, the action of plaster (gypsum) on the soil is not well understood. It has been shown, however, by actual experiment, that plaster is capable of absorbing ammonia from the air, and also from decomposing animal and vegetable matter, holding it in the form of sulphide of ammonium. This, again, may be changed into carbonate of ammonia, by absorption of carbonic acid from the air. These changes occur when gypsum is brought in contact with moisture and vegetable matter. Whatever other purpose it may serve, this must be regarded as the most important, as by it plants are supplied with food of the highest value.

From this fact it may be inferred that

plaster must prove highly serviceable to moist, mossy hills, and also to meadows that are not too wet. The north side of a hill is sometimes greatly benefited by plaster, when upon a southern exposure it produces no perceptible effect. It may be used with confidence on pastures and fields which are strong enough, and moist enough, to support deciduous trees. A hill-side, where moss will grow so as to crowd out good grasses, is, usually, promptly benefited by plaster, white-clover quickly following its application.

Facts about Glass.—Common greenish glass is found to change color under the influence of the sun's light, becoming first yellow, then rose-colored, and finally violet. And even the purest white glass is found sometimes to undergo the same changes. Thus M. E. Siegwart, from whose monograph on "Glass Manufacture," we gather these items, found the abductor tube of a chlorohydric gas apparatus deeply tinged with violet at the parts exposed to sunlight. When fused anew, the original color returns to the glass. It is commonly supposed that glass is not corroded by the atmosphere, nor even by strong acids. But this is an error; for Siegwart found, on actual experiment, that the exposed surface of glass combines with the constituents of the air. If glass is suffered to cool very gradually, it undergoes a transformation which is in most cases visible to the eye. At first there appear specks, which soon dot the entire surface. The glass now becomes cloudy; and finally changes into an opaque body like porcelain, and called Réaumur porcelain. This *devitrification* is the most remarkable phenomenon in the manufacture of glass, and explains several of the *faults* found in that material.

War and Insanity.—It was supposed that the disasters attending the late war had had the effect of increasing the number of insane persons in France, but statistics, so far from confirming this conclusion, show rather that the number of insane patients was smaller during the year ending July 1, 1871, than during the preceding year. Dr. Lunier, who has studied this subject, shows that in 1869–'70 there were admitted into the asylums 11,165 patients; whereas for the year of the war and the insurrection the number was 10,243. Of these 10,243 patients, 1,322 became insane by reason of the calamities produced by the war. During the first half of the year after the war, 400 patients were admitted who had lost their reason from the same cause. The sum total, therefore, of such cases is between 1,700 and 1,800; and the asylums now contain 3,000 less patients than in 1869.

Parliamentary Ventilation.—After spending immense sums of money, and trying numerous methods, the ventilation of the English houses of Parliament is still exceedingly imperfect. The system now in operation is one of exhaustion, or in other words one of suction, the air within the building being sucked out, and, to supply its place, the surrounding external air is sucked in, no matter how impure or how unfit for breathing purposes it may be. This plan is condemned by a writer in the *Journal of the Society of Arts* on the following grounds: Exhaustion creates a partial tendency to a vacuum, when, to maintain the atmospheric equilibrium, the surrounding air rushes in from every quarter. Impure sources are thus as likely to be drawn upon as any other, and the air introduced is scarcely an improvement on that withdrawn. The tendency to a vacuum also favors the occurrence of draughts. Every chink about a door or window, and every crack in the wood-work, becomes an opening for the admission of cold damp air in the shape of a sensible current. A system of suction also perceptibly affects the acoustic properties of rooms to which it is applied. The reason for this is that, whenever there is a partial vacuum, in the same ratio as that has been reached, has the power of the air to transmit pulsations of sound been impaired.

Preparations for observing the Transit of Venus.—The French are making active preparations for observing the approaching transit of Venus, the Assembly having voted $20,000 for the construction of instruments, with the promise of $40,000 more during the coming year. Nine stations have been selected for observation, at four of which the entrance and exit of the planet will be visible, while at the other five but one of the two incidents can be observed. French *savants* are now corresponding with the astronomers of England, Germany, Russia, and this country, with a view to parcelling out the stations to the different observers in such a way that all shall be favorably located, and all the useful points of the earth's surface available for these important observations occupied. After use in 1874, the French apparatus will be carefully preserved for observing the transit of 1882, which is followed by a period of one hundred and twenty years, in which no transit occurs.

The Boring-Organ of Pholades.—It is well known that certain molluscous animals have the power of boring their way into solid substances, making the hole thus excavated their future home. The *teredo* or ship-worm, for example, honeycombs the densest timber, others excavate in clay or chalk, and *pholas* perforates the hardest rocks. With what part of the animal the work is accomplished has long been a matter of dispute, some zoologists regarding the rough, rasp-like shell as the perforating organ, while others believe that the work is done by the foot. In a paper on the subject, read at the recent meeting of the British Association, Mr. John Robertson adopts the former view, maintaining that the perforations are made by the rotating movements which the creature is capable of imparting to its shell. In the discussion which followed, Mr. Bryson, a close observer of the habits of *pholas*, was quoted to the effect that the boring is accomplished by the foot, which, charged with siliceous particles, acts like the leaden wheel of the lapidary. Mr. Gwynn Jeffreys also regards the foot, in all the boring *Conchifera*, as the instrument of perforation. Several facts were cited in support of this. In *Teredo navalis*, as was long ago shown by Sellius, the foot is the only organ of perforation, and the posterior extremity of the shell has a large excavation into which this organ is received. *Pholadidea* in the young state excavates by means of the foot, but afterward the aperture becomes closed by gelatinous matter, when no further excavation takes place. In *pholas*, also, no part of the shell can act at the bottom of the excavation, the foot alone being capable of use in that position.

The Polaris Expedition.—Captain C. F. Hall writes, under date August 24, 1871, from Tossak, North Greenland, that all goes well with his vessel, the Polaris. The captain has abundant supplies, and is well provided with Esquimaux dogs, reindeer-furs, seal-skins, etc. Hans Christian, well known to readers of Kane's narrative, accompanies the Polaris Expedition, together with his family of wife and three children. Various charts and notes of Baron von Otter, commander of the Swedish Expedition, and of other scientific men, are in the possession of Captain Hall, and have led him to abandon the Jones Sound route; to cross Melville Bay to Cape Dudley Diggs; and thence make for Smith's Sound, with a view to reach Kennedy Channel.

Disastrous Volcanic Eruption.—A very violent eruption of the volcano of Merapi, in Java, took place on the 15th of April. The event was totally unexpected, and the loss of life and property was great, many villages being destroyed. In some places the ashes fell for three days, and it became so dark that lamps had to be lit. About 200 dead bodies had at last accounts been found on one side of the volcano.

Chemical Products of Eucalyptus.—Eucalyptus is the name of a genus of trees containing many spécies, mostly natives of Australia, where the tree is very abundant. Several species yield a copious resinous secretion, and are therefore known as *gum trees*. Some of these attain a great size, it is said, exceeding in height the giant red-woods of California. The bodies are slender and without branches, except near the top, where the branchlets droop like those of the weeping-willow. The leaves are entire, of a leathery texture, and, instead of being placed with one surface toward the ground and another toward the sky, hang with their edges in these positions, so that the two surfaces of the leaf are equally exposed to the light. The trees are of very rapid growth, and furnish a timber that when green is soft and easily worked, and that when dry becomes very hard. Eucalyptus has been introduced with success both into Europe and California, and the valuable character of the tree is becoming more and more appreciated as its properties are better known. Ramel first brought it into Europe in 1856, and it has since flourished in the southern portion of the continent. As far north as Paris, however, it does not thrive, the winters proving too cold for it. Owing to the great absorbent power of its roots and leaves, and the fact that the latter yield a strong aromatic odor, the tree is regarded as peculiarly suitable for marshy and unhealthy districts. The leaves contain a notable quantity of a volatile aromatic oil, and afford, both in the fresh and dry state, a very fluid essence, which is slightly colored, and gives off an aromatic odor that reminds one of camphor.

The following preparations are at present manufactured from *Eucalyptus:*

1. The essence already spoken of, which is administered in doses of a few grms. in the form of globules.

2. Leaf-powder, which contains all the active principles of the plant (essence, tannin, bitter principle), and which is prescribed in doses of 4, 8, 12, and even 16 grms. daily.

3. The infusion and decoction of the leaves. With half a leaf (about 1 grm.) it is possible to aromatize three or four cups, affording a good substitute for tea. This is employed as a stimulating drink. For topical applications, 8 grms. in decoction, in a litre of water, forms a liquor well charged with the principles indicated.

4. Water distilled from the leaves, which may be advantageously used with stimulating drinks.

5. Aqueous extract, alcoholic extract, employed as febrifuges.

6. Tincture or alcoholate.

7. A liquor, which is similar to the liquor of mastic, and a wine, which is a tonic and febrifuge.

8. Cigars and cigarettes.

Dr. Gimbert has studied on himself the effects of essence of *Eucalyptus* when taken into the system. He took various doses of from 10 to 20 drops, and found it had a soothing effect. It diminishes the vascular tension, and the sense of comfort arising from it induces sleep. A very strong dose produces temporary excitement, headache, and slight fatigue.

New Method for disintegrating Wheat.—An inventor of Bristol, England, has contrived a mitl for reducing wheat to flour, which is said to do the work much more rapidly than millstones, and at the same time yields a vastly superior product. The arrangement consists of iron cages containing revolving radii, driven at the rate of four hundred revolutions a minute, which almost instantaneously reduces the wheat to powder. At Edinburgh two such mills have been running for more than a year. Each one does the work of twenty-seven pair of ordinary millstones, with a saving of five and a half per cent. in favor of the new mill. The bread made from the flour which this mill turns out is pronounced remarkable for its lightness and good keeping qualities.

Instinct at Fault in a Humming-Bird.—Says a correspondent in the Bulletin of the Torry Botanical Club: "I was reminded the other day of the story told by Pliny, of the painter Zeuxis, who represented a bunch of grapes so naturally that the birds flew at the picture to eat the fruit. My friend Mrs. P. W. told us that a gentleman, the Rev. Mr. P., was sitting on the piazza of her house with his feet encased in a pair of worked slippers, adorned with some highly-colored flowers, and that she saw a humming-bird repeatedly peck at the flowers, in the vain attempt to find in them his accustomed nourishment. This curious fact seems to indicate that the attraction in such cases is not due to the odor of the flowers, but simply to their bright color; and that the Greek story is not so improbable, after all."

White Partridge-Berries.—Of this berry, sometimes called Squaw-berry, and which is normally a brilliant scarlet, a good many white ones were found this autumn at Canaan, Conn. The white berries grew on separate vines, ripened like the red ones, but were much larger.

An Army of Caterpillars.—A writer in the *Gardener's Monthly* gives some interesting particulars concerning the habits of the caterpillars, which last spring visited the region about Memphis in such unheard-of numbers. They were so numerous, that several trains of cars coming into the city were stopped on each of the two roads, the masses covering the rails for hundreds of yards in a body, compelling the brakemen to get down and sweep them off before the driving-wheels could get sufficient hold to pass over the obstruction. They lived on the young leaves of both forest and fruit trees—the oak, quince, apple, and plum, being their favorite food. Whole orchards were denuded of foliage, and great lanes of bare trees marked their track through the forests. They are characterized by one remarkable peculiarity. Unless prowling through thick grass, or when about half grown, descending by the long web which each spins, from a tall rough forest-tree, they are always arranged in military style; and travel, also, in long, straight lines, several abreast.

Insect-Life in a Coal-Mine.—A coal-pit in England having become infested with large-winged insects, which caused the workmen considerable annoyance, by flitting around their lamps and often extinguishing them, a search was made to discover the source from which they came. The wooden props supporting the workings were found to be pierced in several places, as though by gimlets, and in the holes were found a number of moth-like insects. The wood had come from abroad, and had been in the pit some four years before the insects began to make their appearance.

An Unpatentable Pavement.—A writer in the *Journal of the Society of Arts* advocates the adoption of a kind of wooden pavement for the streets of London, which in point of wear he believes to be superior to all other varieties of wooden pavement, and with the additional advantage that it cannot be made the subject of a patent. He says: "Now, the only wood pavement fit to stand London traffic, and entailing the smallest cost, could not be patented by the most astute lawyer. Instead of fashioning the blocks into patent dice, hexagons, polygons, or dove-tailed complications in any form, we have only to slice barked trees of any size or quality into cylindrical slices about thirteen inches in thickness, and put the largest size down first into a good rammed foundation, and then the smaller sizes, until the remaining interstices may be filled up with what may be called pegs, the proper ramming of which will render the whole one solid mass of timber, while the economy of wood is so great that not a chip will be wasted. The surface will present end-grain only, and with the different sorts and sizes will afford a much better foothold than granite blocks."

Gold in Sea-Water.—In a series of researches on the composition of sea-water, a chemist named Sonstadt has been able to make out the presence of gold as one of its constituents. It appears to be completely dissolved, and is held in solution by the action of iodate of calcium, which, as shown by the same chemist, sea-water also contains. He demonstrates the presence of gold by three separate and entirely different methods, and estimates the proportion to be less than one grain per ton of water.

NOTES.

Non-inflammable Fabrics.—Cotton or linen goods may be rendered non-inflammable by being dipped in a solution of equal parts of acetate of lime and chloride of calcium dissolved in twice their weight of water.

Paper Lamp-Shades.—Dr. Mirus mentions two cases in Jena and one in Frankfort where persons using green glazed paper lamp-shades were poisoned by the arsenic of the coloring matter. The heat of the lamp volatilized the arsenic, and rendered the small quantity present very dangerous.

Progress of Chemistry.—One by one the organic products are being copied in the laboratory. The last triumph in this direction which has come to our notice is the production of glycerine by Friedel and Silva. If the vapor of fusel-oil be passed through a red-hot tube, propylen is formed, which readily combines with chlorine, and from this chloride of propylen glycerine is produced by a process in which no glycerine is employed. As glycerine is the base of all true fats, this is an important step in the direction of oil-making.

An officer connected with the Geological Survey of Ireland, Mr. Hull, states the net available tonnage of coal in that country as 182,280,000 tons. Of this amount, Antrim has 16,000 tons; Tyrone, 32,900,000; Queens, Kilkenny, and Carlow, 77,580,000; Tipperary, 25,000,000; Clare, Limerick, and Cork, 20,000,000. Connaught has 10,800-000.

According to J. Ballynski, if the motion of a leaden bullet were all converted into heat, it would amount to three times as much as would be sufficient to melt the quantity of lead found to be melted by actual experiment. This he explains as having been expended in denting the iron plates of the target. By using a hard stone target, he was able to completely melt the bullets fired against it.

An improvement has been made in the process for extracting sugar from the beet by maceration, by adding lime to the liquor and precipitating the lime by a current of carbonic-acid gas. This has the effect of rapidly purifying the liquor and of displacing the remaining air, which would otherwise promote fermentation.

Mr. Wideman states that, by the contact of ozone for twenty minutes with whiskey, the fusel-oil was removed, and the whiskey mellowed as much as if it had been kept for ten years. Further, by adding to whiskey of proof strength seven times its weight of water, the introduction of ozone speedily transformed the mixture into marketable vinegar. In Russia good brandy is said to be made from mosses and lichens.

Paper from Wood.—A letter from Berlin, in the *Elberfeld Gazette*, represents Prince Bismarck in a new light—that of a paper-maker. The paper-manufactory established by the Imperial Chancellor on his estate at Varzin has proved so successful, says the writer, that it is impossible to meet the large orders which come from England. This paper is made of chips of fir—that, at least, is the chief element.

An instance of supposed mimicry in insects is given in *Science Gossip*. The carpet-moth hides in some obscure place during the day, holding the upper wings outspread. When it thus rests on a greenish or obscure ground, it might easily pass for a smaller whitish moth. Is it by mere accident that the upper rather than the lower wings of the insect are spread out, or have we here a provision made to guard against the assaults of its enemies?

The French are making preparations for meteorological observations at elevated points. An observatory is now in course of construction at the summit of Puy-de-Dome, which will be connected by a telegraphic wire with another in a pavilion of the faculty at Clermont. The difference in height between the two is about 3,800 feet, and, by means of the telegraphic wire, the difference of meteorological conditions between the plain and the upper regions of the atmosphere can be shown at any moment.

The opium-poppy in Bengal is suffering serious damage from a fungoid growth which develops itself on the leaves. Sulphur is suggested as a remedy, it having proved useful in a similar disease which attacks the vine.

Timber-Planting in Hall County, Nebraska, has become quite popular. It is predicted that within twenty years the "Great American Desert" will be far better timbered than the Eastern States.

Hops in England.—Says the *Mark Lane Express*, 65,600 acres are devoted to the culture of hops in England, and the area is gradually increasing. Kent, the largest hop-growing county, had 32,000 acres in this crop last season, the early grounds averaging 1,400 to 1,600 pounds per acre; Sussex, next in importance, 14,500 acres, averaging 1,800 to 2,200 pounds per acre. Surrey is noted for a choice quality of hops of bright color and superior aroma.

A correspondent calls attention to a discrepancy of statement occurring in the article entitled "Coal as a Reservoir of Power," published in No. 6 of The Popular Science Monthly. It is there affirmed that a pound of coal in burning yields an energy equal to the power of lifting 10,808,000 pounds one foot; and this is followed by the statement that a cubic yard of coal, 2,240 pounds, possesses a reserve of energy equal to lifting 1,729,200 pounds one foot high: 2,240 pounds (an English ton) would of course yield 2,240 times as much energy as one pound, and consequently would raise 10,808,000 *tons* one foot high.

The extraction of sulphur and the manufacture of sulphuric acid from iron pyrites were first successfully accomplished on the large scale, under the stress of a tyrannical proceeding on the part of the King of the Two Sicilies. At the time, the island of Sicily was the principal source of the sulphur consumed in Europe, and the trade in the article brought an immense revenue to the government. A corrupt administration and a bankrupt treasury led the king to grant a monopoly of the business to a single firm in France, he expecting thereby to secure a large increase of funds. His action had exactly the opposite effect. The price of sulphur was doubled, its extraction from pyrites followed, and the sulphur mines of Sicily have since been of comparatively little consequence.

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THE STUDY OF SOCIOLOGY.

By HERBERT SPENCER.

VI.—*Subjective Difficulties—Intellectual.*

If you watch the management of a child by a mother of small capacity, you may be struck by the inability she betrays to imagine the child's thoughts and feelings. Full of energy which he must expend in some way, and eager to see every thing, her little boy is every moment provoking her by his restlessness. The occasion is perhaps a railway journey. Now he strives to look out of the window; and now, when forbidden to do that, climbs on the seats, or meddles with the small luggage. "Sit still," "Get down, I tell you," "Why can't you be quiet?" are the commands and expostulations she utters from minute to minute—partly, no doubt, to prevent the discomfort of fellow-passengers. But, as you will see at other times, when no such motive comes into play, she endeavors to repress these childish activities mainly out of regard for what she thinks propriety, and does it without any adequate recognition of the penalties she inflicts. Though she herself lived through this phase of extreme curiosity—this early time when almost every object passed has the charm of novelty, and when the overflowing energies generate a painful irritation if pent up; yet now she cannot believe how keen is the desire for seeing which she balks, and how difficult is the maintenance of that quietude on which she insists. Conceiving her child's consciousness in terms of her own consciousness, and feeling how easy it is to sit still and not look out of the window, she ascribes his behavior to mere perversity.

I recall this and kindred experiences to the reader's mind, for the purpose of exemplifying a necessity and a difficulty. The necessity is that, in dealing with other beings and interpreting their actions, we are obliged to represent their thoughts and feelings in terms of our own. The difficulty is that, in so representing them, we can never be more than partially right, and are frequently very wrong. The conception which any one frames of another's mind, is inevitably more or less after the pattern of his own mind—is automorphic; and in proportion as the mind of which he has to frame a conception differs from his own, his automorphic interpretation is likely to be wide of the truth.

That measuring other person's actions by the standards our own thoughts and feelings furnish, often causes misconstruction, is indeed a truth familiar even to the vulgar. But while among members of the same society, having natures nearly akin, it is seen that automorphic explanations are often erroneous, it is not seen with due clearness how much more erroneous such explanations commonly are, when the actions are those of men of another race, to whom the kinship in nature is comparatively remote. We do, indeed, perceive this, if the interpretations are not our own; and if both the interpreters and the interpreted are distant in thought and nature from ourselves. When, as in early English literature, we find Greek history conceived in terms of feudal institutions, and the heroes of antiquity spoken of as princes, knights, and squires, it becomes clear to us that the ideas concerning ancient civilization must have been utterly wrong. When we find Virgil adopted by Dante as his guide, and named elsewhere as one among the prophets who visited the cradle of Christ—when an illustrated psalter gives scenes from the life of Christ in which there repeatedly figures a castle with a portcullis—when even the Crucifixion is described by Langland in the language of chivalry, so that the man who pierced Christ's side with a spear is considered as a knight who disgraced his knighthood[1]—when we read of the Crusaders calling themselves "vassals of Christ;" we need no further proof that by carrying their own sentiments, and ideas, and habits, to the interpretation of social arrangements and transactions among the Jews, our ancestors were led into absurd misconceptions. But we do not recognize the fact that in virtue of the same tendency we are ever framing conceptions which, if not so grotesquely untrue, are yet very wide of the truth. How difficult it is to imagine mental states remote from our own so correctly that we can understand how they issue in individual actions, and consequently in social actions, an instance will make manifest.

The feeling of vague wonder with which he received his first lessons in the Greek mythology, will most likely be dimly remembered by every reader. If not in words, still in an inarticulate way, there passed through him the thought that belief in such stories was unaccountable. When, afterward, he read in books of travels details of the amazing superstitions of this or that race of savages, there was joined with a sense of the absurdity of such superstitions, more or less of astonishment at their acceptance by any human beings, however

[1] Warton's "History of English Poetry," vol. ii., p. 57, note.

ignorant or stupid. That the people of a neighboring tribe had descended from ducks, that rain resulted when certain deities began to spit upon the earth, that the island lived upon had been pulled up from the bottom of the ocean by one of their gods, whose hook got fast when he was fishing—these and countless beliefs equally laughable seem to him to imply an irrationality near to insanity. He interprets them automorphically—carrying with him not simply his own faculties developed to a stage of complexity considerably beyond that reached by the faculties of the savage, but also the modes of thinking in which he was brought up, and the stock of information he has acquired. Usually it never occurs to him to do otherwise. Even if he attempts to look at things from the savage's point of view, he most likely fails entirely; and, if he succeeds at all, it is but very partially. Yet only by seeing things as the savage sees them can his ideas be understood, his behavior accounted for, and the resulting social phenomena explained. These seemingly-strange superstitions are quite natural—quite rational, in a certain sense, in their respective times and places. The laws of intellectual action are the same for civilized and uncivilized. The difference is in complexity of faculty and amount of knowledge accumulated and generalized. Given reflective powers developed only to that lower degree in which they are possessed by the aboriginal man—given his small stock of ideas, collected in a narrow area of space, and not added to by records extending through time—given his impulsive nature incapable of patient inquiry; and these seemingly-monstrous beliefs of his become in reality the most feasible explanations he can find of surrounding things. Yet even after seeing that this must be so, it is not easy to think, from the savage's point of view, clearly enough to follow the effects of his ideas on his acts, through all the relations of life, social and other.

A parallel difficulty stands in the way of rightly conceiving character remote from our own, so as to see how it issues in conduct. We may best recognize our inability in this respect by observing the converse inability of other races to understand our characters, and the acts they prompt.

> "Wonderful are the works of Allah! Behold! That Frank is trudging about, when he can, if he pleases, sit still!"[1]

In like manner Captain Speke tells us:

> "If I walked up and down the same place to stretch my legs, they" (Somali) "formed councils of war on my motives, considering I must have some secret designs upon their country, or I would not do it, as no man in his senses could be guilty of working his legs unnecessarily."[2]

But while by instances like these we are shown that our characters are in a large measure incomprehensible by races remote in nature

[1] Burton's "Scinde," vol. ii., p. 13.

[2] Speke's "Journal of Discovery of Source of the Nile," p. 85.

from ourselves, the correlative fact that their sentiments and motives cannot be rightly conceived by us, is one perpetually overlooked in our sociological interpretations. Feeling, for instance, how natural it is to take an easier course in place of a more laborious course, and to adopt new methods that are proved to be better methods, we are somewhat puzzled on finding the Chinese stick to their dim paper-lamps, though they admire our bright argand-lamps, which they do not use if given to them; or on finding that the Hindoos prefer their rough primitive tools after seeing that our greatly-improved tools do more work with less effort. And, on descending to races yet more remote in civilization, we still oftener discover ourselves wrong when we suppose that under given conditions they will act as we should act.

Here, then, is a subjective difficulty of a serious kind. Properly to understand any fact in social evolution, we have to see it as resulting from the joint actions of individuals having certain natures. We cannot so understand it without understanding their natures; and this, even by care and effort, we are able to do but very imperfectly. Our interpretations must be in a greater or less degree automorphic; and yet automorphism perpetually misleads us.

One would hardly suppose, *a priori*, that untruthfulness would habitually coexist with credulity. Rather our inference might be, that, in virtue of the tendency above enlarged upon, people most given to make false statements must be people most inclined to suspect statements made by others. Yet somewhat anomalously, as it seems, habitual veracity very generally goes with inclination to doubt evidence; and extreme untrustworthiness of assertion often has, for its concomitant, readiness to accept the greatest improbabilities on the slenderest testimony. If you compare savage with civilized, or compare the successive stages of civilization, you find untruthfulness and credulity decreasing together; until you reach the modern man of science, who is at once exact in his statements and critical respecting the evidence on which facts are alleged. The converse relation to that which we see in the man of science is even now very startlingly presented in the East, where greediness in swallowing fictions goes along with superfluous telling of falsehoods. An Egyptian prides himself in a clever lie, uttered even without motive; and a dyer will even ascribe the failure in fixing one of his colors to the not having been successful in a deception. Yet so great is the readiness to believe improbabilities that Mr. St. John, in his "Two Years' Residence in a Levantine Family," narrates how, when the "Arabian Nights' Entertainments" was being read aloud, and when he hinted that the stories must not be accepted as true, there arose a strong protest against such skepticism—the question being asked, "Why should a man sit down and write so many lies?"[1]

[1] *See* pp. 79 and 127.

I point out this union of seemingly-inconsistent traits, not because of the direct bearing it has on the argument, but for the sake of its indirect bearing. For I have here to dwell awhile on the misleading effects of certain mental tendencies which similarly appear very unlikely to coexist, and which yet do habitually coexist. I refer to the belief which, even while I write, I find repeated in the leading journal, that "the deeper a student of history goes, the more does he find man the same in all time;" and to the quite opposite belief embodied in current politics, that human nature may be readily altered. These two beliefs, which ought to cancel one another but do not, originate two classes of errors in sociological speculation; and nothing like correct conclusions in Sociology can be drawn until they have been rejected, and replaced by a belief which reconciles them—the belief that human nature is indefinitely modifiable, but that no modification of it can be brought about rapidly. We will glance at the errors to which each of these beliefs leads.

While it was held that the stars are fixed and that the hills are everlasting, there was a certain congruity in the notion that man continues unchanged from age to age; but now when we know that all stars are in motion, and that there are no such things as everlasting hills—now that we find all things throughout the Universe to be in a ceaseless flux, it is time for this crude conception of human nature to disappear out of our social conceptions; or rather—it is time that its disappearance should be followed by that of the many narrow notions respecting the past and the future of society, which have grown out of it, and which linger notwithstanding the loss of their root. For, avowedly by some and tacitly by others, it continues to be thought that the human heart is as "desperately wicked" as it ever was, and that the state of society hereafter will be very much like the state of society now. If, when the evidence has been piled mass upon mass, there comes a reluctant admission that aboriginal man, of troglodyte or kindred habits, differed somewhat from man as he was during feudal times, and that the customs and sentiments and beliefs he had in feudal times imply a character appreciably unlike that which he has now—if, joined with this, there is a recognition of the truth that along with these changes in man there have gone still more conspicuous changes in society; there is, nevertheless, an ignoring of the implication that hereafter man and society will continue to change, until they have diverged as widely from their existing types as their existing types have diverged from those of the earliest recorded ages. It is true that among the more cultured, the probability, or even the certainty, that such transformations will go on, may be granted; but the granting is but nominal, the admission does not become a factor in the conclusions drawn. The first discussion on a political or social topic reveals the tacit assumption that in times to come society will have a structure substantially like its existing structure. If, for instance, the question of domestic service is raised, it mostly happens that its bearings are considered wholly in reference to those social arrangements which exist around us; only a few proceed on the supposition that these arrangements are probably but transitory. It is so throughout. Be the subjects industrial organization, or class-relations, or rule by fashion, the belief which practically moulds the conclusions, if not the belief theoretically professed, is, that, whatever changes they may undergo, our institutions will not cease to be recognizably the same. Even those who have, as they think, deliberately freed themselves from this perverting tendency—even M. Comte and his disciples, believing in an entire transformation of society, nevertheless betray an incomplete emancipation; for the ideal society believed in by them, is one under regulation by a hierarchy essentially akin to hierarchies such as mankind have known. So that everywhere, more or less, sociological thinking is impeded by the difficulty of constantly bearing in mind that the social states toward which mankind are being carried are probably as little conceivable by us as our present state was conceivable by a Norse pirate and his followers.

Note, now, the contrary difficulty, which appears to be surmountable by scarcely any of our parties, political and philanthropic, from the highest to the lowest—the difficulty of understanding that human nature, though indefinitely modifiable, can be modified but very slowly; and that all laws and institutions and appliances, which count on getting from it within a short time much better results than present ones, will inevitably fail. If we glance over the programmes of societies, and sects, and schools of all kinds, from Rousseau's disciples in the French Convention down to the members of the United Kingdom Alliance, from the adherents of the Ultramontane propaganda down to the enthusiastic advocates of an education exclusively secular, we find in them one common trait. They are all pervaded by the conviction, now definitely expressed and now taken as a self-evident truth, that there needs but this kind of instruction or that kind of discipline, this mode of repression or that system of culture, to bring society into a very much better state. Here we read that "it is necessary completely to refashion the people whom one wishes to make free:" the implication being that a refashioning is practicable. There it is taken as self-evident that, when you have taught children what they ought to do to be good citizens, they will become good citizens. Elsewhere it is held to be a truth beyond question that, if by law temptations to drink are removed from men, they will not only cease to drink, but thereafter cease to commit crimes. And yet the delusiveness of all such hopes is obvious enough to any one not blinded by an hypothesis, or carried away by an enthusiasm. The fact, often pointed out to Temperance-fanatics, that some of the soberest nations in Europe yield a proportion of crime higher than our own, might suffice to show them that England would not be suddenly moralized if they carried their proposed restrictions into effect. The superstition that good behavior is to be forthwith produced by lessons learned out of school-books, which was long ago statistically disproved,[1] would, but for preconceptions, be utterly dissipated by observing to what a slight extent knowledge affects conduct—by observing that the dishonesty implied in the adulterations of tradesmen and manufacturers, in fraudulent bankruptcies, in bubble-companies, in "cooking" of railway accounts and financial prospectuses, differs only in form, and not in amount, from the dishonesty of the uneducated—on observing how amazingly little the teachings given to medical students affect their lives, and how even the most experienced medical men have their prudence scarcely at all increased by their information. Similarly, the Utopian ideas which come out afresh along with every new political scheme, from the "paper-constitutions" of the Abbé Sieyès down to the just-published programme of M. Louis Blanc, and from agitations for vote-by-ballot up to those who have a republic for their aim, might, but for this tacit belief we are contemplating, be extinguished by the facts perpetually and startlingly thrust on our attention. Again and again for three generations has France been showing to the world how impossible it is essentially to change the type of a social structure by any rearrangement wrought out through a revolution. However great the transformation may for a time seem, the original thing reappears in disguise. Out of the nominally-free government set up, a new despotism arises, different from the old by having a new shibboleth and new men to utter it; but identical with the old in the determination to put down opposition, and in the means used to this end. Liberty, when obtained, is forthwith surrendered to an avowed autocrat; or, as we have seen within this year, it is allowed to lapse into the hands of one who claims the reality of autocracy without its title. Nay, the change is, in fact, even less; for the regulative organization which ramifies throughout French society continues unaltered by these changes at the governmental centre. The bureaucratic system persists equally under Imperialist, Constitutional, and Republican arrangements. As the Duc d'Audriffret-Pasquier pointed out, "Empires fall, Ministers pass away, but Bureaux remain." The aggregate of forces and tendencies embodied, not only in the structural arrangements holding the nation together, but in the ideas and sentiments of its units, is so powerful that the excision of a part, even though it be the governmental centre, is quickly followed by the substitution of a like part. It needs but to recall the truth exemplified some chapters back, that the properties of the aggregate are determined by the properties of the units, to see at once that, so long as the characters of citizens remain substantially unchanged, there can be no substantial change in the political organization which has slowly been evolved by them.

[1] "Summary of the Moral Statistics of England and Wales." By Joseph Fletcher, Esq., one of her Majesty's Inspectors of Schools.

This double difficulty of thought, with the double set of delusions fallen into by those who do not surmount it, is, indeed, naturally associated with the once-universal, and still-general, belief that societies arise by manufacture, instead of arising, as they do, by evolution. Recognize the truth that aggregates of men, like other aggregates, grow, and acquire their structural characters through a process of modification upon modification, and there are excluded these antithetical errors that man remains the same and that man is readily alterable; and along with exclusion of these errors comes admission of the inference that the changes which have brought social arrangements to a form so different from past forms will in future carry them on to forms as different from those now existing. Once become habituated to the thought of a continuous unfolding of the whole and of each part, and these misleading ideas disappear. Take a word and observe how, while changing, it gives origin in course of time to a family of words, each changing member of which similarly has progeny; take a custom, as that of giving eggs at Easter, which has now developed in Paris into the fashion of making expensive presents of every imaginable kind enclosed in imitation-eggs, becoming at length large enough to contain a brougham, and which entails so great a tax that people go abroad to evade it; take a law, once quite simple and made to meet a special case, and see how it eventually, by successive additions and changes, grows up into a complex group of laws, as, out of two statutes of William the Conqueror came our whole system of statutes regulating land-tenure;[1] take a social appliance, like the press, and see how from the news-letter, originally private and written, and then assuming the shape of a printed fly-leaf to a written private letter, there has, little by little, evolved this vast assemblage of journals and periodicals, daily, weekly, general, and local, that have, individually and as an aggregate, grown in size while growing in heterogeneity —do this, and do the like with all other established institutions, agencies, products, and there will come naturally the conviction that now, too, there are various germs of things which will in the future develop in ways no one imagines and take shares in profound transformations of society and of its members—transformations that are hopeless as immediate results, but certain as ultimate results.

Try to fit a hand with five fingers into a glove with four. Your difficulty aptly parallels the difficulty of putting a complex conception into a mind not having an adequately complex faculty. In proportion as the several terms and relations which make up a thought become numerous and varied, there must be brought into play numerous and varied parts of the intellectual structure, before the thought can be comprehended; and, if some of these parts are wanting, only fragments of the thought, and not the thought as a whole, can be taken in. Con-

[1] Reeves, "History of English Law," vol. i., pp. 34–36 (second edition).

sider an instance. What is meant by the ratio of A to B may be explained to a boy, by drawing a short line A and a long line B, telling him that A is said to bear a small ratio to B; and then, after lengthening the line A, telling him that A is now said to bear a larger ratio to B. But suppose I have to explain what is meant by saying that the ratio of A to B is equal to the ratio of C to D. This conception is much more complex: instead of two different quantities and one relation, there are four different quantities and three relations. To understand the proposition, the boy has to think of A and B and their difference, and, without losing his intellectual grasp of these, he has to think of C and D and their difference, and, without losing his intellectual grasp of these, he has to think of the two differences as each having a like relation to its pair of quantities. Thus the number of terms and relations to be kept before the mind is such as to imply the co-operation of many more agents of thought, any of which being absent, the proposition cannot be understood: the boy must be older before he will understand it, and, if uncultured, will probably never understand it at all. Pass now to a conception of still greater complexity—say that the ratio of A to B varies as the ratio of C to D. Far more numerous things have now to be represented in consciousness with approximate simultaneity. A and B have to be thought of as not constant in their lengths, but as one or both of them changing in their lengths, so that their difference is indefinitely variable. Similarly with C and D. And then the variability of the ratio in each case being duly conceived in terms of lines that lengthen and shorten, the thing to be understood is, that whatever difference any change brings about between A and B, the relation it bears to one or other of them is always like that which the difference simultaneously arising between C and D bears to one or other of them. The greater multiplicity of ideas required for mentally framing this proposition evidently puts it further beyond the reach of faculties not developed by appropriate culture, or not capable of being so developed. And as the type of proposition becomes still more involved, as it does when two such groups of dependent variables are compared and conclusions drawn, it begins to require a grasp that is easy only to the disciplined mathematician.

One who does not possess that complexity of faculty which, as we here see, is requisite for the grasping of a complex conception, may, in cases like these, become conscious of his incapacity; not from perceiving what it is that he lacks, but from perceiving that, by another person, results can be achieved which he cannot achieve. But, where no such thing as the verifying of exact predictions comes in to prove to one of inferior faculty that his faculty is inferior, he is usually unaware of the inferiority. To imagine a higher mode of consciousness is in some degree to have it; so that, until he has it in some degree, he cannot really conceive of its existence. An illustration or two will make this clear.

Take a child on your knee, and, turning over with him some engravings of landscapes, note what he observes. "I see a man in a boat," says he, pointing. "Look at the cows coming down the hill." "And see, there is a little boy playing with a dog." These and other such remarks, mostly about the living objects in each view, are all you get from him. Never by any chance does he utter a word respecting the scene as a whole. There is an absolute unconsciousness of any thing to be observed, or to be pleased with, in the combination of wood and water and mountain. And, while the child is entirely without this complex æsthetic consciousness, you see that he has not the remotest idea that such a consciousness exists in others, but is wanting in himself. Take, now, a case in which a kindred defect is betrayed by an adult. You have, perhaps, in the course of your life, had some musical culture, and can recall the stages through which you have passed. In early days a symphony was a mystery, and you were somewhat puzzled to find others applauding it. An unfolding of musical faculty, that went on slowly through succeeding years, brought some appreciation, and now these complex musical combinations, which once gave you little or no pleasure, give you more pleasure than any others. Remembering all this, you begin to suspect that your indifference to certain still more involved musical combinations may arise from incapacity in you, and not from defects in them. See, on the other hand, what happens with one who has undergone no such series of changes—say, an old naval officer, whose life at sea kept him out of the way of concerts and operas. You hear him occasionally confess, or rather boast, how much he enjoys the bagpipes. While the last cadences of a sonata, which a young lady has just played, are still in your ears, he goes up to her and asks whether she can play "Polly, put the kettle on," or "Johnny comes marching home." And then, when concerts are talked about at table, he seizes the occasion for expressing his dislike of classical music, and scarcely conceals his contempt for those who go to hear it. On contemplating his mental state, you see that, along with absence of the faculty for grasping complex musical combinations, there goes no consciousness of the absence—there is no suspicion that such complex combinations exist, and that other persons have faculties for appreciating them.

And now for the application of this general truth to our subject. The conceptions with which sociological science is concerned are complex beyond all others. In the absence of faculty having a corresponding complexity, they cannot be grasped. Here, however, as in other cases, the absence of an adequately complex faculty is not accompanied by any consciousness of incapacity. Rather do we find that, in proportion to the deficiency in the required kind of mental grasp, there is an extreme confidence of judgment on sociological questions, and a ridicule of those who, after long discipline, begin to perceive what there is to be understood, and how difficult is the right understanding of it. A simple illustration of this will prepare the way for more involved illustrations.

A few months ago, the *Times* gave us an account of the last achievement in automatic printing—the "Walter Press," by which its own immense edition is thrown off in a few hours every morning. Suppose a reader of the description, adequately familiar with mechanical details, follows what he reads step by step with full comprehension—perhaps making his ideas more definite by going to see the apparatus at work and questioning the attendants? Now he goes away considering he understands all about it. Possibly, under its aspect as a feat in mechanical engineering, he does so. Possibly also, under its biographical aspect, as implying in Mr. Walter and those who coöperated with him certain traits, moral and intellectual, he does so. But under its sociological aspect he has no notion of its meaning, and does not even suspect that it has a sociological aspect. Yet, if he begins to look into the genesis of the thing, he will find that he is but on the threshold of the full explanation. On asking not what is its proximate but what is its remote origin, he finds, in the first place, that this automatic printing-machine is lineally descended from other automatic printing-machines, which have undergone successive developments—each presupposing others that went before: without cylinder printing-machines long previously used and improved, there would have been no "Walter Press." He inquires a step further, and discovers that this last improvement became possible only by the help of *papier-mâché* stereotyping, which, first employed for making flat plates, afforded the possibility of making cylindrical plates. And tracing this back, he finds that plaster-of-paris stereotyping came before it, and that there was another process before that. Again he learns that this highest form of automatic printing, like the many less-developed forms preceding it, depended for its practicability on the introduction of rollers for distributing ink, instead of the hand-implements used by "printer's-devils" fifty years ago—which rollers, again, could never have been made fit for their present purposes, without the discovery of that curious elastic compound out of which they are cast. And then, on tracing the more remote antecedents, he finds an ancestry of hand printing-presses, which, through generations, had been successively improved. Now, perhaps, he thinks he understands the apparatus, considered as a sociological fact. Far from it. Its multitudinous parts, which will work together only when highly finished and exactly adjusted, came from machine-shops, where there are varieties of complicated, highly-finished engines for turning cylinders, cutting out wheels, planing bars, and so forth; and on the preëxistence of these the existence of this printing-machine depended. If he inquires into the history of these complex automatic tools, he finds they have severally been, in the slow course of mechanical progress, brought to their present perfection by the help of preceding complex automatic tools of various kind, that coöperated to make their component parts—each larger, or more accurate, lathe or planing-machine having been made possible by preëxisting lathes and planing-machines, inferior in size or exactness. And so if he traces back the whole contents of the machine-shop, with its many different instruments, he comes in course of time to the blacksmith's hammer and anvil, and even, eventually, to still ruder appliances. The explanation is now completed, he thinks. Not at all. No such process as that which the "Walter Press" shows us was possible until there had been invented, and slowly perfected, a paper-machine capable of making miles of paper without break. Thus there is the genesis of the paper-machine involved, and that of the multitudinous appliances and devices that preceded it, and are at present implied by it. Have we now got to the end of the matter? No; we have just glanced at one group of the antecedents. All this development of mechanical appliances—this growth of the iron-manufacture, this extensive use of machinery made from iron, this production of so many machines for making machines—has had for one of its causes the abundance of the raw materials, coal and iron; has had for another of its causes the insular position which has favored peace and the increase of industrial activity. There have been moral causes at work too. Without that readiness to sacrifice present ease to future benefit, which is implied by enterprise, there would not only have never arisen the machine in question, but there would never have arisen the multitudinous improved instruments and processes that have made it possible. And, beyond the moral traits which enterprise presupposes, there are those presupposed by efficient coöperation. Without mechanical engineers who fulfilled their contracts tolerably well, by executing work accurately, neither this machine itself nor the machines that made it could have been produced; and, without artisans having considerable conscientiousness, no master could insure accurate work. Try to get such products out of an inferior race, and you will find defective character an insuperable obstacle. So, too, will you find defective intelligence an insuperable obstacle. The skilled artisan is not an accidental product, either morally or intellectually. The intelligence needed for making a new thing is not everywhere to be found; nor is there everywhere to be found the accuracy of perception and nicety of execution without which no complex machine can be so made that it will act. Exactness of finish in machines has developed *pari passu* with exactness of perception in artisans. Inspect some mechanical appliance made a century ago, and you may see that, even had all other requisite conditions been fulfilled, want of the requisite skill in workmen would have been a fatal obstacle to the production of an engine requiring so many delicate adjustments. So that there are implied in this mechanical achievement, not only our slowly-generated industrial state, with its innumerable products and processes, but also the slowly-moulded moral and intellectual natures of masters and workmen. Has nothing now been forgotten? Yes, we have left out a whole division of all-important social phenomena—those which we group as the progress of knowledge. Along with the many other developments that have been necessary antecedents to this machine, there has been the development of Science. The growing and improving arts of all kinds have been helped up, step after step, by those generalized experiences, becoming ever wider, more complete, more exact, which make up what we call Mathematics, Physics, Chemistry, etc. Without a considerably developed Geometry, there could never have been the machines for making machines; still less this machine that has proceeded from them. Without a developed Physics, there would have been no steam-engine to move these various automatic appliances, primary and secondary; nor would the many implied metallurgic processes have been brought to the needful perfection. And, in the absence of a developed Chemistry, many of the requirements, direct and indirect, could not have been adequately fulfilled. So that, in fact, this organization of knowledge which began with civilization had to reach something like its present stage, before such a machine could come into existence, supposing all other prerequisites to be satisfied. Surely we have now got to the end of the history. Not quite; there yet remains an essential factor. No one goes on year after year spending thousands of pounds, and much time, and persevering through disappointment and anxiety, without a strong motive: the "Walter Press" was not a mere *tour de force.* Why, then, was it produced? To meet an immense demand with great promptness—to print, with one machine, 16,000 copies per hour. Whence arises this demand? From an extensive reading public, brought in the course of generations to have a keen morning-appetite for news of all kinds—merchants who need to know the latest prices at home and the latest telegrams from abroad; politicians who must learn the result of last night's division, be informed of the latest diplomatic move, and read the speeches at a meeting; sporting-men who look for the odds and the result of yesterday's race; ladies who want to see the births, marriages, and deaths. And, on asking the origin of these many desires to be satisfied, they prove to be concomitants of our social state in general—its trading, political, philanthropic, and other activities; for, in societies where these are not dominant, the demand for news of various kinds rises to no such intensity. See, then, how enormously involved is the genesis of this machine, as a sociological phenomenon. A whole encyclopædia of mechanical inventions—some dating from the earliest times—go to the explanation of it. Thousands of years of discipline, by which the impulsive, improvident nature of the savage has been evolved into a comparatively self-controlling nature, capable of sacrificing present ease to future good, are presupposed. There is presupposed the equally long discipline by which the inventive faculty, almost wholly absent in the savage, has been evolved, and by which accuracy, not even conceived by the savage, has been cultivated. And there is further presupposed the slow political and social progress, at once cause and consequence of these other changes, that has brought us to a state in which such a machine finds a function to fulfil.

The complexity of a sociological fact, and the difficulty of adequately grasping it, will now perhaps be more apparent. For as in this case there has been a genesis, so has there been in every other case, be it of institution, arrangement, custom, belief, etc.; but while in this case the genesis is comparatively easy to trace, because of the comparatively concrete character of process and product, it is in other cases difficult to trace, because the factors are mostly not of a sensible kind. And yet only when the genesis has been traced—only when the various antecedents of all orders have been observed in their coöperation, generation after generation, through past social states—is there reached that interpretation of a fact which makes it a part of sociological science, properly understood. If, for instance, the true meaning of such phenomena as those presented by trade-combinations is to be seen, it is needful to go back to those remote old English periods when analogous causes produced analogous results. As Brentano points out:

> "The workmen formed their Trade-Unions against the aggressions of the then rising manufacturing lords, as in earlier times the old freemen formed their Frith-Gilds against the tyranny of mediæval magnates, and the free handicraftsmen their Craft-Gilds against the aggressions of the Old-burghers." [1]

Then, having studied the successive forms of such organizations in relation to the successive industrial states, there have to be observed the ways in which they are severally related to other phenomena of their respective times—the political institutions, the class distinctions, the family arrangements, the modes of distribution and degrees of intercourse between localities, the amounts of knowledge, the religious beliefs, the morals, the sentiments, the customs, the ideas. Considered as parts of a nation, having structures that form parts of its structure and actions that modify and are modified by its actions, these trade-societies can have their full meanings perceived only when they are studied in their serial genesis through many centuries, and their changes considered in relation to simultaneous changes throughout the social organism. And even then there remains the deeper inquiry—How does it happen that in nations of certain types no analogous institutions exist, and that in nations of other types the analogous institutions have taken forms more or less different?

That phenomena so involved cannot be seen as they truly are, even by the highest intelligence at present existing, is tolerably manifest. And it is manifest also that a Science of Society is likely for a long

[1] Brentano's "Introduction to Early English Guilds," p. cxiv.

time hence to be recognized by but few; since not only is there in most cases an absence of faculty complex enough to grasp its complex phenomena, but there is mostly an absolute unconsciousness that there are any such complex phenomena to be grasped.

To the want of a due complexity of conceptive faculty, there has to be added, as a further difficulty, the want of due plasticity of conceptive faculty. The general ideas of nearly all men have been framed out of experiences gathered within comparatively narrow areas; and general ideas so framed are far too rigid readily to admit the multitudinous and varied combinations of facts which Sociology presents. The child of Puritanic parents, brought up in the belief that Sabbath-breaking brings after it all kinds of transgressions, and having had pointed out, in the village or small town that formed his world, various instances of this connection, is somewhat perplexed in after-years, when acquaintance with more of his countrymen has shown him exemplary lives joined with non-observance of the Sunday. When he adds to his experiences by Continental travel, and finds that the best people of foreign societies disregard injunctions which he once thought essential to right conduct, he still further widens his originally small and stiff conception. Now, the process thus exemplified, in a single belief of a comparatively superficial kind, has to be gone through with numerous beliefs of deeper kinds, before there can be reached the flexibility of thought required for dealing properly with sociological phenomena. Not in one direction, but in nearly all directions, we have to learn that those connections of social facts which we commonly regard as natural, and even necessary, are not at all necessary, and often have no particular naturalness. On contemplating past social states, we are continually reminded that many arrangements, and practices, and convictions, that seem matters of course, are very modern; and we are continually forgetting that many things we now regard as impossible were quite possible a few centuries ago. Still more, on studying societies alien in race as well as in stage of civilization, we perpetually meet with things not only contrary to every thing we should have thought probable, but even such as we should have scarcely hit upon in trying to conceive the most unlikely and even impossible things.

Take in illustration the varieties of domestic relations. That monogamy is not the only kind of marriage, we are, indeed, early taught by our Bible-lessons. But though the conception of polygamy is thus made somewhat familiar, it does not occur to us that polyandry is also a possible arrangement; and we are surprised on first learning that it not only exists, but was once extremely general. When we contemplate these marital institutions unlike our own, we cannot at first imagine that they can be practised with a sense of propriety like that with which we practise ours. Yet Livingstone narrates that, in a tribe bordering one of the Central African lakes, the women were quite disgusted on hearing that in England a man has only one wife. This is a feeling by no means peculiar to them.

"An intelligent Kandyan chief, with whom Mr. Baily visited these Veddahs, was perfectly scandalized at the utter barbarism of living with only one wife, and never parting until separated by death. 'It was,' he said, 'just like the wanderoos' (monkeys)." [1]

Again, one would suppose that, as a matter of course, monogamy, polygamy, and polyandry, in its several varieties, exhausted the possible forms of marriage. An utterly unexpected form is furnished us by one of the African tribes. Marriage, among them, is for so many days in the week—commonly for four days in the week, which is said to be "the custom in the best families:" the wife during the off days being regarded as an independent woman who may do what she pleases. We are little surprised, too, on reading that, by some of the hill-tribes of India, unfaithfulness on the part of the husband is held to be a grave offence, but unfaithfulness on the part of the wife a trivial one. We assume, as self-evident, that good usage of a wife by a husband implies, among other things, absence of violence; and hence it seems scarcely imaginable that in some places the opposite criterion holds. Yet it does so among the Tartars.

"A nursemaid of mine left me to be married, and some short time after she went to the Natchalnick of the place to make a complaint against her husband. He inquired into the matter, when she coolly told him her husband did not love her. He asked her how she knew he did not love her; 'Because,' she replied, 'he never whipped me.'" [2]

A statement which might be rejected as incredible, were it not for the analogous fact that, among the South African races, a white master who does not thrash his men is ridiculed and reproached by them as not worthy to be called a master. Among domestic customs, again, who, if he had been set to imagine all possible anomalies, would have hit upon that which is found among the Basques, and has existed among other races—the custom that on the birth of a child the husband goes to bed and receives the congratulations of friends, while his wife returns to her household work? Or who, among the results of having a son born, would dream of that which occurs among some Polynesian races, where the father is forthwith dispossessed of his property, and becomes simply a guardian of it on behalf of the infant? The varieties of filial relations and of accompanying sentiments continually show us things equally strange, and at first sight equally unaccountable. It seems hardly credible that it should anywhere be thought a duty on the part of children to bury their parents alive. Yet it is so thought among the Fijians; of whom we read also that the parents thus put out of the way, go to their graves with smiling

[1] Lubbock's "Prehistoric Times," p. 344 (first edition).

[2] Mrs. Atkinson's "Recollections of Tartar Steppes," p. 220.

faces. Scarcely less incredible does it seem that a man's affection should be regarded as more fitly shown toward the children of others than toward his own children. Yet the Hill-tribes of India supply an example:

> "Among the Nairs every man looks upon the children of his sisters as his heirs. 'And he would be considered as an unnatural monster were he to show such signs of grief at the death of a child which . . . he might suppose to be his own, as he did at the death of a child of his sister.'"[1]
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> "The philoprogenitiveness of philosophical Europe is a strange idea, as well as term, to the Nair of Malabar, who learns with his earliest mind that his uncle is a nearer relation to him than his father, and consequently loves his nephew much more than his son."[2]

When, in the domestic relations, we meet with such varieties of law, of custom, of sentiment, of belief, thus indicated by a few examples which might be indefinitely multiplied, it may be imagined how multitudinous are the seeming incongruities presented among the social relations at large. To be made conscious of these, however, it is not needful to study uncivilized tribes, or alien races partially civilized. If we look back to the earlier stages of European societies, we find abundant proofs that social phenomena do not necessarily hang together in those ways which our daily experiences show us. Religious conceptions may be taken in illustration.

The grossness of these among civilized nations, as they at present exist, might, indeed, prepare us for their still greater grossness during old times. When, close to Boulogne, one passes a crucifix, at the foot of which lies a mouldering heap of crosses, made of two bits of lath nailed together, deposited by passers-by in the expectation of Divine favor to be so gained, one cannot but have a sense of strangeness on glancing at the adjacent railway, and on calling to mind the achievements of the French in science. Still more one may marvel on finding, as in Spain, a bull-fight got up in the interests of the Church—the proceeds being devoted to a "Holy House of Mercy!" And yet, great as seem the incongruities between religious beliefs and social states now displayed, more astonishing incongruities are disclosed on going far back. Consider the conceptions implied by sundry mystery-plays; and remember that they were outgrowths from a theory of the Divine government, which men were afterward burnt for rejecting. Payments of wages to actors are entered thus:

> "Imprimis, to God, ij^s^
> Item, to Cayphas, iij^s^ iiij^d^
> . . . .
> Item, to one of the knights, ij^s^
> Item, to the devyll and to Judas, xviij^d^."

[1] Quoted in McLennan's "Primitive Marriage," p. 187.
[2] Burton's "History of Sindh," p. 244.

"We have frequently such entries as: "Item, payd for the spret (spirit) of God's cote, ij^d." We learn from these entries that God's coat was of leather, painted and gilt, and that he had a wig of false hair, also gilt."[1]

"Even the Virgin's conception is made a subject for ribaldry; and in the Coventry collection we have a mystery, or play, on the subject of her pretended trial. It opens with the appearance of the somnour, who reads a long list of offences that appear in his book; then come two 'detractors' who repeat certain scandalous stories relating to Joseph and Mary, upon the strength of which they are summoned to appear before the ecclesiastical court. They are accordingly put upon their trial, and we have a broad picture of the proceedings in such a case," etc.[2]

Again, on looking into the illuminated missals of old times, there is revealed to us a mode of conceiving Christian doctrine which it is difficult to imagine as current in a civilized or even semi-civilized society: instance the ideas implied by a highly-finished figure of Christ, from whose wounded side a stream of wafers spouts on to a salver held by a priest. Or take a devotional book of later date—a printed psalter, profusely illustrated with woodcuts representing incidents in the life of Christ. Page after page exhibits ways in which his sacrifice is utilized after a perfectly material manner. Here are shown vines growing out of his wounds, and the grapes these vines bear are being devoured by bishops and abbesses. Here the cross is fixed on a large barrel, into which his blood falls in torrents, and out of which there issue jets on to groups of ecclesiastics. And here, his body being represented in a horizontal position, there rise, from the wounds in his hands and feet, fountains of blood, which priests and nuns are collecting in buckets and jars. Nay, even more astonishing is the mental state implied by one of the woodcuts, which tries to aid the devotional reader in conceiving the Trinity, by representing three persons standing in one pair of boots![3] Quite in harmony with these astoundingly-gross conceptions are the conceptions implied in the popular literature. The theological ideas that grew up in times when Papal authority was supreme, and before the sale of indulgences had been protested against, may be judged from a story contained in the Folk-lore collected by the Brothers Grimm, called "The Tailor in Heaven." Here is an abridged translation:

"God, having one day gone out with the saints and the apostles for a walk, left Peter at the door of heaven with strict orders to admit no one. Soon after a tailor came and pleaded to be let in. But Peter said that God had forbidden any one to be admitted; besides, the tailor was a bad character, and 'cabbaged' the cloth he used. The tailor said the pieces he had taken were small, and had fallen into his basket; and he was willing to make himself useful—he would carry the babies, and wash or mend the clothes. Peter at last let him in, but made him sit down in a corner, behind the door. Taking advantage of

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[1] Wright's "Essays on Archæology," vol. ii., pp. 175, 176. [2] ii., 184.

[3] But four copies of this psalter are known to exist. The copy from which I made this description is contained in the splendid collection of Mr. Henry Huth.

Peter's going outside for a minute or two, the tailor left his seat and looked about him. He soon came to a place where there were many stools, and a chair of massive gold and a golden footstool, which were God's. Climbing up on the chair, he could see all that was happening on the earth; and he saw an old woman, who was washing clothes in a stream, making away with some of the linen. In his anger, he took up the footstool and threw it at her. As he could not get it back, he thought it best to return to his place behind the door, where he sat down, putting on an air of innocence. God now reëntered, without observing the tailor. Finding his footstool gone, he asked Peter what had become of it—had he let any one in? The apostle at first evaded the question, but confessed that he had let in one—only, however, a poor limping tailor. The tailor was then called, and asked what he had done with the footstool. When he had told, God said to him: 'O you knave, if I judged like you, how long do you think *you* would have escaped? Long ago I should not have had a chair or even a poker left in the place, but should have hurled every thing at the sinners.' . . . ."[1]

These examples, out of multitudes that might be given, show the wide limits of variation within which social phenomena range. When we bear in mind that, along with theological ideas that now seem little above those of savages, there went (in England) a political constitution having outlines like the present, an established body of laws, a regular taxation, an emancipated working-class, an industrial system of considerable complexity, with the general intelligence and mutual trust implied by social coöperations so extensive and involved, we see that there are possibilities of combination far more numerous than we are apt to suppose. There is proved to us the need for greatly enlarging those stock-notions which are so firmly established in us by daily observations of surrounding arrangements and occurrences.

We might, indeed, even if limited to the evidence which our own society at the present time supplies, greatly increase the plasticity of our conceptions, did we contemplate the facts as they really are. Could we nationally, as well as individually, "see ourselves as others see us," we might find at home seeming contradictions, sufficient to show us that what we think necessarily-connected traits are by no means necessarily connected. We might learn from our own institutions, and books, and journals, and debates, that while there are certain constant relations among social phenomena, they are not the relations commonly supposed to be constant; and that, when from some conspicuous characteristic we infer certain other characteristics, we may be quite wrong. To aid ourselves in perceiving this, let us, varying a somewhat trite mode of representation, consider what might be said of us by an independent observer, living in the far future—supposing his statements translated into our cumbrous language.

"Though the diagrams used for teaching make every child aware that many thousands of years ago the earth's orbit began to recede

[1] "Kinder- und-Hausmärchen," by William and James Grimm, larger edition (1870), pp. 140–142.

from its limit of greatest eccentricity; and though all are familiar with the consequent fact that the glacial epoch, which has so long made a large part of the northern hemisphere uninhabitable, has passed its climax; yet it is not universally known that, in some regions, the retreat of glaciers has lately made accessible tracks long covered. Amid moraines and under vast accumulations of detritus, have been found here ruins, there semi-fossilized skeletons, and in some places, even records, which, by a marvellous concurrence of favorable conditions, have been so preserved that parts of them remain legible. Just as our automatic quarrying-engines occasionally turn up fossil cephalopods, so little injured that drawings of them are made with the sepia taken from their own ink-bags; so here, by a happy chance, there have come down to us, from a long-extinct race of men, those actual secretions of their daily life, which furnish coloring-matter for a picture of them. By great perseverance our explorers have discovered the key to their imperfectly-developed language; and in course of years have been able to put together facts yielding us faint ideas of the strange peoples who lived there during the last preglacial period.

"A report just issued refers to a time called by these peoples the middle of the nineteenth century of their era; and it concerns a nation of considerable interest to us—the English. Though until now no traces of this ancient nation were known to exist, yet there survived the names of certain great men it produced—one a poet whose range of imagination and depth of insight are said to have exceeded those of all who went before him; the other, a man of science, of whom, profound as we may suppose in many other respects, we know definitely this, that to all nations then living, and that have since lived, he taught how the Universe is balanced. What kind of people the English were, and what kind of civilization they had, have thus always been questions exciting curiosity. The facts disclosed by this report are scarcely of the kind anticipated. Search was first made for traces of these great men, who, it was supposed, would be conspicuously commemorated. Little was found, however. It did, indeed, appear that the last of them, who revealed to mankind the constitution of the heavens, had received a name of honor like that which they gave to a successful trader who presented an address to their monarch; and, besides a tree planted in his memory, a small statue to their great poet had been put up in one of their temples, where, however, it was almost lost among the many and large monuments to their fighting chiefs. Not that commemorative structures of magnitude were never erected by the English. Our explorers discovered traces of a gigantic one, in which, apparently, persons of distinction and deputies from all nations were made to take part in honoring some being—man he can scarcely have been. For it is difficult to conceive that any man could have had a worth transcendent enough to draw from them such extreme homage, when they thought so little of those by whom their name as a race has been saved from oblivion. Their distribution of monumental honors was, indeed, in all respects remarkable. To a physician named Jenner, who, by a mode of mitigating the ravages of a horrible disease, was said to have rescued many thousands from death, they erected a memorial statue in one of their chief public places. After some years, however, repenting them of giving to this statue so conspicuous a position, they banished it to a far corner of one of their suburban gardens, frequented chiefly by children and nursemaids; and, in its place, they erected a statue to a great leader of their fighters—one Napier, who had helped them to conquer and keep down certain weaker races. The reporter does not tell us whether this last had been instrumental in destroying as many lives as the first had saved; but he remarks: 'I could not but wonder at this strange substitution among a people who professed a religion of peace.' Not, however, that this was an exceptional act, out of harmony with their usual acts: quite the contrary. The records show that, to keep up the remembrance of a great victory gained over a neighboring nation, they held for many years an annual banquet, much in the spirit of the commemorative scalp-dances of still more barbarous peoples; and there was never wanting a priest to ask on the banquet a blessing from one they named the God of love. In some respects, indeed, their code of conduct seemed not to have advanced beyond, but to have gone back from, the code of a still more ancient people from whom their creed was derived. One of the laws of this ancient people was, 'an eye for an eye, and a tooth for a tooth;' but sundry laws of the English, especially those concerning acts that interfered with some so-called sports of their ruling classes, inflicted penalties which imply that their principle had become 'a leg for an eye, and an arm for a tooth.' The relations of their creed to the creed of this ancient people are indeed difficult to understand. They had at one time cruelly persecuted this ancient people—Jews they were called—because that particular modification of the Jewish religion, which they, the English, nominally adopted, was one which the Jews would not adopt. And yet, marvellous to relate, while they tortured the Jews for not agreeing with them, they substantially agreed with the Jews. Not only, as above instanced, in the law of retaliation did they outdo the Jews, instead of obeying the quite opposite principle of the teacher they worshipped as divine, but they obeyed the Jewish law, and disobeyed this divine teacher in other ways—as in the rigid observance of every seventh day, which he had deliberately discountenanced. Though they were angry with those who did not nominally believe in Christianity (which was the name of their religion), yet they ridiculed those who really believed in it; for some few people among them, nicknamed Quakers, who aimed to carry out Christian precepts instead of Jewish precepts, they made butts for their jokes. Nay, more; their substantial adhesion to the creed they professedly repudiated was clearly demonstrated by this, that in each of their temples they fixed up in some conspicuous place the ten commandments of the Jewish religion, while they rarely fixed up the two Christian commandments which were to replace them. 'And yet,' says the reporter, after dilating on these strange facts, 'though the English were greatly given to missionary enterprises of all kinds, and though I sought diligently among the records of these, I could find no trace of a society for converting the English people from Judaism to Christianity.' This mention of their missionary enterprises introduces other remarkable anomalies. Being anxious to get adherents to this creed which they adopted in name, but not in fact, they sent out men to various parts of the world to propagate it—one part, among others, being that subjugated territory above named. There the English missionaries taught the gentle precepts of their faith; and there the officers employed by their government exemplified these precepts—one of the exemplifications being that, to put down a riotous sect, they took fifty out of sixty-six who had surrendered, and, without any trial, blew them from the guns, as they called it—tied them to the mouths of cannon, and shattered their bodies to pieces. And then, curiously enough, having thus taught and thus exemplified their religion, they expressed great surprise at the fact that the only converts their missionaries could obtain among these people were hypocrites and men of characters so bad that no one would employ them.

"Nevertheless, these semi-civilized English had their good points. Odd as must have been the delusion which made them send out missionaries to inferior races, who were always ill used by their sailors and settlers, and eventually extirpated by them, yet, on finding that they spent annually a million of their money in missionary and allied enterprises, we cannot but see some generosity of motive in them. They country was dotted over with hospitals and almshouses, and institutions for taking care of the diseased and indigent; and their towns were overrun with philanthropic societies, which, without saying any thing about the wisdom of their policy, clearly implied good feeling. They expended in the legal relief of their poor as much as, and at one time more than, a tenth of the revenue raised for all national purposes. One of their remarkable deeds was that, to get rid of a barbarous institution of those times, called slavery, under which, in their colonies, certain men held complete possession of others, their goods, their bodies, and practically even their lives, they paid down twenty millions of their money. And not less striking was the fact that, during a war between two neighboring nations, they contributed large sums, and sent out many men and women, to help in taking care of the wounded and assisting the ruined.

"The facts brought to light by these explorations are thus extremely instructive. Now that, after tens of thousands of years of discipline, the lives of men in society have become so harmonious—now that character and conditions have little by little grown into adjustment, we are apt to suppose that congruity of institutions, conduct, sentiments, and beliefs, is necessary. We think it almost impossible that, in the same society, there should be daily practised principles of quite opposite kinds; and it seems to us scarcely credible that men should have, or profess to have, beliefs with which their acts are absolutely irreconcilable. Only that extremely rare disorder, insanity, could explain the conduct of one who, knowing that fire burns, nevertheless thrusts his hand into the flame; and to insanity also we should ascribe the behavior of one who, professing to think a certain course morally right, pursued the opposite course. Yet the revelations yielded by these ancient remains show us that societies could hold together notwithstanding what we should think a chaos of conduct and of opinion. Nay, more, they show us that it was possible for men to profess one thing and do another, without betraying a consciousness of inconsistency. One piece of evidence is curiously to the point. Among their multitudinous agencies for beneficent purposes, the English had a 'Naval and Military Bible Society'—a society for distributing copies of their sacred book among their professional fighters on sea and land; and this society was subscribed to, and chiefly managed by, leaders among these fighters. It is, indeed, suggested by the reporter, that for these classes of men they had an expurgated edition of their sacred book, from which the injunctions to 'return good for evil,' and 'to turn the cheek to the smiter,' were omitted. It may have been so; but, if not, we have a remarkable instance of the extent to which conviction and conduct may be diametrically opposed, without any apparent perception that they are opposed. We habitually assume that the distinctive trait of humanity is rationality, and that rationality involves consistency; yet here we find an extinct race (unquestionably human, and regarding itself as rational) in which the inconsistency of conduct and professed belief was as great as can well be imagined. Thus we are warned against supposing that what now seems to us so natural was always natural. We have our eyes opened to an error which has been getting confirmed among us for these thousands of years, that social phenomena and the phenomena of human nature necessarily hang together in the ways we see around us."

Before summing up what has been said under the title of "Subjective Difficulties—Intellectual," I may remark that this group of difficulties is separated from the group of objective difficulties, dealt with in the last chapter, rather for the sake of convenience than because the division can be strictly maintained. In contemplating difficulties of interpretation—phenomena being on the one side and intelligence on the other—we may, as we please, ascribe failure either to the inadequacy of the intelligence or to the involved nature of the phenomena. The difficulty is subjective or objective according to our point of view. But the difficulties above set forth arise in so direct a way from conspicuous defects of human intelligence, that they may be, more appropriately than the preceding ones, classed as subjective.

So regarding them, then, we have to beware, in the first place, of this tendency to automorphic interpretation; or rather, having no alternative but to conceive the natures of other men in terms such as our own feelings and ideas furnish, we have to beware of the errors likely hence to arise—discounting our conclusions as well as we can. Further, we must be on our guard against the two opposite prevailing errors respecting Man, and against the sociological errors arising from them: we have to get rid of the two beliefs that human nature is unchangeable, and that it is easily changed; and we have, instead, to become familiar with the conception of a human nature that is changed in the slow succession of generations by social discipline. Another obstacle not to be completely surmounted by any, and to be partially surmounted by but few, is that resulting from the want of intellectual faculty complex enough to grasp the extremely complex phenomena which Sociology deals with. There can be no complete conception of a sociological fact, considered as a component of Social Science, unless there are present to thought all its essential factors; and the power of keeping them in mind with due clearness, as well as in their proper proportions and combinations, has yet to be reached. Then beyond this difficulty, only to be in a measure overcome, there is the further difficulty, not, however, by any means so great, of enlarging the conceptive capacity, so that it may admit the widely divergent and extremely various combinations of social phenomena. That rigidity of conception produced in us by experiences of our own social life, in our own time, has to be exchanged for a plasticity that can receive with ease, and accept as natural, the countless different combinations of social phenomena utterly unlike, and sometimes exactly opposite to, those we are familiar with. Without such a plasticity there can be no proper understanding of coexisting social states allied to our own, still less of past social states, or social states of alien civilized races and races in early stages of development.

SPONTANEOUS MOVEMENTS IN PLANTS.

By ALFRED W. BENNETT, M. A., B. Sc., F. L. S.

THAT there are no "hard and fast lines" in Nature is a truth which is more and more forcing itself upon the minds of men of science. The older naturalists delighted to circumscribe their own special domains within sharply-marked boundaries, which no trespassers were allowed to pass. We have long given up the attempt thus accurately to map out the kingdom of Nature. Her varied productions are connected with one another by innumerable links and cross-links; and our systems of classification, even the most "natural," are but an imperfect human contrivance for bringing together those forms which present the most evident marks of resemblance or affinity. While the truth of this law is most familiar in the case of those smaller subdivisions of the animal and vegetable kingdoms—classes, orders, and genera—which are connected with one another by innumerable intermediate forms, it is none the less certain in the line of demarcation which separates these two great kingdoms themselves from one another. In attempting to draw up a definition which shall serve accurately and infallibly to distinguish between the Animal and Vegetable Kingdoms, we find ourselves compelled to abandon one supposed crucial test after another, and to content ourselves at last with framing, as in the case of the lower subdivisions, an assemblage of characters, by the *tout-ensemble* of which we must decide whether our organism is an animal or a plant. So great is the uncertainty as to the actual boundary-line, that large groups of lowly organisms, such as those known as Diatoms and Desmideæ, have been regarded by experienced authorities as belonging to each kingdom; and one of the ablest of living naturalists, Ernst Haeckel, of Jena, has proposed the division of the material universe not into three but into four kingdoms—animals, plants, protista, and minerals, the new kingdom of Protista including the most lowly-organized forms of what are generally considered animals and plants, from the Flagellate Infusoria to the Fungi, distinguished by the absence of sexes, and the mode of reproduction by gemmation or fission alone. The soundness of this new classification is not, however, admitted by the best remaining authorities in England or Germany.

One of the most obvious distinctions between the Animal and Vegetable Kingdoms consists in the possession by the former of a power of voluntary motion of either the whole or a part of the body, dependent on the presence of a distinct nervous system, which is absent in the latter; a distinction obvious enough when contrasting any of the higher forms of the two kingdoms, but which, like all other individual characters, fails when pressed to too rigid a test. There are animals, so regarded by the best naturalists, and possessing other characters which compel us to refer them to this class, whose power of motion is confined to the "contractility" common to all protoplasmic substance, and which are absolutely devoid of a nervous system; and there are plants, unquestionable plants, which possess powers of spontaneous motion strictly comparable to those exhibited by the lower animals. It may be interesting to collect together a few illustrations of this last-named fact, some of which appear to the writer scarcely explicable by the application of any of those laws which govern inert unorganized matter.

The movements to which reference is here made belong in most cases to a part rather than to the whole of a plant; in some cases, however, we find the whole organism endowed with spontaneous motion of a very remarkable character. An instance of this occurs in the case of the regular undulating motion, exceedingly similar to that of some of the lower animals, characteristic of a class of Algæ hence called Oscillatoriæ. The mode of reproduction of the Algæ, the lowest class of the vegetable kingdom, to which the sea-weeds and the fresh-water confervæ belong, is often obscure, and in some cases different distinct processes exist in the same species. In certain fresh-water Algæ, reproduction takes place by the formation of "Zoospores" (Fig. 1), which are the results of the separation and isolation of the protoplasmic contents of certain special cells. According to the observations of M. Thuret, who has paid great attention to this subject, these zoospores, which are of extreme minuteness, are ovoid in form, and are furnished, either over their whole circumference or toward one extremity, with very fine cilia, varying from two to a large number. As soon as these minute bodies free themselves from the cell in which they are enclosed, the cilia begin to vibrate with great rapidity, the vibration being accompanied by a movement of rotation of the bodies themselves on their axis, occasioned apparently by rapid and spontaneous contractions; the result being a quick motion of the body through the water—undistinguishable, in fact, from that of some of the lower forms of

FIG 1.

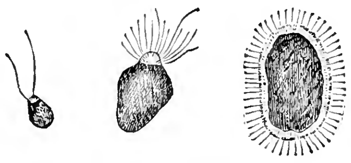
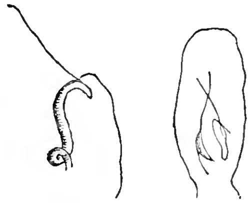


FIG. 2.



animal life—continuing for a period varying from half an hour to several hours, at the expiration of which they settle down, reassume the characters of ordinary vegetable cells, lose their cilia, and give rise, by cell-division, to new individuals resembling the parent-plant. Those zoospores which are furnished with cilia at one extremity only, direct that extremity, which is destitute of chlorophyll or green coloring-matter, toward the light. Closely resembling these zoospores are the "spermatozoa" of the higher orders of cryptogamic plants, ferns, equisetums, and mosses. These bodies (Fig. 2) are produced in the antheridia or male organs, again by a modification of the protoplasmic cell-contents; they are filiform bodies of various forms, mostly presenting one or more spiral curves, and furnished with vibratile cilia. When released from the parent-cells, they move about with great activity until they come into contact with the opening of the archegonium or female organ, which they enter, and thus fructify the germ of the new plant. Pringsheim describes the process by which the spermatozoa enter the archegonium as a very peculiar twisting motion, due to the action of the mucus or protoplasm of the germ-cell. He has seen a large number of spermatozoa enter a single cell, forming a kind of chain.

In describing these curious bodies, of the connection of which with the vegetable kingdom there is no room for doubt, one is irresistibly reminded of these lowly forms of animal life known as *Amœba* and *Gromia*, consisting apparently of shapeless masses of protoplasm possessing indeed far more restricted powers of locomotion than the zoospores and spermatozoa, their faculties in this respect being confined to the protrusion and retractation of arms or pseudopodia, by means of which a slow movement is effected. If the possession of consciousness and of a voluntary control over the movements of the body belongs to the animal kingdom even to its lowest forms, it is difficult to frame any cogent reason for denying these faculties to the vegetable organisms which we have been considering. A very interesting problem also presents itself for solution in the almost perfect identity of constitution between these lowest forms of animals and the protoplasmic elements in the constitution of more highly-organized forms. If the *Amœbæ* and *Gromiæ* are admitted to be distinct individual animals, the same line of reasoning would almost compel us to admit to the same rank the white corpuscles of the blood of mammalia, which present almost the same characters and possess the same power of protrusion and retractation of a portion of their substance.

The instances above cited illustrate the faculty of spontaneous motion possessed by detached portions of protoplasm endowed with the power of forming themselves into new individuals. This phenomenon appears, however, to be but a form of the property possessed by all protoplasm, of constant motion in some form or other. The circulation of the protoplasmic mucous fluid within the cells of plants is one of the most beautiful phenomena of vegetable life revealed by the microscope, and one of which the explanations at present offered appear quite inadequate. A favorite object for exhibiting this circulation or rotation is formed by the jointed hairs which cover the stamens of the Virginian spider-wort (*Tradescantia Virginica*). The movement is rendered visible by the presence, in the otherwise colorless fluid, of minute opaque granules of chlorophyll or other coloring-matter; and is observable with great ease in the semi-transparent tissue of certain water-plants, as *Chara*, or the *Valisneria* commonly grown in fresh-water aquariums. It consists of a slow movement of the protoplasmic fluid up one side of the cell, across the ends, and down the other side; not perpendicularly, but in an oblique or spiral course. The subject has been carefully investigated by three French physiologists, MM.

Prillieux, Roze, and Brogniart, who find that the rotation is directly influenced, in a remarkable manner, by the presence of light. M. Prillieux kept a moss in the dark for several days, when the cells presented the appearance of a green net-work, between the meshes of which was a clear, transparent ground. All the grains of chlorophyll were applied to the walls which separate the cells from one another; there were none on the upper or under walls which form the surfaces of the leaf. Under the influence of light, the grains, together with the thin mucous plasma in which they are embedded, change their position from the lateral to the superficial walls, this change taking place, under favorable circumstances, in about a quarter of an hour. On attaining their new position, the grains do not remain absolutely immovable, but continually approach and recede from one another; and, if again darkened, they leave their new position, and return to the lateral walls. Artificial light produces the same effect as daylight.

Analogous to the circulation of the protoplasm, within the cell, is that of the sap or nutritive fluid through the whole plant, passing through the permeable walls of the cells. This circulation of the sap, by which fluid is conveyed equally to all parts of the plant, apparently in opposition to the laws of gravity, is no doubt explicable, to a certain extent, by the application of known physical laws, of which the most important are capillary attraction, osmose, or the law by which a less dense fluid passes through a permeable diaphragm to mingle with a denser fluid, and the upward-pumping force, to supply the partial vacuum occasioned by the evaporation of water from the leaves. Allowing, however, full scope to all these physical forces, there would seem to be a residuum of energy, still unaccounted for, connected with the vitality of the plant itself. In particular, the selective power of plants, in absorbing from the soil a larger portion of those ingredients which are required for the formation, or healthy life, of their tissues, is an absolutely unexplained phenomenon. A familiar instance of this is furnished by the difference in the amount of silica absorbed by corn-crops and by leguminous plants, amounting, in the former case, to 2.5 per cent., in the latter, to 0.3 per cent., of the dry foliage. Indeed, if any two plants are grown together, side by side, in the same soil, the constitution of the ash, i. e., of the solid ingredients derived from the soil, will be remarkably different; while, in the same plant, in the same soil, the constitution is constant. It was pointed out, by the Duke of Argyll, when criticising Darwin's "Origin of Species," how unavoidable it seems, in describing the phenomena of Nature, to use language involving the idea of contrivance and design. In the same manner, it seems impossible to describe the process of vegetative life without appearing to attribute to the plant some conscious power of its own. A striking instance of this, as well as of the liability to consider a mere statement of an obscure law in other terms as an explanation of that law, occurs in an admirable treatise on the growth of plants—

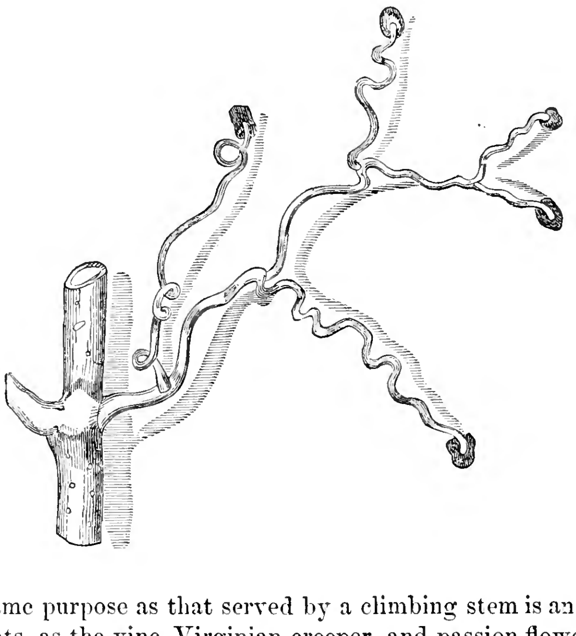
Johnson's "How Crops Grow."[1] "The cereals *are able to dispose* of silica by giving it a place in the cuticular cells; the leguminous crops, on the other hand, *cannot remove it* from their juices; the latter remain saturated, and thus further diffusion of silica from without becomes impossible except as room is made by a new growth. It is in this way that we have a *rational and adequate* explanation of the selective power of the plant." The "rational and adequate explanation" seems to me, on the contrary, to be merely a restatement of this selective power of the tissues in other terms. Because the tissues want the silica, is no explanation of how they get it.

The curious and interesting movements of climbing plants have been investigated by Palm, Mohl, and Asa Gray, and form the subject of one of the most charming of Mr. Darwin's works. It is well known that climbing plants, such as the hop, honeysuckle, or major convolvulus, always twine round the stem or other object which supports them in one direction, that is, always either from right to left or from left to right; but few, probably, have reflected, and fewer still attempted to observe, by what process the end of the growing shoot contrives to change its position from one side to the other of the stem. If the extremity of a living stem, say of convolvulus, growing perfectly free, and in a normal position, is observed, it is seen to hang over from its support in a horizontal direction; and this horizontal portion is found, if observed at intervals of some hours, to point in different directions. The end of the growing shoot has, in fact, the property of revolving in a large circle, round the support, always, with the same species, in the same direction, either with the sun or opposed to the sun. The rate of revolution varies with different plants, and with the same plant at different periods of its growth; it is much quicker in warmer than in cooler weather. With the hop, Darwin found it to vary from two and a half hours to nine hours. The object of the climbing power of plants is no doubt to reach the light, and to expose a large surface of leaves to its action and to that of the free air; but the mode by which this power of motion is gained is by no means clear. The late eminent physiologist Mohl supposed that it was caused by a dull kind of irritability in the stem, which caused it to bend toward the support when in contact with it. Mr. Darwin has, however, carefully tested this theory experimentally, and always with negative results. He rubbed many shoots, much harder than was necessary to excite movement in any tendril, or in any foot-stalk, of a leaf-climber, but without result. This view seems also entirely negatived by the fact that not only do the stems of climbing plants revolve when they are not in contact with any support, but even more freely, under such circumstances, than

[1] "How Crops Grow:" A Treatise on the Chemical Compositions, Structure, and Life, of the Plant, for Agricultural Students. By S. W. Johnson. Revised and adapted for English Use, by A. H. Church and W. T. T. Dyer. London: Macmillan & Co., 1869 pp. 345.

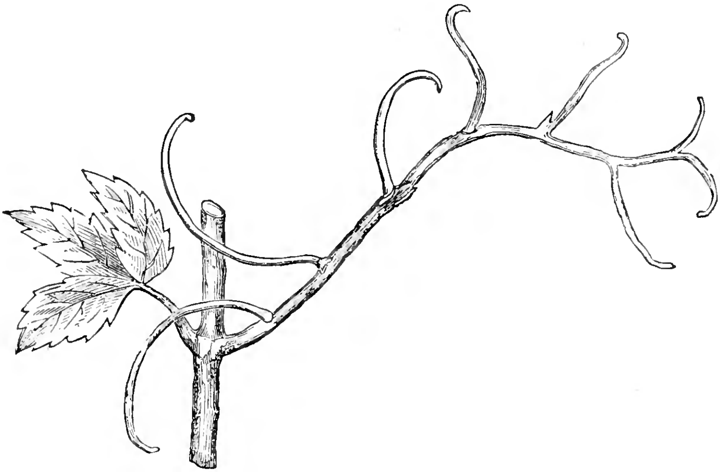
when climbing. When a climbing plant first springs from the ground, the extremity of the shoot performs slow gyrations in the air, as if, as Darwin expresses it, it were *searching* for a support. I do not here discuss the question whether this habit may be the result of a tendency transmitted and enhanced through thousands of generations; the movement itself is, in the individual plant, entirely "spontaneous," in every sense of the term; that is, is not the necessary result of known physical laws acting upon the individual. Darwin's paper, "On the Movements and Habits of Climbing Plants," published in the *Journal of the Linnæan Society*, contains a number of the most interesting observations on this class of plants; and the language employed is everywhere suggestive of some hidden, sentient controlling power in the plant itself.

FIG. 3.



The same purpose as that served by a climbing stem is answered in other plants, as the vine, Virginian creeper, and passion-flower, by tendrils; and the phenomena of spontaneous motion in tendrils are, if possible, still more curious. Some tendrils display the same power of rotatory motion possessed by the extremities of the shoots of climbing plants; others do not revolve, but are sensitive, bending to the touch. The curling movement, consequent on a single touch, continues to increase for a considerable time, then ceases; after a few hours the tendril uncurls itself, and is again ready for action. A tendril will thus show a tendency to curl round any object with which it comes into contact, with the singular exception that it will seldom twine itself round another tendril of the same plant. It is also very curious that, with some exceedingly sensitive plants, the falling of drops of rain on the tendril will produce no effect whatever. The mode in which a tendril of a *Bignonia* catches hold of a support is thus described by Darwin: "The main petiole is sensitive to contact with any object; even a small loop of thread after two days caused one to bend upward. The whole tendrils are likewise sensitive to contact. Hence, when a shoot grows through branched twigs, its revolving movement soon brings the tendril into contact with some twig, and then all three

FIG. 4.



'toes' bend (or sometimes one alone), and, after several hours, seize fast hold of the twig, exactly like a bird when perched." The Virginian creeper has another mode of attaching itself to a wall or other solid support, by the formation, at the extremities of the branches of the tendril, of little disks or cushions, very similar to the disks on the foot of the house-fly, by which it is enabled to attach itself to our windows, and to walk along the ceiling. These disks secrete a glutinous fluid, which attaches the tendril to the support with such strength that it is often impossible to detach it without destroying the tendril, or even removing a portion of the wall itself. As soon as the attachment is accomplished, the tendril gradually thickens, and contracts spirally, as shown in Figs. 3 and 4. This spiral contraction, indeed, is always the result of the tendril meeting with a support; and, if no support is found, the tendril soon shrinks and withers away. Some tendrils exhibit a most remarkable power of selection, which, to use Mr. Darwin's words, "would, in an animal, be called instinct." The tendrils of a species of *Bignonia* slowly travelled over the surface of a piece of wood, and, when the apex of one of them came to a hole or fissure, it inserted itself; the same tendril would frequently withdraw from one hole and insert its point into a second one. Mr. Darwin has seen a tendril keep its point, in one instance, for twenty hours, and, in another instance, for thirty-six hours, in a minute hole, and then withdraw it. After the record of this fact on such unexceptional evidence, we are the more prepared to credit the statement of Mr. Anderson-Henry, that a climber will, in running up a wall, carefully avoid contact with another climber which it dislikes; and even the account by M. Paul Lévy,[1] that the *lianes* of tropical forests have an affinity for certain trees, toward which they direct their growth, and not toward those nearest to them; carefully drawing themselves away when they encounter one of the objectionable trees.

We may conclude our account of climbing plants with the following remarks by Mr. Darwin: "It has often been vaguely asserted that plants are distinguished from animals by not having the power of movement. It should rather be said that plants acquire and display this power only when it is of some advantage to them, but that this is of comparatively rare occurrence, as they are affixed to the ground, and food is brought to them by the wind and rain. We see how high in the scale of organization a plant may rise, when we look at one of the more perfect tendril-bearers. It first places its tendrils ready for action, *as a polypus places its tentacula.* If the tendril be displaced, it is acted on by the force of gravity, and rights itself. It is acted on

FIG. 5.

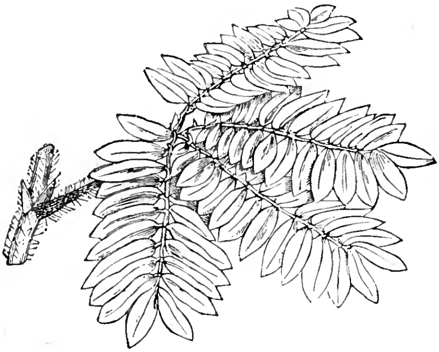
by the light, and bends toward or from it, or disregards it, whichever may be most advantageous. During several days the tendrils or internodes, or both, spontaneously revolve with a steady motion. The tendril strikes some object, and quickly curls round, and firmly grasps

[1] Bulletin de la Société Botanique de France. Translated in the *Gardener's Chronicle*, March 19, 1870.

it. In the course of some hours it contracts into a spire, dragging up the stem, and forming an excellent spring. All movements now cease. By growth, the tissues become wonderfully strong and durable. The tendril has done its work, and done it in an admirable manner."

The phenomenon known as Sensitiveness is of by no means uncommon occurrence in the vegetable kingdom. It consists of a sudden movement of the leaf, a portion of the flower, or the whole plant, on contact with, or even on the approach of, a foreign body. One of the most familiar examples is that of the Sensitive-plant (*Mimosa pudica* and *sensitiva*), Figs. 5 and 6, in which three distinct movements are

FIG. 6.

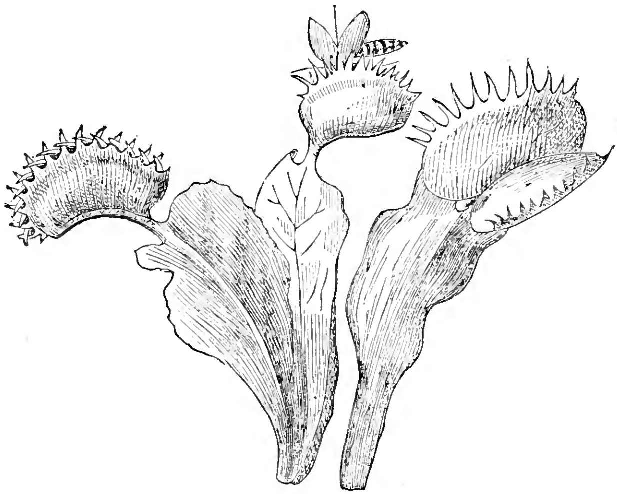


observable when the leaf is touched by the hand or the warm breath. First, the numerous leaflets close in pairs, bringing their upper faces together, and also inclining forward; then the four branches of the leaf-stalk, which were outspread like the rays of a fan, approach each other; at the same time the main leaf-stalk turns downward, bending at its joint with the stem. The explanation offered in one of our best botanical text-books, of this phenomenon, is as follows: "There is a swelling at the base of the petiole, the cells of which constitute, as it were, two springs acting in contrary directions, so that, if the one from any cause be paralyzed, the other pushes the leaf in the direction of least resistance. These springs, if they be so called, are set in action by the rush of fluid creating a turgid state of the one set of cells and an empty state of the other. What circumstances regulate the turgescence are only imperfectly known." It will be obvious that, even if this is correct as a statement of facts, it offers no real explanation of the phenomenon; for it is quite as difficult to understand how the mere approach of the hand, which gives rise to a sensitiveness commencing, it will be remarked, at the *extremity* of the leaf, will account for a "turgescence" of the springs at the *base* of the leaf, which then causes the movement. It should be observed also that we are unaware of any use which these movements are to the plant. Similar sensitiveness occurs in the leaves of some other leguminous plants, in several species of *Oxalis*, etc. M. Bert has observed that the sensitiveness is destroyed by the continual application of chloroform, and also by placing the plant constantly in the dark or in green light.

Similar movements to that of the Sensitive-plant, but occurring spontaneously, may be observed in other plants. Thus in the *Desmodium gyrans* or "Telegraph-plant," sometimes grown in our hothouses, belonging to the same order, Leguminosæ, the leaf consists of three leaflets, a large central, and two smaller side ones. The motion is especially observable in the small side-leaflets, which on a warm summer's day may be seen to rise and fall by a succession of jerking movements; now stopping for some time, then moving briskly, always resting for a while in some part of their course, and starting again without apparent cause, "seemingly of their own will," as Prof. Asa Gray remarks. The movement is not simply up and down, but the end of the moving leaflet sweeps more or less of a circuit. It is not set in motion by a touch, but begins, goes on, and stops, of itself.

An exceedingly remarkable instance of sensitiveness occurs in the case of the "Venus's Fly-trap" of North Carolina (*Dionæa muscipula*),

Fig. 7.

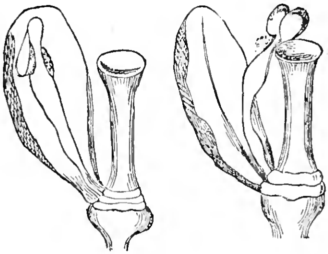


represented in Fig. 7. The mid-rib of each leaf serves as a kind of hinge. When the inside of the blade of the leaf, or the fine bristles which grow on its surface, are touched by any foreign substance, the hinge suddenly closes, and if the intruding substance be a fly or other small object, it is immediately imprisoned as represented in the figure, the teeth on the margin of the leaf closing firmly upon one another like a steel trap, the sides of the trap then flatten down and press firmly upon the victim, and it now requires a very considerable force to open the trap. If nothing is caught, the trap presently reopens of itself, and is ready for another attempt. With regard to the object of this strange proceeding, there can be no doubt that the insect is retained until the softer parts of the body are completely dissolved in the thick mucous fluid which is exuded by the leaves; and Prof. Asa Gray considers that the evidence is nearly complete that the animal matter is actually absorbed in the leaf itself. It is even stated that pieces of raw beef are digested by the leaf in the same manner! Seeing, however, that it is now generally admitted by physiologists that even pure water is not absorbed through the pores of leaves, which serve only for the *exhalation* of vapor, this explanation is very hard of belief. The "pitchers" of the *Nepenthes*, or pitcher-plant, act also as fly-traps, large numbers of insects being enticed into them by the fluid they secrete, and are then unable to extricate themselves.

The sensitiveness of the leaves of plants is but an excessive development of the phenomenon known as the Sleep of Plants. In the case of the Sensitive-plant the position assumed by the leaf and leaflets in the night is the same as that which they assume when disturbed in the daytime; and with many other plants, such as the clover and the *Robinia* or "acacia" tree, the change in the position of the leaflets, morning and evening, is a familiar fact. The Sleep of Plants extends also to the flowers, many plants opening their flowers only at particular times of the day. Thus the major convolvulus of the gardens and the goat's-beard open at sunrise and always close by about noon, the evening primrose opens only in the evening, and many others last for but a single day. So regular is the time of opening and closing of some flowers, that Linnæus drew up a list, which he termed a "floral clock." The singular part of the affair is, that with many flowers the time of opening and closing is determined, not by the degree of light, or by the temperature or humidity of the atmosphere, but absolutely by the hour of the day. The giant water-lily of the Amazons, the *Victoria regia*, opens, for the first time, about 6 P.M., and closes in a few hours, then opens again at 6 P.M. the next day, remaining open until the afternoon, when it closes and sinks below the water. Other plants, again, open their flowers only in the bright sunshine, as the beautiful yellow centaury (or *Chlora perfoliata*) the sundew (*Drosera rotundifolia*), etc. In the latter plant, belonging to the same natural order as the Venus's Fly-trap, and possessing a slight irritability of the leaves, Mr. Worthington Smith has noticed also a strong sensitiveness in the petals, the flowers closing suddenly when touched.

Irritability or sensitiveness, similar to that of the leaves of the Sensitive-plant, is not uncommon in the flower. An instance has been alluded to in the petals of the sundew; it occurs also in the lip of the corolla of several of the orchis tribe. It is, however, more common in the proper organs of reproduction, as the style of *Stylidium*, the stamens of the berberry, etc., and is then directly connected with the process of fertilization of the ovule. In *Stylidium*, an Australian genus, the style and filaments are adherent into a column, which hangs over on one side of the flower. When touched, it rises up and springs over to the opposite side, at the same time opening its anthers and scattering the pollen. The stamens of the various species of *Berberis* and *Mahonia*, to the former of which our common berberry belongs, exhibit this irritability to a remarkable degree. If touched with a pin or other object at the base of the inside face of the filament, the stamen will spring violently forward from its place within the petal, so as to bring

Fig. 8.



the anther into contact with the stigma, as shown in Fig. 8, and will after a time slowly resume its original position. At first sight it may seem as if this contrivance were intended to insure the fertilization of the pistil from the pollen of its own flower. In reality, however, the reverse is the case; the excitation takes place in Nature when an insect entering the flower, for the sake of the honey in the glands at the base of the pistil, touches the inside of one of the stamens. The pollen is thus thrown on to the head or body of the insect, which carries it away to the next flower it visits, and leaves some of it on the stigma, and thus cross-fertilization instead of self-fertilization is secured. Similar motion of the stamens toward the pistil, but spontaneous, takes place in the case of the London Pride, and other species of *Saxifraga*.

Elasticity is, indeed, a common property of organized tissue, though it is not often developed to so evident an extent. In the "touch-me-not," or *Impatiens*, we have a familiar instance in the seed-vessel, which, if touched when nearly ripe, suddenly coils back, throwing the seeds to a considerable distance. The "squirting cucumber" (*Momordica elaterium*) marks the period of ripeness by the fruit separating from its stalk, and expelling the seeds and juice with great violence. Mr. Thomas Meehan described a remarkable instance of elasticity at a recent meeting of the Academy of Natural Sciences ot Philadelphia. The seeds—or, as would appear from his description, more correctly the embryos of the seeds—of the American "witch-hazel" (*Hamame-*

lis Virginica) are thrown out with such force as to strike people violently in the face who pass through the woods. Collecting a number of the capsules, and laying them on the floor, he found the seeds or embryos were thrown out generally to the distance of four or six feet, and in one instance as much as twelve feet.

Many of the instances of spontaneous motion or irritability we have now recorded may doubtless be explained by the application of known physical laws. With others this is not so easy; and it is but reasoning in a circle to say that, because the organisms which manifest them belong to the vegetable kingdom, therefore the phenomena cannot be the result of a sentient force acting upon, and independent of, matter. Darwin has described how certain movements of the tendrils of climbing plants would be termed instinctive if they were observed in animals. The rapid rotatory motion of the zoospores of the lower Algæ is absolutely undistinguishable from that of certain undoubted lowly organized forms of animal life. It is very difficult to distinguish between the movement of a shoot of a climber performing its circles in the air in search of a support, and that of the tentacula of a coral-polyp in search of food. The mode in which the Venus's Fly-trap seizes and encages its prey is very like that adopted by a sea-anemone. Every fresh addition to our knowledge seems to confirm us in the view that it is unwise to dogmatize by laying down too rigid generalities, and absolutely to deny certain functions to whole classes of animated beings because we do not find them exhibited in the forms most familiar to us. I do not wish distinctly to claim for plants the actual possession of a voluntary or sentient faculty. But I do wish to point out that facts do not support us in asserting that a clear line of demarcation separates the animal from the vegetable kingdom; the power of voluntary motion belonging to the one and not to the other. Taking all the facts we have described into consideration, the statement seems justified which has been made by one of our most experienced naturalists, Prof. Wyville Thomson: "There are certain phenomena, even among the higher plants, which it is very difficult to explain without admitting some low form of a general harmonizing and regulating function, comparable to such an obscure manifestation of reflex nervous action as we have in sponges and in other animals in which a distinct nervous system is absent."—*Popular Science Review.*

LIGHT AND LIFE.

By FERNAND PAPILLON.

TRANSLATED FROM THE FRENCH BY A. R. MACDONOUGH, ESQ.

THE organized being that we observe on the surface of the globe does not subsist solely by the nourishment absorbed, sometimes in the form of aliment, sometimes in that of atmospheric air; it needs besides, heat, electricity, and light, which are like a secret and life-giving spring for the world. Its organs are subject to the twofold influence of an inner medium, represented by the humors moistening its tissues, and of an outer medium, composed of all those subtle and fluid agents with which space is filled. This close interdependence of beings and of the media in which they are immersed, too plain to have quite escaped notice, yet too complex for analysis by science in its infancy, has been brought in our day under piercing and methodical investigation, yielding results of remarkable interest. Light especially takes a part in this combination deserving deep study. Whether organic existence in its simplest expression and its lowest degree be considered, or whether we regard it in its highest functions, the influence of light upon it strikes us in the most strange and unlooked-for relations. Lovely forms and vivid colors, the hidden harmonies of life as well as its dazzling brightness and bloom, alike claim mysterious connection with that golden mist diffused by the sun over the world.

From this point of view, modern science finds reason in the simple worship paid by primitive man. It helps us to understand the divine honors given to the star of day among the earliest civilized nations, and the pathetic terror those child-like races suffered when, at evening, they saw the crimson globe, that was the source for them of all power and all splendor, slowly disappear in the horizon. That pious idolatry, far from being a mere utterance of gratitude for the wealth of fertility scattered by the sun over earth, was a homage, too, to the comforting source of brightness and joy, revealing the natural affinity between man and light. The Vedas, the Orphic hymns, and other remains of the earliest religions, are full of this feeling, which appears again in many poets and philosophers of antiquity, Lucretius and Pliny among others. Dante, invoking so often "the divine and piercing light," crowns his poem by a hymn which more than any thing else is a symbolic description of the supreme brightness. On the other hand, laborers, gardeners, physicians, unite in bearing witness to the beneficial effects of light. Naturalists and philosophers, too, in all ages, impressed with the power of the sun, have described its manifold effects. Alexander Humboldt, following Goethe and Lavoisier, often notices its its various influences. Yet it was not until the middle of the eighteenth century that so rich a subject of study began to attract serious experimental research; and such are the difficulties of this grand and complex problem, that its solution is only partly revealed, in spite of a long series of attempts. Great deficiencies remain to be supplied, and many vaguely-known points to be cleared up, nor has an effort even been made as yet to systematize all the groups of results gained. The latter task we propose to attempt here, with the purpose of showing by a remarkable instance the manner of evolving knowledge through the power of the experimental method, the sequent, cumulative, and mutually-supporting character of well-conducted experiments, and their endless wealth of instruction; in a word, the process adopted by eminent men in the great art of wresting her secrets from living Nature.

I.

Plants gain their nourishment by the absorption through their roots of certain substances from the soil, and by the decomposition, through their green portions, of a particular gas contained in the atmosphere—carbonic-acid gas. They decompose this gas into carbon, which they assimilate, and oxygen, which they reject. Now, this phenomenon, which is the vegetable's mode of respiration, can only be accomplished with the assistance of solar light.

Charles Bonnet, of Geneva, who began his career by experimenting on plants, and left this attractive subject, to devote himself to philosophy, only in consequence of a serious affection of his sight, was the first to detect this joint work, about the middle of the eighteenth century. He remarked that vegetables grow vertically, and tend toward the sun, in whatever position the seed may have been planted in the earth. He proved the generality of the fact that, in dark places, plants always turn toward the point whence light comes. He discovered, too, that plants immersed in water release bubbles of gas under the influence of sunlight. In 1771, Priestley, in England, tried another experiment. He let a candle burn in a confined space till the light went out, that is until the contained air grew unfit for combustion. Then he placed the green parts of a fresh plant in the enclosure, and at the end of ten days the air had become sufficiently purified to permit the relighting of the candle. Thus he proved that plants replace gas made impure by combustion with a combustible gas; but he also observed that at certain times the reverse phenomenon seems to result. Ten years later, the Dutch physician, Ingenhousz, succeeded in explaining this apparent contradiction. "I had but just begun these experiments," says that skilful naturalist, "when a most interesting scene revealed itself to my eyes: I observed that not only do plants have the power of clearing impure air in six days or longer, as Priestley's experiments seem to point out, but that they discharge this important duty in a few hours, and in the most thorough way; that this singular operation is not due at all to vegetation, but to the effect of sunlight; that it does not begin until the sun has been some time above the horizon; that it ceases entirely during the darkness of night; that plants shaded by high buildings or by other plants do not complete this function, that is, they do not purify the air but that, on the contrary, they exhale an injurious atmosphere, and really shed poison into the air about us; that the production of pure air begins to diminish with the decline of day, and ceases completely at sunset; that all plants corrupt the surrounding air during the night, and that not all portions of the plant take part in the purification of the air, but only the leaves and green branches."

How do this transformation of impure air into pure air under the influence of sunlight, and the reverse process during darkness, take place? Senebier, the countryman and friend of Bonnet, gives us the answer. Applying to the problem the late discoveries of Lavoisier, he showed that the impure air absorbed and decomposed in the daytime by plants is nothing more than the carbonic acid thrown off by a burning candle or a breathing animal, and that the pure air which results from this decomposition is oxygen. He proved besides that the gas released by vegetables during the night is also carbonic acid, and consequently that the respiration of plants in the night-time is the reverse of that in the daytime. He also demonstrated that heat cannot supply the place of light in these processes. Thus the nature of the phenomenon was explained, but it remained to be learned what relation exists between the volume of carbonic acid absorbed and that of the oxygen released. Another Genevese, Theodore de Saussure, proved that the quantity of oxygen released is less than that of carbonic acid absorbed, and at the same time that a part of the oxygen retained by the plant is replaced by nitrogen thrown off; and supposed that this nitrogen was furnished by the substance of the plant itself. This function of the green portions of vegetables is, moreover, performed with great rapidity and energy. Boussingault, who has made some remarkable experiments on this subject, filled a vessel of water with vine-leaves, placed it in the sun, and sent a current of carbonic acid through it; on its passing out, he collected nothing but pure oxygen. It is calculated that a leaf of nenuphar gives out in this way during the summer more than 66 gallons of oxygen.

In 1848 Cloëz and Gratiolet contributed new facts. They showed that aquatic plants follow the same course during the day as others, but that at night they are at rest, and give rise to no release of carbonic acid. They proved the powerful, instantaneous action of solar light on vegetable respiration. If a few leaves of *potamogeton* or of *nayas* are put into a gauge full of water saturated with carbonic acid, as soon as the apparatus is placed in the sun, an immense number of light bubbles, of almost pure oxygen, are seen to detach themselves from the surface of the leaves. The shadow of a slight cloud, crossing the sky, suffices to check their disengagement at once, followed by sudden activity after it has passed. By intercepting the solar beam with a screen, the alternations of quickness and slowness in the production of gas-bubbles may be very plainly seen, according as the plant receives the rays or not. Water-plants show other interesting peculiarities. Diffused light has no power to excite the production of carbonic acid, unless the phenomenon has been first called forth by direct sunlight. Still further, the solar influence having once been applied, the evolution of carbonic acid continues even in darkness. The vegetable keeps up at night its mode of breathing by day. The living force of solar light, therefore, can be fixed and stored away in living plants, as Van Tieghem, the discoverer of this curious property, very well remarks, to act afterward in complete darkness, and exhaust itself by slow degrees, through transformation into equivalent chemical energy. It appears to lodge itself in phosphorescent sulphur, to reappear under the form of less intense radiations; it hoards itself up in paper, starch, and porcelain, to come forth anew, after a greater or less lapse of time, through its action on the salts of silver. The peculiarity residing in these green cells of vegetables, then, is not an isolated one: it is a special instance of the general property, inherent in many bodies, of retaining, within their mass, in some unknown form, a part of the vibrations that fall upon them, and of preserving them through transformation, to be afterward emitted, either in the state of luminous radiations, or in the condition of chemical or mechanical energy. The great principle of the transformation of forces thus holds good in the vegetable kingdom. And we end with the remark that these facts of persistent activity, called out by an initial excitement, lend support to the idea that living forces hold a close connection with the molecular structure of bodies, and may even be the determinate expression of that structure. We cannot conceive manifold energy in a mathematical and irreducible atom; but in a molecule, made up of a certain number of atoms, we can fancy dynamic figures of a very complex order.

We have thus far regarded only the action of white light, the effect of the totality of rays sent us by the sun; but this light is not simple. It is composed of a great number of radiations, of distinct colors and properties. When white light is decomposed by the prism, we obtain seven groups of visible rays, of unequal refractive power, violet, indigo, blue, green, yellow, orange, and red. The spectrum or ribbon of colors thus obtained widens and spreads out by invisible radiations. Beyond the red, there exist radiations of dark heat, or calorific-rays, and, outside of the violet, radiations which are called chemical or ultraviolet rays. The first affect the thermometer, the last occasion energetic reactions in chemical compounds. What is their influence upon vegetation? Does solar light act by its colored rays, its heat-rays, or its chemical rays?

The question has been subjected to many important experiments, and is, perhaps, not yet determined. Daubeny, in 1836, was the first to watch the respiration of plants in colored glasses, and he found that the volume of oxygen released is always less in the colored rays than in white light. The orange rays appeared to him most energetic; the blue rays coming next. A few years later, Gardner, in Virginia, exposed young, feeble plants, from two to three inches long, to the different rays of the spectrum, and observed that they regained a green color with a maximum rapidity under the action of the yellow rays and those nearest them. In one of his experiments, green color was produced, under the yellow rays, in three hours and a half, under orange rays in four hours and a half, and under the blue, only after eighteen hours. Thus it is seen that the highest force of solar action corresponds neither with the maximum of heat, which is placed at the extremity of the red, nor with the maximum of chemical intensity, situated in the violet, at the other edge of the spectrum. Those radiations which are most active, from a chemical point of view, are the ones which have the least influence over the phenomena of vegetable life.

Mr. Draper, at present a professor in the New York University, and the author of a very remarkable history of the intellectual development of Europe, undertook new and more accurate experiments about the same time. He placed blades of grass in tubes filled with water which was charged with carbonic gas, and exposed these tubes, near each other, to the different rays of the solar spectrum. Then measuring the quantity of oxygen gas disengaged in each one of these little vessels, he proved that the largest production of gas occurred in the tubes exposed to the yellow and green light; the next, in the orange and red rays. In 1848, Cloëz and Gratiolet discovered the singular fact that the action of light on vegetation is more powerful when it passes through roughened glass than when transmitted through transparent glass. Julius Sachs, more lately, conceived the idea of measuring the degree of intensity of light-action, upon aquatic plants, by counting the number of gas-bubbles released by a cutting of a branch exposed to the sun in water charged with carbonic acid. He thus observed that the bubbles thrown off under the influence of orange light are very little less numerous than under white light, while the branch put under blue light throws out about twenty times less. These experiments are decisive. Neither the chemical nor the calorific rays of the solar beam act on plants. The luminous rays only, and chiefly the yellow and the orange, have that property. To these clearly-settled results, Cailletet added a new fact, that green light acts on vegetation in the same way as darkness. He assigns this reason for the feebleness of vegetation bathed in green light under the shade of large trees. It is true, this discovery of Cailletet has been warmly questioned recently, but it has found defenders too, Bert among others and we shall find soon that it harmonizes with the whole system of the actions of light in the two kingdoms of life.

A year ago, science had gone thus far, when a very distinguished botanist, Prillieux, published the result of a course of experiments made with an entirely different purpose, and taking up the study of the action of light from a new point of view. Resting on the twofold consideration that the distinctly-colored rays are not equally luminous, and that those of the greatest illuminating power are also those which act with most energy on plants, Prillieux undertook to examine what influence will be exercised on plants by rays different in color, but known to be equal in intensity, and whether this influence differs in the case of different colors, or is the same, provided they do not vary in illuminating power. The long and conscientious researches of this experimenter led him to the conclusion, that rays of different colors act with equal force on the green parts of plants, and produce an equal release of gas, when they have the like luminous intensity. He holds that all luminous rays effect the reduction of carbonic acid by vegetables in proportion to their illuminating power, whatever their refrangibility may be. If the yellow and orange rays are more active in this respect, it is because their luminous glare is much greater than that of the extreme rays.

The luminous rays also promote the production of green tissue, the green matter of all vegetables. Gardeners blanch certain plants by raising them in the dark. They thus obtain plants of a pale yellow, spindling, without strength or crispness. They are attacked by a true chlorosis, and waste away, as if sprung from barren sand. The sun also aids the transpiration of plants, and the constant renewal of healthy moisture in their tissues. On failure of the evaporation of moisture, the plant tends to grow dropsical, and its leaves fall, from weakness of the stem.

This love of plants for light, which is one of the most imperious needs of their existence, displays itself also in other interesting phenomena, which show that solar rays are, in very truth, the fertilizer that produces color. The corolla of vegetable species growing at great heights on mountains has livelier colors than that of species that spring in low spots. The sun's rays, in fact, pass more easily through the clear atmosphere that bathes high summits. The hue of certain flowers even varies according to the altitude. Thus the corolla of the *Anthyllis vulneraria* shades down from white to pale red and vivid purple. In general, the vegetation of open, well-lighted places is richer in color and development than that of regions not accessible to the sun. Some flowers originally white afterward deepen in color by the direct action of light. Thus *Cheiranthus cameleo* has a flower at first whitish, afterward yellow, and, at last, a violet-red. The *Hibiscus mutabilis* bears a flower which opens at morning with a white hue, and grows red during the day. The flower-buds of the *Agapanthus umbellatus* are white when they begin to unclose, and afterward take on a blue tint. If, at the moment of leaving its spathe, the flower is wrapped in black paper, intercepting the light, it remains white, but regains its color in the sun. The tints of fruits in the same way develop under the healthy action of daylight, and the rule extends to those principles of every nature which give taste and odor to the different parts of the the plant.

Flowers, fruits, and leaves, then, are elaborated by the help of luminous vibrations. Their tissue holds the sun's rays. Those charming colors, those fragrant perfumes, and delicious flavors, all the innocent pleasures the vegetable kingdom yields us, owe their creation to light. The subtle working of these wonderful operations eludes us, as does that which guides the fleeting diffusion and thousand-fold refractions displayed by the imposing spectacle of the dawn; but is it nothing to gain a glimpse of those primal laws, and to possess even a twilight ray upon these magnificent phenomena?

II.

Light exerts a mechanical influence on vegetables. The sleep of flowers, the bending of their stems, the nutation of heliotropic plants, the inter-cellular movements of chlorophyll, offer proofs of an extremely delicate sensitiveness of certain plants in this respect. Pliny mentions the plant called the sunflower, which always looks toward the sun, and steadily follows its motion. He notices, too, that the lupin always follows the sun in its daily movement, and points out the hour for laborers. Tessier, at the end of the last century, took up the study of these phenomena, and inferred in a general way that the stems of plants always turn toward the light, and bend over, if necessary, to receive it. He noted, too, that leaves tend to turn toward the side whence daylight comes. Payer made more exact experiments. He tried them with young stems of common garden cresses grown on damp cotton in the dark. These stems have the property of curving and turning quickly when placed in a room lighted only from one side or in a box receiving light on one wall only. The upper part of the stem curves first, the lower part remaining straight. By a second movement the top erects and the bottom bends over, so that the plant, though leaning, becomes almost rectilinear again. When put in a room receiving light from two windows, the following results are noticed: If the openings are on the same side admitting light equally, the stem bends in the direction of the middle of the angle formed by these two beams; if one of the two windows admits more light than the other, the stem leans toward it; if the windows are opposite each other, the stem stands erect, when light comes equally from both sides, and, if it does not, turns toward the stronger rays. Payer discovered, moreover, that the part of the irradiating light most active in its effects corresponds in this case to the violet and the blue. The red, orange, yellow, and green rays, do not seem to produce any movement in plants. Gardner carried the investigation still further. He sowed turnips, and let them develop in the dark to two or three inches in length. Then he threw the solar spectrum by a prism on this little field. The plants inclined toward a common axis. Those exposed to the red, orange, yellow, and green rays, leaned toward the deep blue, while the part lighted by violet bent in the opposite direction. Thus the crop took the appearance of a wheat-field bowing under two contrary winds. The turnips placed in the violet-blue region looked toward the prism. Gardner thus determined, as Payer had done, that the most refrangible rays are those which effect the bending of the young stems. He proved also that the plants grow erect again in the dark.

These experiments, repeated and varied in many ways by Dutrochet and Guillemin, uniformly gave like results, but the phenomenon itself still remains almost unexplained. This remark also applies to the very singular facts of the twisting of running plants. The stems of these plants, in twining about their supports, usually curl from the left to the right. Others follow the contrary course, and some twist indifferently in either way. Charles Darwin inferred, from his investigation, that light has an effect on this phenomenon. If twining plants are put in a room near a window, the tip of their stalk takes longer to complete the half circuit during which it turns toward the darker part of the room than that which is described nearer the window. Thus one of them, having gone through a whole turn in five hours and twenty minutes, the half circle toward the window employed a little less than an hour, while the other was not traversed in less than four hours and a half. Duchartre placed some China yams in full vegetation in a garden, and others in a completely dark cellar. The stems of the plants uniformly lost in the dark the power of twisting around their supporting sticks. Those exposed to the sun presented one portion twisting, but when put in the cellar they shot out straight stems. Yet some twining plants are known that seem to be independent of light in twisting.

The sleep of plants, in connection with light particularly, is still less understood. The flowers and leaves of certain vegetables droop and wither at fixed hours. The corolla closes, and after quiet inaction the plant again expands. In others, the corolla drops and dies without closing. In others still, as the convolvulus, the closing of the flower occurs only once, and its sleep marks its death. Linnæus noted the hours of opening and shutting in certain plants, and thus arranged what has been called Flora's clock; but the relations of these closings with the intensity of light have not yet been scientifically determined.

The green coloring of vegetable leaves and stems is due to a special substance called chlorophyll, which forms microscopic granulations contained in the cells which make up these stems and leaves. These grains are more or less numerous in every cell, and it is their number as well as intensity of color that determines the tint of the plant's tissues. Sometimes they are closely pressed together, covering the whole inner surface of the cell; sometimes the quantity is smaller, and they are separate. Now, it has lately been discovered that in the latter case, under the influence of light, the green corpuscles we speak of undergo very singular changes of position. Some twelve years ago, Boehm noticed for the first time that in certain unctuous plants the grains of chlorophyll gather at one point of the wall of the cells under the action of the sun. He remarked that the phenomenon does not take place in the dark, nor in the red rays. The flat sheet made up of a single layer of cells, without epidermis, which composes the leaves of mosses, seemed to Famintzin the most suitable for this delicate kind of observations. He followed the movements, that take place in these sheets, by microscopic study. During the day the green coloring-grains are scattered about the upper and lower parts of the leaf-cells. At night, on the contrary, they accumulate toward the lateral walls. The blue rays affect them like white light; the yellow and the red ones keep the chlorophyll in the position it takes at night. The order of activity in the rays seems, then, to differ in this case from that in the phenomena of respiration. The researches of Borodine and Prillieux proved that these movements of coloring-corpuscles within the cells occur in almost all cryptogamous plants, and in a certain number of phanerogamous ones. The lately-published experiments of Roze show that in mosses the grains of chlorophyll are connected by very slender threads of plasma, and may suggest the idea that these threads are the cause of the changes of position just described. Perhaps there is some real relation between them; but it must not be forgotten that these movements of the plasmatic matter inside the cell take place by day and night, and that light has no marked effect on them. The green particles, on the contrary, creep over the walls of the cell, and move toward the lightest part as zoospores and some infusoria do.

Biot relates that in 1807, while at Formentera, employed in the work of extending the meridional arc, he devoted his leisure hours to the analysis of the gas contained in the swimming-bladder of fishes living at different depths in the sea. The oxygen required for these analyses was furnished him by the leaves of the *cactus opuntia*, which he exposed in water to sunlight, under hand-glasses, ingeniously applying the discovery of Ingenhousz and Senebier. It occurred to him one day to expose these leaves, in a dark place, to the illumination thrown by lamps placed in the focus of three large reflectors, used for night-signals in the great triangulation. He threw the light from three of these reflectors on the cactus-leaves. The eye, placed in this concentration of light, must have been struck blind, Biot says. The experiment, kept up for an hour, did not cause the release of a single gas-bubble. The glass was then taken into the diffused light outside the hut. The sun was not shining, but the evolution of gas took place at once with great rapidity. Biot is a little surprised at the result and concludes that artificial light is impotent to do what solar light can. The labors of Prillieux and other contemporary botanists have proved that all light acts on the respiration of plants, provided only it is not too powerful. In Biot's case artificial light had no effect, because it it was far too intense.

III.

Lavoisier somewhere says: "Organization, voluntary movement, life, exist only at the surface of the earth, in places exposed to light. One might say that the fable of Prometheus's torch was the expression of a philosophic truth that the ancients had not overlooked. Without light, Nature was without life; she was inanimate and dead. A benevolent God, bringing light, diffused over the earth's surface organization, feeling, and thought." These words are essentially true. All organic activity was very clearly at first borrowed from the sun, and if the earth has since stored away and made its own a quantity of energy, that sometimes suffices to produce of itself that which originally proceeded from solar stimulus, it must not be forgotten that those living forces, of startling and complex aspects, sometimes our pitiless enemies, often our docile servants, have descended, and are still descending upon our planet, from the inexhaustible sun. The study of animal life shows us by striking instances the physiological efficacy of light, and the immaterial chain, it may be called, which links existences with the fiery and abounding heart of the known universe.

In plants, as we have seen, respiration at night is the reverse of that by day. There are infusoria which behave, under the influence of light, exactly like the green portions of plants. These microscopic animalcula are developed in fine weather in stagnant water, and in breathing produce oxygen at the expense of the carbonic acid contained in the liquid. Morren saw that the oxygenation of the water occasioned by these little beings varied very perceptibly in the course of twenty-four hours. It is at the minimum at sunrise, and reaches its maximum toward four in the afternoon. If the sky is overcast, or the animalcula disappear, the phenomenon is suspended. This is only an exception. Animals breathe at night in the same way as in the daytime, only less energetically. Day and night they burn carbon within their tissues, and form carbonic acid, only the activity of the phenomenon is much greater in light than in darkness.

Light quickens vital movements in animals, especially the act of nutrition, and darkness checks them. This fact, long known and applied in practical agriculture, is expressly noted by Columella. He recommends the process of fattening fowls by rearing them in small dark cages. The laborer, to fatten his cattle, shuts them up in stables lighted by small low windows. In the half-light of these prisons the work of disassimilation goes on slowly, and the nutritive substances, instead of being consumed in the circulating fluid, more readily accumulate in the organs. In the same way, for the sake of developing enormous fat livers in geese, they are put into dark cellars, kept entirely quiet, and crammed with meal.

Animals waste away as plants do. The absence of light sometimes makes them lose vigor, sometimes entirely changes them, and modifies their organization in the way least favorable to the full exercise of their vital powers. Those that live in caverns are like plants growing in cellars. In certain underground lakes of Lower Carniola we find very singular reptiles resembling salamanders, called proteans. They are nearly white, and have only the rudiments of eyes. If exposed to light they seem to suffer, and their skin takes a color. It is very likely that these beings have not always lived in the darkness to which they are now confined, and that the prolonged absence of light has destroyed the color of their skins and their visual organs. Beings thus deprived of day are exposed to all the weaknesses and ill effects of chlorosis and impoverishment of the blood. They grow puffy, like the colorless mushroom, unconscious of the healthy contact of luminous radiance.

William Edwards, to whom science owes so many researches into the action of natural agents, studied, about 1820, the influence exercised by light on the development of animals. He placed frogs'-eggs in two vessels filled with water, one of which was transparent, and the other made impermeable to light, by a covering of black paper. The eggs exposed to light developed regularly; those in the dark vessel yielded nothing but rudiments of embryos. Then he put tadpoles in large vessels, some transparent, others shielded from the light. The tadpoles that were shone upon, soon underwent the change into the adult form, while the others either continued in the tadpole condition, or passed into the state of perfect frogs with great difficulty. Thirty years later, Moleschott performed some hundreds of experiments in examining how light modifies the quantity of carbonic acid thrown off in respiration. Operating on frogs, he found that the volume of gas exhaled by daylight exceeds by one-fourth the volume thrown off in darkness. He established, in a general way, that the production of carbonic acid increases in proportion to the intensity of light. Thus, with an intensity represented by 3.27, he obtained 1 of carbonic acid, and, with an intensity of 7.38, he obtained 1.18. The same physiologist thinks that in batrachians the intensity of light is communicated partly by the skin, partly by the eyes.

Jules Béclard made more thorough researches. Common flies'-eggs, taken from the same group, and placed at the same time under differently-colored glasses, all produce worms. But if the worms, hatched under the different glasses, are compared at the end of four or five days, perceptible differences may be seen among them. Those most developed correspond with the violet and blue ray; those hatched under the green ray are far less advanced; while the red, yellow, and white rays exert an intermediate action. A long series of experiments on birds satisfied Béclard that the quantity of carbonic acid thrown out in breathing, during a given time, is not sensibly modified by the different colors of the glasses the animals are placed under. It is the same with small mammifers, such as mice; but it is to be observed in this case that the skin is covered either with hair or feathers, and the light does not strike the surface. The same physiologist examined also the influence of the different-colored rays of the spectrum on frogs. Under the green ray, the same weight of frogs produces in the same period of time a greater quantity of carbonic acid than under the red ray. The difference may be a half greater; it is usually a third or a fourth greater; but if the skin is afterward taken off the frogs, and they are replaced under the same conditions, the result alters. The amount of carbonic acid thrown out by the flayed frogs is greater in red than in green light. A few experiments tried by Béclard on the exhalation of the vapor of water by the skin show that in the dark, temperature and weight being alike, frogs lose by evaporation a half or a third less moisture than under white light. In the violet ray the quantity of moisture lost by the animal is perceptibly the same as in white light.

Light acts directly on the iris of almost all animals, and thus produces contraction of the pupil, while heat produces the reverse phenomena. This stimulus is observed in eyes that have been separated for some time from the body, as Brown-Séquard has shown.

Bert lately took up some very curious experiments on the preference of animals for differently-colored rays. He took some of those almost microscopic crustacea, common enough in our fresh waters, the daphne-fleas, remarkable for their eager way of hurrying toward light. A number of these insects were put into a glass vessel, well darkened, and a spectrum of the ray then thrown into it. The daphnes were dispersed about the dark vessel. As soon as the spectrum-colors appeared, they began to move, and gathered in the course of the luminous track, but, when a screen was interposed, they scattered again. At first all the colors of the spectrum attracted them, but it was soon noticed that they hurried much more toward the yellow and green, and even moved away a little if these rays were quickly replaced by the violet. In the yellow, green, and orange parts of the spectrum there was a thronging and remarkable attraction. A pretty large number of these little beings were remarked in the red, too, a certain number in the blue, and some, fewer in proportion to the distance, in the most refrangible portions of the violet and ultra-violet. For these insects, as for ourselves, the most luminous part of the spectrum was also the most agreeable. They behaved in it as a man would do who, if he wished to read in a spectrum thrown about him, would approach the yellow and avoid the violet. This proves, in the first place, that these insects see all the luminous rays that we see ourselves. Do they perceive the chlorific and chemic rays, that is to say, the ultra-red and ultra-violet ones, which do not affect our retina? Bert's experiments enable us to answer that they do not. That physiologist is even led to assert that, with regard to light and the different rays, all animals experience the same impressions that man does.

Let us now look at the influence of light upon the color of the skin in animals, noticing first the being which presents the strangest peculiarities in this respect, the chameleon. This animal, indeed, experiences very frequent modifications of color in the course of the same day. From Aristotle, who attributed these changes to a swelling of the skin, and Theophrastus, who assigned fear as their cause, to Wallisniéri, who supposes them to result from the movement of humors toward the surface of the animal's body, the most different opinions have been expressed on this subject. Milne-Edwards, thirty years ago, explained them by the successive inequalities in the proportions of the two substances, one yellowish and the other violet, which color the skin of the reptile, inequalities due to the changes in volume of the very flattened cells that contain these substances. Bruck, renewing these researches, proves that the chameleon's colors follow from the manifold dispersion of solar light in the colored cells, that is to say, from the production of the same phenomenon remarked in soap-bubbles and all very thin plates. Its colors, then, come from the play of sunlight among the yellow and violet substances distributed very curiously under its wrinkled skin. It passes from orange to yellow, from green to blue, through a series of wavering and rainbow-like shades, determined by the state of the light's radiation. Darkness blanches it, twilight gives it the most delicate marbled tints, the sun turns it dark. A part of the skin bruised or rubbed remains black, without growing white in the dark. Bruck satisfied himself, moreover, that temperature does not affect these phenomena.

All animals having fur or feathers are darker and more highly colored on the back than on the belly, and their colors are more intense in summer than in winter. Night-butterflies never have the vivid tints of those that fly by day, and among the latter those of spring have clearer, brighter shades than the autumn ones. The gold-and-azure dust that adorns them harmonizes with the tones of colors in surrounding Nature. Night-birds, in the same way, have dark plumage, and the downiness of their coverings contrasts with the stiffness of those that fly by day. Shells secluded under rocks wear pale shades, compared with those that drink in the light. We have spoken above of cave-animals. What a distinction between those of cold regions and those of equatorial countries! The coloring of birds, mammals, and reptiles, peopling the vast forests or dwelling on the banks of the great rivers in the torrid zone, is dazzling in its splendor. At the north we find gray tints, dead and of little variety, usually close upon white, by reason of the almost constant reflection from snow.

Not only the color of organized beings, but their shape too, is linked with the action of light, or rather of climate. The flora of the globe gain increasing perfection as we go from the poles toward the equator. The nearer these beings approach the highest degree of heat and light, the more lavishly are richness, splendor, and beauty, bestowed on them. The energy and glory of life, perfect forms as well as brilliant arraying, are the distinguishing mark of the various and manifold races in tropical regions, giving this privileged world its characteristic aspect. A pure emanation from the sun, Nature here lives wild and splendid, gazing unshrinkingly, like the Alpine eagle, on the eternal and sublime source which inundates it with heat and glow. Look, now, at the regions of the pole! A few dwarfish shrubs, a few stunted and herbaceous plants, compose all its flora. Its animals have a pale covering and downy feathers; its insects, sombre tints. All around them are the utmost limits of life—ice invades every thing, the sea alone still breeds a few acalephs, some zoophytes, and other low rudimentary organizations. The sun comes aslant and seldom. At the equator he darts his fires, and gives himself without stint to the happy Eden of his predilection.

IV.

It remains to note the relations of light to that being most sensitive to its influence, and best able to express its effects, man himself. The new-born child seeks the day by instinct, and turns to the side whence light comes, and, if this spontaneous movement of the infant's eyes is thwarted, strabismus may be the consequence.

Of all our organs the eye is the one that light especially affects. Through the eyes come all direct notions of the outer world, and all impressions of an æsthetic kind. Now, the excitability of the retina shows variations of every kind. Prisoners confined in dark cells have been known to acquire the power of seeing distinctly in them, while their eyes also become sensitive to the slightest changes in the intensity of light. In 1766 Lavoisier, in studying certain questions upon the lighting of Paris, which had been given for competition by the Academy of Sciences, found after several attempts that his sight wanted the necessary sensitiveness for observing the relative intensities of the different flames he wished to compare. He had a room hung with black, and shut himself up in it for six weeks in utter darkness. At the end of that time his sensitiveness of sight was such that he could distinguish the faintest differences. It is very dangerous, too, to pass suddenly from a dark place into a strong flood of light. The tyrant Dionysius had a building made with bright, whitewashed walls, and would order wretches, after long seclusion from light, to be suddenly brought into it. The contrast struck them blind. Xenophon relates that many Greek soldiers lost their sight from reflections off the snow in crossing the mountains of Armenia. All travellers who have visited the polar regions have often seen like results produced by the glare of the snow. When the impression of light on the eye is sudden and overpowering, the retina suffers most. If it is less powerful, but longer continued, the humors of the eye are affected. The phenomenon called sunstroke results from the action of light, and not, as is often supposed, from excessively high temperature. It sometimes occurs in the moderately warm season of spring; or a very intense artificial light, and particularly the electric light, may occasion it. The violet and ultra violet parts of the sunbeam seem to be the cause of this action, for screens of uranium glass, that absorb these portions, protect the eyes of experimenters occupied in studying the electric light. This disorder is a true inflammation.

The action of light on the human skin is manifest. It browns and tans the teguments, by calling out the production of the coloring-matters they contain. The parts of the body usually bare, as the skin of the face and hands, are darker than others. In the same region, country-people are more tanned than town residents. In latitudes not far apart, the inhabitants of the same country vary in complexion in a measure perceptibly related to the intensity of solar light. In Europe three varieties of color in the skin are distinctly marked: olive-brown, with black hair, beard, and eyes; chestnut, with tawny beard and bluish eyes; blond, with fair, light beard and sky-blue eyes. White skins show more readily alterations occasioned by light and heat; but, though less striking, facts of variation in color are observable in others. The Scytho-Arabic race has but half its representatives in Europe and Central Asia, while the remainder passes down to the Indian Ocean, continuing to show the gradual rising heat of climate by deepening brown complexions. The Himalayan Hindoos are almost white; those of the Deccan, of Coromandel, Malabar, and Ceylon, are darker than some negro tribes. The Arabs, olive and almost fair in Armenia and Syria, are deep brown in Yemen and Muscat. The Egyptians, as we go from the mouths of the Nile up-stream toward its source, present an ascending chromatic scale, from white to black, and the same is true of the Tuariks on the southern side of Mount Atlas, who are only light-olive, while their brethren in the interior of Africa are black. The ancient monuments of Egypt show us a fact equally significant. The men are always depicted of a reddish brown; they lived in the open air, while the women, kept shut up, have a pale-yellow complexion. Barrow asserts that the Mantchoo Tartars have grown whiter during their abode in China. Rémusat, Pallas, and Gutzlaff, speak of the Chinese women as remarkable for a European fairness. The Jewesses of Cairo or Syria, always hidden under veils or in their houses, have a pallid, dead color. In the yellow races of the Sumatra Sound and the Maldives, the women, always covered up, are pale like wax. We know, too, that the Esquimaux bleach during their long winter. These phenomena, no doubt, are the results of several influ ences acting at once, and light does not play the sole part in them. Heat and other conditions of the medium probably have a share in these operations of color. Still, the peculiar and powerful effect of luminous radiation as a part of them is beyond dispute.

The whole system of organic functions shares in the benefits of light. Darkness seems to favor the preponderance of the lymphatic system, a susceptibility to catarrh in the mucous membranes, flaccidity of the soft parts, swellings and distortions of the bony system, etc. Miners and workmen employed in ill-lighted shops are exposed to all these causes of physiological suffering. We may notice, with regard to this, that certain rays of the solar beam affect animals like darkness; among others, the orange light, which, according to Bert, hurts the development of batrachians. Now, if this light is injurious to animals, it is not so to plants, as we have seen. In exchange, green light, which is hurtful to vegetables, is extremely favorable to animals. There is a kind of opposition and balance, then, as respects luminous affinities, between the two great kingdoms of life. White light, as Dubrianfant says, seems to split up under the influence of living beings into two complementary groups, a green group and an orange group, which exhibit in Nature antagonistic properties. It is quite certain that green light is a very lively and healthful stimulant for our functions, and that, for that reason, spring is the favored and enchanted season.

The correspondence between perfection of forms and heightening of luminous intensity proves true in the human race as in others. Æsthetics, agreeing with ethnography, demonstrate that light tends to develop the different parts of the body in true and harmonious proportion. Humboldt, that nice observer, says, speaking of the Chaymas: "The men and women have very muscular bodies, but plump, with rounded forms. It is needless to add that I have never seen a single one with any natural deformity. I will say the same of so many thousands of Caribs, Muycas, Mexican and Peruvian Indians, whom we have observed during five years. These bodily deformities and misgrowths are extremely rare in certain races of men, especially among people who have a deep-colored skin." No doubt there is great difficulty in conceiving how light can model—can exert a plastic power. Yet, reflecting on its tonic effect on the outer tegument, and its general influence over the functions, we may assign it the part of distributing the vital movement orderly and harmoniously throughout the whole of the organs. Men who live naked are in a perpetual bath of light. None of the parts of their bodies are withdrawn from the vivifying action of solar radiation. Thence follows an equilibrium which secures regularity in function and development.

It is commonly said that an ordained causality rules the operations of matter, and that free spontaneity is the privilege of those of spirit. It might well be said on this subject that, in many cases, the causes acting in matter elude us, and, not less often, the causes which act in spirit overpower us; but it is not our task to elucidate that terrible antithesis of law, when the genius of Kant failed in it. We would only ask it to be observed how great an influence light has on the system of the intellectual functions. The soul finds in it the least deceiving of the consolations it seeks for the eternal sadness of our destiny—the bitter melancholy of life. Thought, fettered and dumb in a dark place, springs into freedom and spirit at evening, in a room brilliant with light. We cannot shun the sad moods caused by gloomy and rainy weather, nor resist the impulse of joy given by the spectacle of a brilliant day. Here we must confess our slavery—yet a slavery to be welcomed, that yields only delights. And why should we not join in the chorus of all animate and inanimate things, which, at the touch of light, quiver, and thrill, and betray in a thousand languages the magical, rapturous stimulus of that contact? By instinct, and spontaneously, we seek it everywhere, always happiest when it is found. In some sort, it suffices us. And what a part it plays, what a charm it gives, in works of poetry and art!

This is not the place to unfold that attractive and hardly-opened chapter of æsthetics—to demonstrate the relation between the atmosphere and art, by interrogating the climates of the globe and the great masters of all ages, not following a system of empirical analogies and far-fetched suggestions, but led by strict physiology and rigid optic laws. A charming picture would unfold in tracing the countless and changeful aspects of the sky, and all the caprices of light and air in their influence over the moral and physical nature of painters, poets, and musicians. The ever-varying face of the sun, the fires of dawn and sunset, the opalescent play of air, the shimmer of twilight, the blue, green, shifting hues and iridescent gleams of sea or mountain—all these things find a destined answer in the inmost and unconscious ongrowings of life, as in the soul of one who looks understandingly at Nature's works. In it they reveal and transform themselves by subtlest thrills—tender and creative. He who shall detect these—shall link, range, and embrace them in their wonderfully complex unity—will render a great service to science and to art. He will not make the artist an automaton, nor prove man the copy of a plant, drawing all its virtues from the soil it springs in, but he will lay his hand upon the mechanism, as yet scarcely guessed, moving a whole system of mighty combinations of energy.—*Revue des Deux Mondes.*

A NEW PHASE OF GERMAN THOUGHT.

THE PHILOSOPHY OF THE UNCONSCIOUS.

FROM THE FRENCH OF LÉON DUMONT.

II.

HARTMANN adopts the following words as the title of his principal work: "Speculative results according to the inductive method of the natural sciences." If we were to trust to these words, we might suppose that the author's system takes an essentially scientific form, and relies exclusively on the observation and analysis of facts. But the reading of a very few chapters soon leaves quite an opposite impression. Although Hartmann gives proof of abundant acquisitions in physics and physiology, he puts himself completely at odds with the naturalist school, and, soaring away at once, launches into the metaphysical regions haunted by Schelling and Schlegel. He begins, it is true, by setting forth quite a number of facts belonging to the domain of the natural sciences, but he follows with the immediate declaration that such facts can only be explained by a cause of the supernatural order. Now, to take any fact whatever, and endeavor to show that it is not a result of physical conditions, but has its cause in a spiritual principle, intelligent and distinct from its reality, may not, we suppose, be necessarily false, but we certainly cannot recognize, in such a procedure, "the inductive method of the natural sciences."

The principle of final causes is the starting-point of the system. In vain Bacon, Descartes, Spinoza, Kant, have successively combated it; in vain Darwin has given it its death-blow, by the proof that every thing heretofore conceived as a final cause in the organic world might be hypothetically, if not by demonstration, explained as a result; in Hartmann's teaching, the idea of finality once more takes a place perhaps as high as in that of ancient philosophic systems. He says, the causes of a fact are necessarily either material or spiritual—there is no middle way; therefore, when material circumstances fail to explain a fact sufficiently, we must resort to the admission of a spiritual cause. Now, when the mind acts, there is always a will joined with an idea, a force tending to the realization of an end conceived; in a word, there is always a final cause. Therefore, to prove the existence of a providential principle, it is enough to show that certain facts cannot possibly be reduced to material conditions.

This doctrine may be thus stated: Whatever we have not yet succeeded in grasping by observation is of a spiritual nature, or, whatever in the production of a fact has hitherto eluded our experimental research, must be *a priori* a principle like the human intellect. Is not this simply going back to that old anthropomorphism of primitive philosophy, according to which imagination was childishly led to conceive, behind any phenomenon inexplicable by ignorance, a will, a force, like that we are conscious of within ourselves? This illusion has gradually lost ground, for two reasons: first, because the sphere of the unknown has gone on diminishing, as the conquests of science have continually revealed new natural explanations of phenomena; and, next, because we are brought more and more nearly to the conviction that the human intellect, the will, instead of being principles of a transcendent order, are themselves only results of material conditions. We can maintain such a doctrine, and yet repel the charge of materialism; for matter, in our view, is far from being a principle; we regard it only as a fact which is capable of being analyzed in its turn, and of being reduced to yet simpler elements, to forces, which are not in themselves substances, but merely phenomena.

One of the most characteristic traits of the spiritualist temperament is this—that in the explanation of facts it always prefers metaphysical hypotheses to purely physical ones; that it clings to the former as long as it is possible to do so without too violent a contradiction of irresistible truths; that it never yields to such truths, except in the last extremity, nor ever until they have been established by proofs beyond refutation. This is the mental bent of which we find the signs in Hartmann's theories. There are, in fact, a certain number of phenomena, of which the physical and physiological sciences have succeeded in giving probable explanations, without going beyond their own domain; but these explanations are as yet in the state of conjectures, or at least have not been verified by experiences so decisive as to compel the most hardened metaphysicians to accept them. Instead of these solutions, Hartmann, in conformity so far with spiritualistic traditions, prefers to hold to the hypothesis of an intelligent principle, yet an unconscious one. Let us examine the principal facts of this kind in order.

Hartmann contends that any voluntary movement must be impossible, without an idea of the extremity of the nerve that serves to produce it; and, as this idea does not exist in consciousness, it must exist, as he holds, in an unconscious intelligence, of which my conscious intelligence is doubtless only a mode, a manifestation. I will to move my arm, and it moves. How can that effect be produced, Hartmann asks, without the knowledge of the intermediate organs, which must be set at work to effect the intended act? How otherwise can we explain the action of the will on some one particular muscle, rather than on some other one? We may well be astonished to find such a theory held by a philosopher who admits that acts of the conscious will are phenomena of the brain. Is it not a more natural and probable sequence to suppose an organic adaptation between the cerebral phenomenon and the modification of the motor nerve? But, it is objected, What has the power to establish such adaptation, except an intelligent being? We shall reply, that all those phenomena which are usually simultaneous in the organism have the power of suggesting each other, that is to say, of acting reciprocally as causes. They do in the end compose a circle, which vibrates throughout, whichever one of its links it may be that receives the impulse. Every gesture, every external movement of the body, is naturally followed by its perception, and consequently by its idea; by dint of being contemporaneous with the organic facts which determine the production of motion, the idea forms in connection with them habits of adaptation, the result of which is to give it the property of exciting them. Thus, the movement was at first involuntary, and theretofore it was the movement which stirred its idea in the intellect, through the intermediate means of perception; afterward the movement became voluntary, and it may be was caused, in its turn, by the cerebral phenomenon of its idea, which had had time to contract habits of coexistence, and of suggestion with the intermediate modifications of the nerves and the muscles. Such habits may even show themselves, so far as they are hereditarily reproduced and continued, as if they were innate with the individual.

It is the same with regard to those reflex movements which Hartmann also refers to an unconscious will and intelligence. He defines a reflex movement as "that which takes place when the excitement of a nerve of motion is transmitted to a nervous centre, which transmits it on to another nerve of motion, that produces in the last place a muscular contraction." This definition is evidently too broad, and would equally embrace all those movements that result from cerebral action; for the brain is also a nervous centre, which only transforms movements that come from outside of it, so as to transmit them to motor nerves. Physiologists usually confine the description of "reflex" to those movements as to which the series of facts intermediate between the external excitement received and the final act does not pass through the me, or the thinking brain.[1] Now, among these movements, certain distinctions must be established. In a great number of them the most prejudiced mind could not discover any sign of finality, and therefore as to those there cannot even be any question of applying an hypothesis of an intelligence, whether conscious or unconscious; when, for instance, some one tickles me, and I laugh, I cannot recognize any thing between these two facts of laughing and of tickling, beyond an accidental and mechanical coincidence. Other reflex movements are very easily explained upon the hypothesis of natural selection; such, for instance, is the action of the spinal marrow on the

[1] In the strictest meaning of the term, a reflex phenomenon is a movement called forth in one part of the body by an excitement proceeding from that part, and acting intermediately through a new centre, other than the brain, properly called, and consequently without the intervention of the will.—(VULPIAN, *Lectures on the General and Comparative Physiology of the Nervous System.*)

muscles of the blood-vessels; such are the movements of the respiratory organs, etc. Again, there are a great number of cases in which the adaptation between the excitement and the act must have been originally regulated by conscious intelligence; but, the habit once acquired, the concurrence of intelligence has become useless. The player on a musical instrument needs at first to combine, by an act of his will, the movements of the fingers with the visual perception of the notes; but, after a sort of organic coexistence between these facts is established by repetition and practice, the one may become directly the cause of the other, without the concurrence of the power that regulated their adaptation; the movements of the hand then follow the impressions on the sight mechanically, while the intellect may be occupied with something quite different. Thus a machine, once constructed and regulated, has no need of the intelligent workman, who adjusted its cogs and wheels, to keep it going. If we pinch a frog after its brain is removed, it makes motions as though to repel the hand that hurts it; it is a reflex action resulting from habits contracted under the cerebral influence, and strongly enough established to survive the removal of the intellectual organs. After this we do not deny that a certain degree of intelligence may exist in other nervous centres besides the brain; we grant that they may have a peculiar consciousness of their modifications and their movements. But we go no further, and we refuse to follow Hartmann, as soon as his hypotheses needlessly take on a metaphysical or supernatural character.

Still less shall we follow him when, throwing himself into theories which remind us of those of Stahl, he insists that the organization of living bodies can be formed no otherwise than by the action of an intelligent but unconscious principle; that, in diseases, a regulating intelligence, a *vis medicatrix naturæ*, presides over the restoration of the functions to their normal state; that the reproduction of organs observed in some animals is caused by the unconscious idea of the usefulness of such organs, for the preservation of the individual; that in every part of the living being there resides an unconscious idea of the type of the species, which directs the reproduction of the organ removed, the reparation of tissues, etc. These facts, all having relation to the study of forms, types, or species, are exactly those which Darwin's theory best succeeds, as we think, in explaining. Hartmann, however, does not altogether reject the ideas of the great English naturalist; but he limits their application considerably, and interprets them in a manner quite contrary to their author's. He admits natural selection, indeed, in the struggle for existence; but this selection is not, in his view, a primordial fact, resulting from the force of things; he calls it simply one of the means that unconscious intelligence would employ in arriving at its ends. Besides, selection would be insufficient still, according to Hartmann, to account for the organic forms of the species, for what he calls the morphological facts, and ought to be applied to physiological facts exclusively. This distinction is opposed to the tendencies of contemporaneous science, whose analyses reduce all morphological facts to physiological facts. Selection, Hartmann says, explains the progress in perfection of an already existing type, within its own degree of organization; but it cannot explain the passage from an inferior degree of organization to a superior one, a passage which always consists in an augmentation of the morphological type; and he gives, as a reason for his argument, that there is no more vitality in one morphological type than in another, and that selection is applicable only to facts that increase the vitality of the organism. All the degrees of organization possessing equal vitality, it is only, Hartmann insists, within the limits of a particular degree that different species or varieties are distinguished by more or less important advantages in the struggle for existence: if Darwinism were true of all species without restriction, there could only subsist one single morphological type in each locality, and, in the millions of years that the vital competition has lasted, all the inferior classes of animals and plants must have been extinguished by the superior classes; there are, in a word, a great number of facts which form part of the plan of the world, and yet are of no service in giving more vitality; such facts, in order to keep themselves in existence, need some other support than that of natural selection and the struggle for life.

We understand how many minds feel a certain repugnance in accepting the daring views of Darwin, so contrary to old associations of ideas. It is as yet nothing more than an hypothetic induction, which is waiting for its experimental verification. But it is no less true that this is the most probable of all the theories hitherto put forth upon the forms of life, and in default of that palpable and decisive demonstration that time only can furnish, we shall at least maintain that this opinion deserves to be preferred to all those still far more hypothetic doctrines which cannot dispense with a supernatural principle.

No doubt Darwinism does not succeed in explaining every thing. It has never assumed to account for the existence of forces, for the origin of those movements which are the source, and as it were the substance of life; it takes into view only their direction and the procedure of their organization. Putting aside the mysterious problem of being, it takes cognizance only of the methods of being. Is this saying that selection is only one of the means employed by a superior intelligence to govern the other forces of the world toward its ends? Nothing permits us to suppose that, for, on the contrary, the peculiarity of selection, in all the cases to which it applies, is to explain order without calling in the aid of intelligence, and as a necessary resultant of the reciprocal action of forces.

We think, with Hartmann, that Darwinism can explain only those facts that relate to the vitality of beings. But what fact is there in living Nature which can be regarded as indifferent from the point of view of the struggle for life? Can one imagine, in the recesses of an organ, a single cell, a single element, which is not fighting for existence? If there could be one, then there would exist in reality something else than forces encountering forces, and that is a consequence which Hartmann himself could not admit, recognizing, as he does, nothing but forces in the atoms of matter, and explaining, as he does, reality and consciousness by the opposition of contending forces. We shall find him, farther on, maintaining that, when two contrary but equal forces meet, they annul and annihilate each other, and all reality vanishes; and yet the same author, arguing against Darwin, supposes a reality which is not the result of the encounter and strife of forces. For Hartmann, more than any other reasoner, the sphere of selection ought to be coextensive with that of reality, and whenever conflict and selection cease, by reason of the equilibrium of forces, there should be nothing but annihilation. But contradiction, we all know, is the hereditary vice of metaphysics.

In proof that certain facts have no concern with the struggle for life, Hartmann mentions beauty, and especially the beauty of plants, which it would be difficult to explain by selection. Here we find ourselves face to face with German æsthetics, with its mystical theories, and its metaphysical entities. For ourselves, regarding beauty not as a real fact, but simply as a relation between things and our faculties, we do not feel this difficulty. We admit that selection has nothing to do with the matter, because beauty is neither an act, nor an organ, nor a function: it is simply a mode in us of feeling outward objects; it is a sentiment inspired by things which answer to our habits of thought, and correspond with our associations of ideas. There is not, in Nature, any fact which is beautiful only; whatever is beautiful is at the same time an object, and the forces that produce it, produce it, so far as it is an object, and not so far as it is beautiful. We are not speaking of art, in which selection again comes up; and, in fact, if there is no natural selection as to beauty, there may be, in very many cases, artificial or intelligent selection: among animals, and especially as regards man, we know that beauty exerts a certain influence on choice in sexual passion. As to the plant, which cannot choose, we have to take account of natural selection by man, whose culture promotes the preservation of the species most agreeable to the eye; we may even admit a certain selection by insects, which assist the transfer of the pollen, and are perhaps not wholly insensible to size among flowers, to their brilliancy of color, etc.

Can an argument against Darwinism be founded on the equality of vitality among different species? When selection has induced a very considerable difference between two varieties, developing in two more or less opposite directions, it often occurs that these two varieties or species no longer have the same conditions of existence, and cease to compete with each other. The farther apart the types grow, the more there may exist between them that equality of vitality which is merely the negation of competition. This explains why we oftener remark equal vitality between different species than between varieties of the same species. Certain species even suggest each other, and have mutual need each of the other for their existence. If, for instance, the quantity of vegetables, or of certain animal species which we require for our nourishment, were to decrease, it would necessarily follow that population would diminish proportionately; but that diminution would allow the other species to resume their former development; therefore the equilibrium is maintained of necessity.

As to the possibility of morphological alterations, by the accumulation of individual modifications, Hartmann himself admits that Darwin has cited more than one instance of it, and a marked one in the skeleton of pigeons: he objects, it is true, that there was some aid from art in these different cases. Very true! but that proves that analogous changes are at least possible through natural selection. Hartmann adds, that a pair of teeth, or vertebræ, or fingers, more or less, or a vertebra shaped in such or such a way, are exactly the marks by which zoologists oftenest distinguish species, and yet he says such marks are of no importance in the struggle for life. This seems to us an oversight; for they are precisely those scarcely appreciable modifications which have the greatest importance from the point of view of selection and competition.

Darwin and Hartmann stand at the opposite poles of modern thought. To Darwin belongs the most fertile idea of the age, an idea which upsets all the ancient ways of conceiving the world, and includes the first natural explanation yet given of order, of organization, and of intelligence itself. Hartmann, on the contrary, takes us back to the ancient labyrinths of teleology; between two explanations, one natural and the other supernatural, we have always found him, thus far, pronouncing for the latter. We detect a new instance of this predilection in his way of regarding instinct. Darwinism explains it admirably as an hereditary habit resulting from natural selection; a habit can only become formed and inveterate on condition of its aiming at a result useful for the preservation of the individual and the species; that which is not useful cannot become habitual, or at least not hereditary. Vices can be only individual accidents, or else the race is tending toward extinction; all that flows from the force of things, and there is no call for the supposition that the utility of fact grown into habit must have been foreseen, and willed by a supernatural being. But Hartmann prefers to define instinct as "the conscious will (choice) of a means in view of an end unconsciously willed;" and this he does to raise a necessity for the supposition of an intelligent principle, distinct from conscious intelligence, in the bosom of which he may lodge the seat of these unconscious volitions.

Hartmann's love of the supernatural goes so far as to make him accept, with the fullest faith, a certain number of extraordinary facts which stand much in need of confirmation, such as the facts of second sight and of artificial somnambulism. He admits the truth of dreams, visions, and presentiments; he cites cases of warnings given by mysterious revelations of coming dangers, of the death of one absent, or of other occurrences taking place at a distance, as in the well-known story of Swedenborg. Nothing is wanting but spiritism and turning tables. It is clear that such facts would justify and even compel the hypothesis of a supernatural principle. If the existence of a superior intelligence in the world can be demonstrated by physical proofs (we are not now speaking of metaphysical proofs), it is not by the spectacle of order and regularity which indicate, on the contrary, the absence of any disturbing or interposing force, but really by abnormal and contradictory facts; in a word, by miracles. Only, it is necessary that the authenticity of such facts should be above all question.

As to what concerns thought itself, we share Hartmann's views on almost all the points of psychological analysis, and only when his transcendental explanations begin do we feel obliged to part company with him. Thus we think, as he does, that the *I* does not make the greater part of its ideas, that its ideas come to it without its volition, and without its consciousness of the causes producing them. But what must be concluded from this, except that intelligence in general is a resultant and not a principle, and that it is simply, as Taine and the later English psychologists have so well shown, the series, the grouping, the *ensemble*, of a multitude of phenomena, the greater part of which have their cause outside of the *me*. Hartmann sets out on quite a different path, and supposes behind my consciousness another intelligence, which elaborates these ideas for me, and imparts them to me ready made; and in support of this theory he invokes the mysticism for which he betrays sympathies that recall the romantic school; he invokes the inspiration of genius, which he holds to be only the revelation of luminous thoughts to certain privileged natures. But is genius any other thing than the combination of those cerebral conditions which permit new relations of ideas to manifest themselves in an intelligence, under the mere stimulus of life, of the organic functions, and of the perceptions?

We remark the production, in history, of a great number of facts which are independent of human volitions. Men set an end before them, and yet the result is quite different from the one they had foreseen and willed. How could it be otherwise, since individual volitions are but elements in the midst of an immense complexity, and all the elements are thwarting, checking, neutralizing each other? Moreover, the struggles for existence and selection explain historic progress as clearly as they do physiological development. But Hartmann prefers, in this instance, as in others, to resort to a metaphysical principle, and imitates Joseph de Maistre, in calling for the interposition of a providential action, which guides humanity toward an end, sometimes even in spite of human efforts.

At the same time that Hartmann endeavors to prove, by the facts we have just spoken of, the existence of "a psychical principle maintaining itself above matter," he fancies that he has evolved from these same facts the idea of what he calls "the unconsciousness," the idea of an intelligence which has no consciousness of itself, of unconscious manifestations (Vorstellungen), of unconscious volitions. We declare that we have not succeeded in comprehending this idea—it even seems to us self-contradictory. What *is* an idea or a volition without the consciousness of that idea or that volition? Can the idea be any thing else than one form of consciousness, as the volition is another form of it? Hartmann is able to cite facts of intelligence which are outside of the consciousness of the *me*, but without being able to prove that these facts must be unconscious, absolutely and in themselves. Who can even prove to us that the *I* is the totality of the conscious phenomena of the brain? The *I* is nothing more than a series of facts, and may there not be alongside of this series a multitude of facts which become real, without being attached to it by any bond of continuity? For instance, personal character is made up of a great number of conditions, which, without any consciousness on the part of the *I*, modify the direction of its volitions: these facts only make themselves known to us by their influence on the acts and the morals of the individual. But does it follow, from their being unconscious relatively to the *me*, that they are unconscious in themselves? Hartmann's own doctrines, on the contrary, would lead us to allow that the other nervous centres, the spinal marrow, the ganglia, etc., are endowed with their own consciousness; that there is a special consciousness in each cell of a plant or animal, perhaps even in every material atom; in a word, that consciousness coincides everywhere with reality, unconsciousness being outside of real facts. But what is to be concluded from this, except that none of the real facts, which Hartmann has set forth with so many details, offer us the idea of the unconscious? And then what foundation is there for this definition, that "the unconscious is the cause of all those facts, in an organic and conscious individual, which lead us to the supposition of a psychical and unconscious cause?" We will even say that Hartmann seems to us to have succeeded better in widening the sphere of consciousness, than in founding a philosophy of the unconscious.

If we put ourselves the question, What is the real motive that determined him to attribute unconsciousness, rather than consciousness, to the supreme intelligence, to God? we find only an *a priori* reason, drawn from the idea that evil rules the world: "If, at the time of the creation of the world, there was in God any thing like consciousness, the existence of the world would be an inexcusable cruelty, and the development of the world a useless absurdity." Hartmann finds himself driven to suppose God unconscious, to escape supposing him wicked. "This consideration," he says, "is decisive against the admission of consciousness in God." But stay!—if God has not the consciousness of what there is evil in the world, Hartmann argues, on the other hand, that he has the idea of it (the Vorstellung). Does not this idea suffice, as well as consciousness could (in our view they are exactly the same thing), to pledge the Divine responsibility?

EVOLUTION AND THE SPECTROSCOPE.

By F. W. CLARKE.

MEN of science may be divided into two great classes—thinkers and observers. And, although both classes are often represented in one individual, the distinction between them is practically valid. For, in classifying mankind, no sharp boundaries can be drawn. The observer, on the one hand, contents himself with merely ascertaining facts, and rarely deduces more than the simplest and most obvious conclusions from them. He is in some measure an intellectual miser, who accumulates, but never uses. It is the thinker, however, who gives shape to science. His generalizations make true science possible. To him, a discovery amounts to something more than its mere self, and is valuable, like a choice seed, largely for what it may become. He ranges facts into series, gives each series its proper place in a science, clusters the sciences into groups, and, studying these groups with reference to each other, and to the grand problems with which thought is always busied, seeks to arrive at higher conceptions of the universe, and of the essential unity of all material things. At the present day this method of comparison has led to the announcement of the philosophy of evolution; a philosophy which places the physical world in a clearer light, and classifies a greater number of facts, than any other scheme that human earnestness and ingenuity ever devised. Surely it is worth while for us to study all great discoveries with reference to their bearings upon this philosophy.

Probably none of the many remarkable discoveries of the nineteenth century are more important or more striking than those achieved by means of the spectroscope. It is now less than fifteen years since this famous instrument was devised, and already it ranks in importance side by side with the telescope and the microscope. New fields of research have been opened, which, widening ever since, show as yet no signs of approaching limits. Chemical analysis has been simplified, many optical researches facilitated, and four new metals discovered. Our knowledge of the sun and stars has in some respects been more than doubled. Problems which were deemed insoluble, have been settled with the greatest ease. The magnitude of the discoveries already made leads us to expect still greater revelations in the future. Let us see what the spectroscope has to say for the philosophy of evolution.

Among the doctrines held by evolutionists, the all but proved Nebular Hypothesis occupies a very prominent position. Originating with Kant more than a century ago, and afterward furnished with secure foundations by Laplace, it has since striven for complete acceptance with ever-varying strength. According to this hypothesis, our solar system began existence as a nebulous cloud of incandescent vapor, which, rotating about a centre, and cooling as it revolved, cast off rings of matter that gathered into globes and became planets, while the central portion, undergoing less change, formed the sun. A vast weight of physical and mathematical evidence supported this theory, and the nebulæ seen in different parts of the heavens lent to it the confirmation of analogy. From the first, the hypothesis was strong.

But soon doubts began to arise. Larger and more powerful telescopes were constructed, and many nebulæ were resolved into clusters of stars. Astronomers began to hope that all these bodies might be similarly resolved, and the nebular hypothesis lost a little ground. But the spectroscope came apparently to the rescue. In the skilful hands of Mr. Huggins, the narrow slit was made to receive the light of several unresolved nebulæ, and nebula after nebula gave up its secret to the observer. Some yielded spectra, consisting of from one to four bright lines, while others gave continuous bands of feeble light. The former class told the story. Spectra like theirs could belong only to the light emitted by incandescent gas, and therefore of such material, true nebulous vapor, these distant bodies consisted. But even more was revealed. The bright lines were characteristic of two well-known substances, nitrogen being the more distinct of the two, and hydrogen the less clearly visible. No other elements could be detected, nor could any good reason be found for supposing others to be present. But the main fact of the existence of genuine nebulæ was fairly demonstrated, and the nebular hypothesis received a great accession of strength. To-day it almost commands acceptance, although it is capable of being made much stronger. Even the evidence which analogy might offer in its favor is far from complete. We must look to the spectroscope for its completion.

In this connection a great variety of interesting questions suggest themselves. We assume that our planet originated from a gaseous cloud by a slow process of condensation and cooling, and point to the visible nebulæ to confirm our views. Now, in evolving a solar system from a nebula, a long series of changes would necessarily occur. We see the extremes of such a line of development, and also a few of the intermediate links. And we are at once led to ask whether we can hope to find existing to-day, among the heavenly bodies, examples of all the stages of evolution through which matter must pass in forming solid globes from shapeless clouds of incandescent vapor. The task will be a difficult one, but not hopeless. We have much material to begin upon, and can safely look to the spectroscope to furnish us with an abundance in the future. If the work can be done, the nebular hypothesis will become so well grounded that we are scarcely able to conceive of any possible arguments which could afterward disturb it.

In beginning upon such an inquiry, we must start with a consideration of the nebulæ themselves. And, at the outset, their varieties of form, and the visible changes which they undergo, offer strong suggestions of processes of evolution actually going on. The spiral nebulæ hint of rotary motion, and some annular forms speak to us of rings of vapor from which planets are yet to grow. In the double nebulæ we see future pairs of suns, companion stars; and in every true nebula are signs of condensation in the brighter portions. The nuclei which are so common may be the germs of central luminaries, around which systems like our own are yet to revolve. But all these observations are due to the telescope. We have to consider what the spectroscope has done.

Now, as regards spectroscopic work, the nebulæ may be divided into three classes: First, those which give spectra consisting only of bright lines. Secondly, nebulæ whose spectra are continuous. And, in the third place, the nebulæ described by Lieutenant Herschel, which are apparently intermediate between the other two classes, and furnish spectra of bright lines upon a continuous background.

The nebulæ of the first class I have partly described. They consist mainly, if not wholly, of two common gases, nitrogen and hydrogen. But gases give somewhat different spectra under different circumstances of temperature and pressure; and the spectrum of a nebula indicates that the gases of which it is composed are in a highly-rarefied condition, and at a temperature *considerably lower than that of our sun!* Of this we are tolerably sure, though perhaps not absolutely certain.

The nebulæ whose spectra are continuous speak to us with less certainty. Lord Oxmantown has shown that the resolved nebulæ—those which are known to be mere star-clusters—give this kind of spectrum, as do also most of those which appear to be resolvable. Accordingly, it is reasonably inferred that all the nebulæ of this class probably belong to the resolvable order; but here is where a slight doubt may arise: gases, under great pressure and at a high temperature, give continuous spectra; possibly, then, some of these nebulæ may consist of gases under just such conditions. Here is a problem yet to be solved. The third class of nebulæ may, perhaps, strengthen this latter view. Their spectra are intermediate between those of the other classes. It may be that a more careful study will show them to be gaseous, with their spectral lines in a state of transition to the full continuous spectrum; but this is little more than bare conjecture at present; for the published descriptions of these nebulæ are too incomplete to admit of very satisfactory discussion.

This consideration of nebular spectra plunges us at once into a sea of difficulties. We say that the sun and planets were formed by condensation and cooling from incandescent vapors, and hail the nebulæ as confirming this opinion. But could a sun be evoked, by cooling, from a body less hot than itself? Moreover, the sun is known to contain at least sixteen elements and probably many more. Were these developed from a nebula containing only nitrogen and hydrogen? Or did the original nebulæ differ in constitution? All those which the spectroscope has analyzed are chemically alike. We know nothing of any whose constitution differs in this respect from theirs; and, therefore, if we point to them as confirmatory of the nebular hypothesis, we are compelled to ask this portentous question: Did our planet, with all its chemical complexity, arise, by a slow process of evolution, from a glowing cloud of but two familiar gases? Upon our answer to this question depends largely the value of our spectroscopic confirmation of the great hypothesis. The safety of the hypothesis itself is not involved; merely that of this one argument in its favor. We can easily conceive of more complex nebulæ, which could give rise to systems like ours, although we know nothing of them. And, if we interpret the spectra of some nebulæ of the second class as due to gases at very high temperature and pressure, the difficulty regarding the heat of our sun will be easily gotten over.

Let us consider the question suggested, as to the possible evolution of complex from simple matter. It is easy to speak out boldly, in an *ex-cathedra* manner, and say that an affirmative answer to such a question would be absurd; but dogmatism of this sort is, in the highest sense, unphilosophical and foolish. We do not know but that the evolution of one element from another may be possible, under circumstances over which we have as yet no mastery; indeed, such a view would have many points of probability about it. Although unsupported, it is quite strongly suggested by evidence. The demonstrated unity of force leads us, by analogy, to expect a similar unity of matter; and the many strange and hitherto unexplained relations between the different elements tend to encourage our expectations. These elements, which seem to-day so diverse in character, may be, after all, one in essence. This idea is philosophically strong, but waits for experimental evidence to support it. At present, it can neither be discarded as false, nor accepted as true. But what an addition the proof of such a doctrine would bring to the philosophy of evolution!

Now, although questions like these cannot be settled by any evidence which we are likely to obtain for many years to come, speculation upon them is not altogether unprofitable. The time spent in conjectures and surmises is not wholly wasted; for it is impossible to follow up any of the lines of thought thus opened, without reaching some valuable suggestions, which may pave the way to new discoveries. New truth, in one direction or another, is sure to be reached in the long-run. So, then, we may proceed to theorize in the most barefaced manner, without entirely quitting the legitimate domain of science.

It is plain that the nebular hypothesis would be doubled in importance, and our views of the universe greatly expanded, if it could be shown that an evolution of complex from simple forms of matter accompanied the development of planets from the nebulæ. Evolution could look for no grander triumph. For the evidence to support such a theory, we must depend mainly upon the spectroscope. Let us continue upon our task of finding the intermediate links between the two extremes of planetary growth, and see whether, as we ascend in the line of change, an increased chemical complexity can be observed. Upon this theory, the planets should contain more elements than the sun; the sun more than some of the less advanced among the fixed stars; and these, in turn, should be more highly organized than the nebulæ. But we must not fail to remember that we are merely speculating, and that the spectroscope, in telling us of the presence of certain substances, does not give us accurate information with regard to the absence of others. In this investigation, we can look to the spectroscope only for hints, not certainties. Difficulties will abound in our path, and, in a paper of this length, we cannot stop to scrutinize them closely. We must bridge many chasms with guesses.

The evidence concerning the constitution of the fixed stars has been furnished chiefly by Secchi and Huggins. The former observer, favored by Italian skies, has done, perhaps, the major portion of the work, and has given us a classification of these bodies. According to Secchi, the stars may be divided into four classes, as follows:

In the first class, which is by far the largest, we find most of the *white* stars, Sirius, Altair, Vega, Regulus, and Rigel, being especially prominent. These give spectra characterized by the intense development of the four hydrogen lines, which stand out with great distinctness upon a background of the seven primary colors. Lines belonging to some of the metals, particularly to sodium, magnesium, and iron, are also visible, but are exceedingly faint in comparison with those of hydrogen. The distinctness of this element, as compared with the faintness of the metallic lines, is characteristic of the stars of this type. The absence of bands, indicating an absorptive atmosphere, is also noteworthy.

In the second class of stars we find our sun, Arcturus, Aldebaran, Capella, Pollux, Procyon, and many others. Here we have spectra in which the lines of the metals are apparently more numerous, and certainly more distinct, the hydrogen being less conspicuous. In Aldebaran, Mr. Huggins detected sodium, magnesium, calcium, iron, bismuth, antimony, tellurium, mercury, and hydrogen.

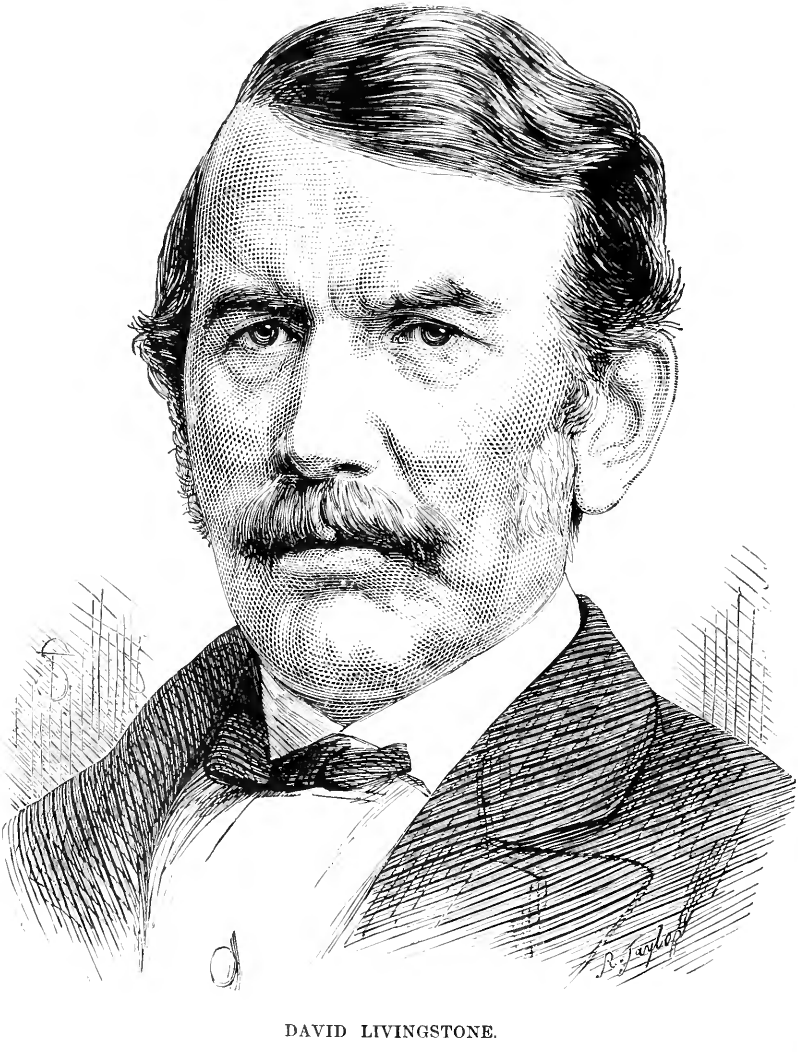
The third class, in which are some stars of a red color, is comparatively small in numbers. Alpha Orionis or Betelgeux, Alpha Herculis, Beta Pegasi, Mira beti, and Antares, are good examples of this type. Their spectra, as a rule, resemble the spectrum of a solar spot, and sometimes contain bright lines. Hydrogen is still present, but so difficult to detect that, at first, it was supposed to be wanting in the spectrum of Betelgeux. But, in a state of combination, as aqueous vapor, it has been found in the stars of this order, and, most notably, in Antares. In the spectrum of Betelgeux, Mr. Huggins observed lines belonging to magnesium, sodium, iron, calcium, and bismuth.

The stars of the fourth type are very inconspicuous, but give quite peculiar spectra, consisting chiefly of three bright bands, separated by dark spaces. Such a spectrum suggests that of carbon, but really tells us nothing, as yet, of the constitution of these stars. We must, therefore, leave them out of account in our speculations. It would be easy to theorize about them, only the theories would find no place in our argument.

Now, taking the spectra of stars of the first, second, and third classes as a basis for our speculations, we have quite decent evidence of a gradual increase in chemical complexity. And, if we bring the nebulæ into line, we can devise a very neat progressive series of development up to the solid planet. Beginning with a nebula consisting mainly of nitrogen and hydrogen at low temperature and pressure, we can easily conceive of several ways by which it might gain great accessions of heat, and give a bright, continuous spectrum. A collision with meteoric or cometary matter would account for such an increase of temperature. But, given a nebula which is sufficiently hot, and from which a sun *might* be evolved by cooling, what shape will our speculations assume? This intensely-heated body undergoes a certain condensation, rings are thrown off from it, and a nucleus appears, which soon becomes a star or sun of the first type. Hydrogen still predominates in its constitution, but metals begin to show themselves, though very faintly. But the cooling continues, and gradually the hydrogen lines become fainter, the metallic lines stronger, a larger number of substances are detected, and we have a sun of the second class. By another slow transition, chemical action, as we recognize it, begins to set in. The hydrogen lines disappear; aqueous vapor is formed; spots, like those of the sun, which are probably centres of chemical activity, become more and more abundant, and the star enters the third order. As the spots accumulate, the star becomes more decidedly a "variable," and, after violent and prolonged convulsions of its surface, solidity is reached, the emission of light ceases, and a planet is formed. Some volcanic heat, however, yet remains; but this slowly dies away, the volcanoes become extinct, and, at the end of the line of change, we have a body like our moon, dead and sterile. And here our speculations end. What next ensues, no one can say. We are seeking the past history of our planet, not looking into its future.

Now, a paper of this sort should always contain a summary of the steps by which its conclusions have been reached. Beginning with the nebular hypothesis, as it is commonly understood, we saw that it was philosophically strong, was supported by much evidence, and opposed by none. Bringing the spectroscope to bear upon it, we found that true nebulæ undoubtedly exist, and that there is tolerably good proof of different degrees of complexity among the fixed stars. Notwithstanding these differences, however, we know that the universe is built throughout of essentially the same materials. In order to bring unity out of this diversity in the constitutions of the heavenly bodies, we arranged a series of development, from nebula to planet. This made it apparent that an evolution of matter from lower to higher stages might have accompanied the formation of planets and suns; an idea which was suggested also by physical analogies, and which had decided elements of philosophical strength. And thus we gave to the nebular hypothesis the somewhat novel form which it has received in our speculations. Without our additions, it could derive no real support from the spectroscopic evidence adduced in its behalf. The known nebulæ are simple, our systems of suns complex. By assuming the evolution of matter, these difficulties cease to exist, and we have a coherent hypothesis, in which the evidence offered by the spectroscope is used to good advantage. To be sure, although it is in harmony with many observed facts, it is open to many objections. And yet we can admit its probability, to a certain extent, without giving it the adherence of actual belief. Such theorizing is profitable, partly because it aids us in making out the limits of our present knowledge, suggests to us new paths of investigation, and, by uniting masses of different ideas, helps the mind to handle more easily the facts and conceptions with which it has to deal.

But, when one is fairly started on a line of thoughts, it is hard to come to an end. Problem after problem, theory after theory, law after law, crowd forward for inspection. If we assume one hypothesis to be true, a hundred others rush in upon the mind, and demand consideration. From every one of these a host of interesting conclusions can be drawn, each suggesting another, until the brain grows weary of action. The present case is no exception to the rule. Objections must be answered, consequences foreseen, demonstrations sought. In an article of this scope few points can receive due attention. Let it then suffice, in closing, to say that science has done so much in the past that we can justly expect almost any achievement in the future. And perhaps, in days yet to come, an evolution of matter may be experimentally be brought about, and our speculations of to-day proved to be not altogether foolish.



DAVID LIVINGSTONE.

DR. LIVINGSTONE.

By L. J. PROCTER.

DAVID LIVINGSTONE was born at Glasgow early in the present century. His grandfather was originally the occupier of a small farm in Ulva, one of the Hebrides, but, owing to the requirements of a large family, found himself obliged to quit his island home to seek employment at the Blantyre cotton works on the Clyde, above Glasgow. Livingstone's father and uncles having been fairly educated, easily obtained situations as clerks at the factory, though the former appears to have relinquished his employment with the pen, and to have occupied himself during the later years of his life in keeping a shop as a tea dealer in Glasgow. He died a member of the Independents in 1856, but brought up his children in connection with the old Kirk of Scotland.

At ten years of age, David Livingstone was put to work as a "piecer" at the Blantyre factory. Even at this early date his character was remarkable for a gravity, and steady, plodding earnestness. Reading took the place of ordinary amusements; and, after a hard day's work, the boy would often sit at his studies so far into the night as to call for his mother's peremptory interference. To economize time, he accustomed himself while at work to place an open book on a portion of the spinning jenny, and catch sentence after sentence as he passed backward and forward in front of it, quite undisturbed by the noise of the machinery. An evening-school was made to help in his education, and it may well be supposed no leisure time was wasted. While still a youth, the truths of religion took a deep hold of his mind; and under the feeling thus produced, "in the glow of love," as he says, "which Christianity inspires, I soon resolved to devote myself to the alleviation of human misery." "Turning this idea over in my mind," he adds, "I felt that to be the pioneer of Christianity in China might lead to the material benefit of some portions of that immense empire; and therefore set myself to obtain a medical education, in order to be qualified for that enterprise." Being promoted at nineteen to higher work in the factory, the increased wages he received enabled him, by working during the greater part of the year, to support himself at Glasgow while attending the medical, Greek, and divinity classes, which were held in the winter. By the advice of friends, he was induced, though reluctantly, to offer himself for the service of the London Missionary Society, and was accepted. His admission as a "Licentiate of Faculty of Physicians and Surgeons" completed his preparatory labors. Just at the time, however, the opium war broke out in China, and this presented an obstacle so great as to render it advisable that he should abandon his original design, and look elsewhere for a sphere of enterprise. It was soon offered. Mr. Moffat, another of the London Society's missionaries, was laboring successfully in Southern Africa among the tribe of the Bechuana. Livingstone heard of this; and, as both the scene and the work were attractive, he resolved to join him.

Accordingly in 1840, with the full approval of his Society, he left England for Kuruman, Mr. Moffat's station. There he spent the first three years. In 1843 he moved to Mabotsa, some three hundred miles to the northeast, where, in the effort to help his Bakatta *protégés*, the memorable encounter with the lion occurred, which so nearly proved fatal to him. In 1844 he married the veteran missionary's daughter. Having made a friend of Sechele, chief of the Bakwains, he ultimately removed to his country, and built a station with his own hands, near a small stream called the Kolobeng.

Some years pass in hard and successful work, and then Livingstone renounces his life as a stationary teacher; and, though never entirely relinquishing his missionary character, assumes that of an explorer, by which he is best known. The change came about in this way:

To the southeast of Kolobeng lay the Kashan Mountains, to which a number of Dutch Boers, fugitives from English law, had migrated, and formed a small republic. Having appropriated their territory, they had compelled the natives themselves to live, if not in absolute slavery, yet under a system of unpaid labor very closely allied to it. Livingstone, with his missionary views, was of course looked upon as an interloper, and hated in a corresponding degree. To add to the grievance of the settlement at Kolobeng, his subsequent discovery of Lake Ngami had encouraged traders to advance from the south, who, by giving the natives ideas about commercial matters they never had before, tended to raise disaffection toward themselves. The result was a determination on the part of the Boers to make a raid on the Bakwains, which a report that the latter were well armed with guns and cannon (an amusing myth about a black pot of Livingstone's) alone prevented. They then tried to get the governor at the Cape, Sir G. Cathcart, to interfere, and negotiations which followed ended in a treaty far more favorable to the natives than to themselves. In spite of this, however, an attack was made by the Boers on Sechele and the Bakwains in 1852, in which Livingstone's house was burnt down, and all his property destroyed, while he was absent on a journey to the Cape.

This opposition was very provoking to Livingstone; and the determination to carry out his plans for bettering the condition of the natives set him at work forthwith to open up the country northward. In company with two English gentlemen, Mr. Oswell and Major Vardon, the great Kalahari Desert was crossed, and Lake Ngami discovered, in August, 1849. Livingstone's opinion of this country deserves notice: "Not only the natives," he says, "but Europeans whose constitutions have been impaired by an Indian climate, find the tract of country indicated"—the southern borders of the Kalahari—"both healthy and restorative . . . . Cases have been known in which patients have come from the coasts with complaints closely resembling, if they were not actually those of consumption; and they have recovered by the influence of the climate alone."

A subsequent journey in the same direction brought him to the town of Sebituane, chief of the Makololo, from whom he met with a most cordial reception. Unfortunately, the chief fell sick and died shortly after his arrival; but the promise of assistance made before this occurred was confirmed by his successor, a daughter, Ma-Mochisane. In order to confer with her on the matter, Livingstone made a journey to Shesheke, where she lived, 130 miles to the northeast, in company with Mr. Oswell. It was on this journey that they discovered the Zambési, toward the end of June, 1851, even then, the dry season of the year, a magnificent stream 300 or 400 yards broad. In defence of his claim to the discovery, Dr. Livingstone says: "The Portuguese maps all represent the Zambési as rising far to the east of where we now were; and, if ever any thing like a chain of trading-stations (as is asserted) had existed across the country between the latitudes 12° and 18° south, this magnificent portion of the river must have been known before." The discovery was indeed important; and, impelled not only by the prospects it presented, but by the remembrance of his difficulties at Kolobeng, Livingstone decided to explore the river thoroughly, and meanwhile send his family home to England.

The journey undertaken with this view commenced in the early part of June, 1852, and "extended from Capetown, at the southern extremity of the continent, to St. Paul de Loando, the capital of Angola on the west coast, and thence across south Central Africa in an oblique direction to Quelimane in Eastern Africa." Besides geographical research, Livingstone tells us that his object was to find if he could "a healthy district that might prove a centre of civilization, and open up the interior by a path to either the east or west coast."

Glancing rapidly along his route, we are to see our traveller first at Kuruman, where the panic in the country on account of the attack on Kolobeng delayed him. Then at Linyanti, capital of the Makololo, where Sekeletu now reigned in place of his sister Ma-Mochisane, showing himself, like his predecessors, favorable to Livingstone. Then with a large body of Makololo, provided by the chief, on December 27, 1853, at the confluence of the two streams Leeba and Leeambye, where we pause.

The Leeambye—also called the Kabompo and Zambési—is a large river 300 yards wide, flowing from the eastward, while the Leeba, 250 yards wide, comes from the N. N. W. The junction of the two forms Livingstone's Zambési, lat. 14° 10′ 52″ S., long. 23″ 35′ 40″ E. Lake

Dilolo, a small body of water, reached February 20, 1854, is the source of the Leeba. It was only on his return that Livingstone ascertained this. But the courses taken by the different streams he crossed struck him; and the observations he made on his journey back impressing him with the conviction that the Dilolo country was the water-shed of the streams running east and west, led him to confirm the theory of Sir R. Murchison, of which he had not heard at the time, that the form of the interior of the South African Continent is that of an elevated, saucer-shaped plateau. In other words, that the country is gradually depressed toward its centre, sloping from an inner environing mountain-ridge toward which the land rises from the coast. The western ridge was crossed at a spot called Tala Mungongo, lat. 9° 42′ 37″ S., and, by carefully noticing the course of the various streams flowing thence to the centre, and forming his judgment from what Arab traders had told him—subsequently confirmed by his own observation—that the rivers set inland from a similar ridge on the eastern side of the continent, the conclusion forced itself on Livingstone's mind, that these river systems, uniting at last, pass out to the north and south in two main drains; the northern finding its way to the Atlantic as the Congo on the west coast, and the southern to the Indian Ocean as the Zambési on the east. The configuration of the country alluded to will account for the course of the Leeba from the lake being about S. E., while the Leeambye joins it flowing west from the eastern ridge of the central plateau. But Livingstone also speaks confidently of "a sort of elevated partition in the great longitudinal valley" between the latitudes about 6° and 12° S. It would not be fair to him to suppress the fact that, considering this peculiar configuration of the country, and hearing from some Zanzibar Arabs of the existence of a lake Tanganyenka (Tanganyika) and Nyanja (Nyassa) to the east of Londa where he then was, he was led to the probable conjecture that the region about them would be found to be the water-shed of the Nile to the north, as it was that of the Zambési to the south. Thus his sagacity brought him to anticipate the existence of facts which have since been confirmed by the travels of Burton, Speke, and Grant, and Sir S. Baker; and which only remain to be thoroughly investigated and defined in the completion of those researches the exciting story of whose partial accomplishment we have recently heard.

A few words must dispose of Livingstone's westward journey. Passing various tribes as he wends along, chiefly on oxback, accompanied by his faithful Makololo, he encounters no opposition, but the contrary, till he enters the territory of the Chiboque. There, however, he gets on the track of the Mambari, or half-caste Portuguese slave-traders, from whom the native chiefs exacted heavy tribute, and the hostilities with which he is threatened, on his stanch refusal to submit to their impositions, were avoided simply by his firmness and tact. On his arrival at Loando, May 31, 1854, he was well received by the

Portuguese, whose kind treatment did much to restore his health, which had been impaired by fever, and the poor food, chiefly manioc-root, on which he had been obliged to live. But his task was bootless. The country was unhealthy. The coast tribes were inhospitable. Wagons would be impracticable among the interminable forests, marshes, and rivers. The westward route being thus out of the question, instead of availing himself of the offer of a passage home from the officers of H. M.'s cruisers at Loando, Livingstone determined to retrace his steps, and seek a path along the Zambési to the east.

In August, 1854, he is once more at Linyanti; on November 3d, starting down the Zambési with a large retinue of Makololo.

The country beyond Linyanti is greatly infested by the "tsetse" fly, the bite of which, fatal to oxen, horses, and dogs, is perfectly harmless to man, as well as to goats and sheep, and wild animals. After its bite is received, the victim gradually pines as if seized with consumption, and in a longer or shorter time dies. There is no cure for it known. In appearance the "tsetse" resembles the honey-bee, and is about the size of the common horse-fly. It is common throughout the whole of Central Africa, and infests certain well-defined districts, usually those frequented by game; numbers may be found in a particular spot, and yet a few yards farther on not a singly fly is to be seen. It only bites in the daytime.

Starting at night, therefore, to get safely through the "tsetse" tract, on November 4th Livingstone arrived at the island of Kalai, where the rapids commence above the "Victoria Falls," as he loyally named them. They are known among the natives as "Mosi oa tunya" (Smoke does sound there). Nothing can be grander than their appearance, which is perhaps unique. Columns of vapor, darkening upward from a white base, first become visible, rising at distinct intervals like jets of smoke in the far distance. The broad stream sweeps along, its surface dotted in every direction with beautiful green islands, and then the vast body of water is seen to descend suddenly into a deep perpendicular fissure 180 yards wide, extending across the entire bed of the river, and is lost to view. Looking down from the brink opposite, masses of dense white vapor conceal the seething volume of fallen water below, from which feathery columns of spray like those described, rainbow-covered and the source of ceaseless showers, perpetually ascend far up into the air. Passing eastward (the river here flows north and south), along the edge of the cleft in front of the falls, the fissure is seen to extend, from a gap near the end, with still narrower dimensions in a zigzag course, down which the whole mass of Zambési water, compressed into a deep, swift column, rolls along, boiling and foaming, till it finds an outlet at a lower level. The rock through which the chasm runs is a dark-brown basalt, covered at the projecting angles, and wherever there is root-hold, with a dense growth of tropical vegetation. The length of the fissure into which the river falls is, by a measurement made in the year 1860, rather more than that number of yards; and the depth, from its edge to the surface of the basin water, about 400 feet. On account of clouds, Livingstone was unable to take the position of the falls; but Kalai, a few miles above (north) is, according to his observation, in lat. 17° 51′ 54″ S., and long. 25° 41′ E.

Passing the confluence of the Kafue, on January 14, 1856, he reached that of the Loangwa, where are the ruins of Zumbo, formerly a Portuguese settlement, and probably the farthest point inland to which they have penetrated from the east, long. 30° 32′ E. Crossing from the north side of the Zambési, along which he had hitherto been travelling, on February 6th, he entered the extensive district of Chicova, where silver-mines were said to have once existed. After examining the geological structure of the country—a soft gray sandstone—he was unable to meet with traces of silver; but crossing some dikes of basalt running north and south, "the sandstone," he says, "is then found to have been disturbed, and at the rivulet called Nake we found it tilted up and exhibiting a section which was coarse sandstone above, sandstone flag, shale, and lastly, a thin seam of coal." This seam, it is true, was not traced far, being displaced by a fault formed by a dike of basalt. But its existence can hardly be deemed an unimportant matter, especially when it is considered that the discovery was made in the very centre of a cotton-producing district, that iron is plentiful in the hills to the north, and that, if, as Livingstone thinks, silver may not prove to be one of the products of the country, gold certainly is, specimens of which the writer has in his possession. That the Portuguese of the lower settlements have not availed themselves more of the advantages thus offered them, is owing much to their indolence and want of enterprise, but more to the hostility of the tribes of these districts, who vigorously oppose any attempts to advance into their territory. A considerable quantity of gold, however, comes into their nands, though it is all obtained from natives living on the borders, who bring it to their settlements. The gold in the form of dust is put into goose-quills, and one quill is sold for twenty-four yards of calico. A singular superstition keeps down the produce. The natives believe the earth to consist of a thin, flat, pancake-like crust of matter, poised in space; and, for fear of breaking through this crust, and falling headlong into the fathomless depths that they suppose yawn for them below, they will never venture to dig deeper than the level of their chin. Whenever a flake or nugget of gold is met with, it is put back into the earth again, under the impression that it forms the seed of the gold!

Striking away from the river southward, Livingstone failed on this occasion to see the rapids of Kebrabasa, 50 miles above Tette. These rapids no doubt present a formidable barrier to the navigation of the Zambési—especially at one point where the whole volume of the stream, compressed within the limits of a few yards, rushes down with tremendous force between high perpendicular banks of solid rock. But, from the Victoria Falls to the central Luabo mouth-branch, there is nothing else in the shape of hindrance except shoals, and these are only troublesome at the dry season of the year.

Tette, in native momenclature Nungwé, the farthest Portuguese settlement westward, was reached safely on March 3d. The commandant, Major Sicard, received the travellers kindly, and, on hearing the account of the coal discovered at Chicova, mentioned the fact of the existence of five other seams lower down. They were found on the banks of a small river, Lofubu, the visible width of the largest seam, according to Livingstone's measurement, being 58 inches. The whole of the district two miles below Tette proved to be carboniferous; and, if rumor counts for any thing, it extends into the Maravi country far to the north in the region of the lakes.

But the protracted journey is drawing to a close. Passing the Lupata gorge, Senna was reached April 27th. Morambala and the Shiré mouth, May 11th. Thirty miles below, Shupanga. It was here Mrs. Livingstone died of virulent fever, six years after she had joined her husband from England, on April 22, 1862. She lies buried under a fine baobab-tree, close to a modern Portuguese house, and a simple white monument marks her grave. From Mazaro, at the head of the Delta, down the Mutu River to Quelimane, and so the east coast is touched at last, May 26, 1856. A few weeks after, H. M. S. Frolic anchored off Quelimane, and, giving him a passage to Mauritius, the traveller embarked in a steamship of the Peninsular and Oriental Company, and on December 12th, landed in England.

Livingstone was the observed of all observers after his return. The feeling regarding him amounted to enthusiasm; and the eagerness with which his book was read, published in 1857, proved the interest that was taken in all he had done. A high estimate was formed of his abilities; but a still higher one, perhaps, of the qualities he had displayed, the energy, the perseverance, the tenacity of purpose, combined with powers of endurance and a courage and activity that certainly revealed a man of no ordinary calibre. Nor was the integrity of his personal character forgotten. On what just grounds this opinion rested, is proved by the fact that after a lapse of more than fifteen years, in spite of severe criticisms, and not a few hard words, his reputation stands as high as ever. And what had he done? He had overthrown the belief which previously existed, "that a large part of the interior of Africa consisted of sandy deserts into which rivers ran and were lost." He had filled up considerable portions of the map of Central Africa, lying between the 15th and 28th parallels of S. latitude. A splendid river was found crossing nearly two-thirds of the continent, and he had accomplished the work of tracing it down to its outlet with the hope of its becoming a path for the missionary and the merchant. He had shown, too, that the African, with all his faults, was open to the influence of reason, truth, and kindness, that he was capable of improvement, and often eager for it: while all that he wrote of such chiefs as Sechele and Sebituane had corroborated the opinion of every unprejudiced observer that the country could produce men of a far higher stamp than was generally believed.

And now he might have rested. Most men would; but not Livingstone. Feeling more than ever, after his experience on the Zambési, the enormous evils of the slave-trade which prevails along its banks; feeling, too, that the best corrective was to go with commerce and civilization as the handmaids of religion, he endeavored, by public speeches at most of our principal places, to increase the interest in the country his return had excited. At Manchester and Liverpool a strong feeling was aroused among the mercantile and cotton-manufacturing communities; and on the side of religion the universities embraced his cause. Perhaps he never created a deeper impression than at Cambridge, where he concluded a telling speech in the Senate-House, before the leading members of the university, in these words: "I know that, in a few years, I shall be cut off in that country which is now open. Do not let it be shut again!—I go back to Africa to try to make open a path for commerce and Christianity; do you carry out the work which I have begun. I leave it with you!"

There was no resisting such an appeal. It went abroad, and Englishmen were stirred. And they were stirred to a depth that impelled them to come forward, as they heard the man and felt what he was. The Government, under Lord Palmerston, made a liberal grant of money, and furnished him besides with a small steamer to aid him in his further researches. To give him influence with the Portuguese, he was appointed H. B. M. consul at Quelimane. An expedition was formed, composed of picked men, who, as well as assisting Livingstone in the direct objects of his undertaking, were to examine and report on scientific matters. This object, as concisely stated in Livingstone's second book, was "to explore the Zambési, its mouths and tributaries, with a view to their being used as highways for commerce and Christianity to pass into the vast interior of Africa." The expedition left England in H. M. S. Pearl, on March 10, 1858; and in the following May the little steamer Ma-Robert—Mrs. Livingstone's Makololo name—was put together and launched in the Kongone mouth of the Zambési.

But, while this was all doing, the universities did not forget Dr. Livingstone's legacy. Oxford, in addition to the Glasgow M. D., recently conferred, had given him the honorary degree of D. C. L.; but she showed much more how she appreciated his merits by uniting with the other universities to promote the religious objects he had in view. His first work in the Ma-Robert was to ascend the Shiré, and discover a beautiful region along its banks to the eastward, which he strongly recommended, in subsequent letters home, as a field for missionary enterprise. In the same letters he referred to the organization of a mission, which, he suggested, should consist of a missionary bishop as leader, a staff of clergymen, and a small band of laborers and skilled artisans to instruct the natives in industrial work. This advice was acted upon. The then Bishop of Oxford, Dr. Wilberforce—suitably to the prestige of that honored name—took an active part in establishing what was afterward known as the "Universities' Mission to Central Africa." The Rev. C. F. Mackenzie, Archdeacon of Pieter-Maritzburg, in Natal, was chosen as bishop; and, £17,000 having been subscribed, of which a large portion was contributed by the manufacturing towns, the mission left England on October 6, 1860. After Bishop Mackenzie's consecration at Capetown, on January 1, 1861, he set sail with his companions for the Kongone mouth of the Zambési, in two parties, on board H. M. ships Sidon and Lyra. The Ma-Robert had proved too weak for her work, and, besides carrying the missionaries, the Sidon had the task of taking out the Pioneer in convoy, a new and larger steamer granted to Livingstone by Government. Arriving off the Kongone early in February, they found the doctor with his party waiting for them, having just returned from the Makololo Country, where he had gone to take home the men he had been obliged to leave at Tette, in 1856.

Dr. Livingstone threw himself into the plans of the missionaries, and, without absolutely identifying himself with their work, gave it his hearty support and coöperation. The Pioneer was offered for their passage up the rivers Zambési and Shiré; and the proposal that he should himself accompany them to the place where they were to settle, near Lake Shirwah, was accepted with even greater satisfaction. This good office accomplished, he proceeded with his own work of exploring the southern end of Lake Nyassa (lat. 14° 25′ S., long. 35° 30′ E.), discovered, like Lake Shirwah, a few miles S. S. E. of it, in 1859.

Parenthetically: a figure of medium height, the tough, wiry frame denoting great powers of endurance, the left arm slightly shortened, recalling the perilous encounter with the lion; firm-set features, weather-beaten and browned, though not roughened, by exposure, passive and thoughtful rather than demonstrative; the eyes' keen glance, and a rapidly-changing expression, betraying furtive enthusiasm; a low voice, winning address, manners quiet, frank, and unaffected, even reserved; such was David Livingstone as he is remembered in his favorite dress of rough blue naval cloth, the jacket short, and the low cap, of the same material, surrounded by a broad silver band. Nor is it easy to forget the kindliness of disposition, and the readiness to give sympathy wherever there was zeal, though hesitation or a self-sparing timidity was derided as much as it was despised. Full of courage and self-reliant, he expects to find something of a like spirit in others; and he gives them credit for it, never assuming backwardness or incapacity, but sternly meeting and dealing with it when its existence is perceived. With a fund of quiet humor—and sarcasm, too, if he pleased—Livingstone possessed a keen sense of the ridiculous, and entered thoroughly into a joke. He might often be seen talking to the Makololo he had brought down from the country of Sekeletu, and their attention and respect, as they listened or replied to him, plainly showed the influence he had with them. Indeed, one of Livingstone's strongest points, and one that has conduced, no doubt, as much to his safety as his success, is his power of understanding and dealing with the natives, and of winning their confidence, while he overawes their truculence.

As regards the practical objects with which it started, this expedition fell short of success. Little was done beyond laying down the position of the comparatively unimportant lakes of Shirwah and Nyassa, and a complete survey of the Shiré and lower parts of the Zambési. Several circumstances combined to bring about this result. Though the natives of the Shiré country were found to grow very little cotton, and that, moreover, of an inferior quality, there can be no doubt that the soil is cotton-producing, and that, with proper attention, and the introduction of the better sorts of the plant, its cultivation would be remunerative. The land will grow sugar-cane, cereals on the upland plateaux—the wheat near Tette is exceptionally fine—the tropical fruits that are known, and some that are not. Indigo grows wild. The forests contain valuable woods, such as ebony and lignum-vitæ, and large-sized timber of different kinds. The rocks are metalliferous; plumbago and hematite abound; gold is not far off; and the quartz shows traces of amethyst and garnet. And something might be said about ivory. All these advantages, however, were supposed, as accounts one by one reached England, to be counterbalanced by the difficulties presented by the nature of the country, the roughness of the upland tracts, the shallowness of the rivers, and the formidable bars of the Zambési mouths.

But other things were adverse. A tribal war, which was raging on the Shiré, and a drought of unusual length and severity, threw insuperable obstacles in the way of the expedition, causing a famine in the higher country, and a disastrous loss of time in the journeys to the coast, which were rendered necessary to procure provisions. The same causes compelled the mission—after the death of Bishop Mackenzie and one of his followers—to abandon the position they had taken on the hills, and find a temporary abode on the banks of the Shiré. The hope that it would either develop into, or, at least, promote the establishment of a central trading station or factory, was in this way disappointed for the present. The subsequent death of three more of the missionaries, besides two of the expedition and Mrs. Livingstone—added to the illness from which most in the country suffered—gave to it a character for malignancy of climate which might apply to the valley regions, but not to the highlands. All these things, as they were looked at, in England, from different points of view, led to the impression that the pictures on the Zambési had been too highly colored, and public interest flagged.

But it was not duly considered, perhaps it was never thoroughly understood, that the jealousy and secret opposition of the Portuguese colonists contributed largely to Livingstone's want of success. It was to their interest to encourage the upper slave-trade with all its demoralizing influences; and dispatches from the home government, in favor of the expedition, if ever received, if ever sincerely written, would be of small avail: the distance from Europe was fatal; and then the colony consisted chiefly of political refugees and convicts. Livingstone's aim was to abolish the slave-trade; and, as long as they felt that, the Portuguese on the Zambési, themselves prospering, would do all they could to throw moral obstacles in his way. They would simply not coöperate; the better disposed would sit still with their slaves around them; the less scrupulous would combine to misrepresent the country, cry down the people, and talk as loudly as possible of the hopelessness of the inland trade. Their slave-drivers all the while might be putting their gangs into the fork-stick shackles; but get rid of Livingstone and the English, and who would be the wiser?

However, things were just beginning to look brighter. A new steamer, sent out by Livingstone's friends, for the navigation of the Upper Shiré, had been taken to the foot of the Murchison Falls. Several miles of broken country divide the Upper from the Lower Valley, over which the steamer, built accordingly, was to be carried piecemeal; a road had been already commenced for the purpose, when Mackenzie's successor arrived from England, in the middle of June, 1863, bringing the dispatch from Lord John Russell, recalling the expedition. This, in connection with other ostensible grounds, induced Bishop Tozer to remove the mission to another sphere of work; and, in the summer of 1864, the original members who survived were once more in England, Dr. Livingstone himself following in the autumn.

And now commences what is likely to prove the most eventful period of this remarkable life. It would seem that the independent spirit which chafed under control at the outset, could find a stimulus only in roaming over its congenial wilds, and must be left to work out its grand problems at its own unfettered will. For in the autumn of 1865 Dr. Livingstone is again on his way out to Eastern Africa, unsupported by public aid, and entirely alone, crossing first to Bombay. His object was—the words are Sir Roderick Murchison's, in 1867—"to discover whether there was an outlet to the south from Lake Tanganyika, discovered by Burton and Speke, which was a fresh-water lake, and which, but for such an outlet as was supposed, ought to be a saline lake." The Rovuma River, between latitude 10° and 11° S., had previously engaged his attention, and he thought by ascending this to be able to connect it with Lake Nyassa, in which case, having no mouth bar, and lying beyond Portuguese territory, it would afford a better entrance to the Shiré country than the Zambési. Starting from Zanzibar, he found no connection to exist between the Rovuma and Lake Nyassa, and, from a thorough examination of its north end, that there was no communication between that lake and Tanganyika. Livingstone's idea has been mentioned, on first hearing of these lakes in the interior, that, on the supposition of a central dividing line, between the north and south river systems, the region about them would be found to be the water-shed of the Nile. This theory it seems to have been his object now to establish, by tracing, if he could, a northern outflow from Tanganyika into Sir S. Baker's great lake, the Albert Nyanza. "Go," said Sir Roderick, even before he left England, "and you will then be the real discoverer of the sources of the Nile!"

Soon after starting toward Tanganyika, a little to the west of Nyassa, the men he had engaged at Johanna were frightened by a report of native ferocity, and, deserting him in a body, returned to the coast with the story that he had been murdered. The story ran, that in marching westward from the north end of the lake, the party was attacked by a body of Mazitu—a Kaffre tribe, who are known to have emigrated from the south side of the Zambési. The Johanna men were some distance behind with unloaded guns, and saw three men attack the doctor, who had fired, and was trying to reload. One struck him behind the head with an axe; he gave a loud cry and fell dead. Two of the Mazitu were found lying near him, shot with his revolver, and the bodies of some boys he had brought with him from Bombay. The Johannese hid in the bush till the Mazitu had retreated, and then, having buried their master, travelling by night made the best of their way back to Zanzibar.

The murder was said to have taken place in August, 1866, and the details were circumstantial. In July, 1867, an expedition left the mouth of the Zambési, dispatched by the Royal Geographical Society, under the leadership of Mr. Young, formerly master of the Pioneer, with a view of obtaining some clew to Livingstone's fate. The voyage to Nyassa and back was accomplished in a little steel boat which could be taken to pieces, and on November 11th they were once more at the Zambési mouth. On his return to England, Mr. Young gave his report. He had ascertained the route taken by Livingstone in crossing Lake Nyassa, and had been able to trace him to the village of a chief, Marenga, at least five days' journey beyond the point of the reported murder! The chief was an old friend of Livingstone's, and assured Mr. Young that, if the doctor had been killed one month's journey beyond his village, he, Marenga, must have heard of it. Mazitu had never been seen in that part of the country; and the story of the Johanna men was a gross fabrication to cover their own cowardice!

A letter from Livingstone himself, dated February, 1867, and received many months later, confirmed the facts brought out by Young: but, after the arrival of that, nothing but vague and unreliable rumors reached England. We were again left in doubt as to the fate of the intrepid traveller. At last tidings came. A letter appeared in the *Times* of December 13, 1869, written by Dr. Livingstone to Dr. Kirk, at Zanzibar, and dated Ujiji, 30th May, 1869. After referring to the untrustworthiness of the Arab traders, both in taking charge of goods and carrying letters—which accounts, by-the-way, for his long silences —the doctor writes as follows:

"As to the work to be done by me, it is only to connect the sources which I have discovered from 500 to 700 miles south of Speke and Baker's, with their Nile. The volume of water which flows north from latitude 12° south is so large, I suspect that I have been working at the sources of the Congo as well as those of the Nile. I have to go down the eastern line of drainage to Baker's turning-point. Tanganyika, Nj-ige Chowambe (Baker's?), are one water, and the head of it is 300 miles south of this. The western and central lines of drainage converge into an unvisited lake west or south of this. The outflow of this, whether to Congo or Nile, I have to ascertain. The people of this, called Manyema, are cannibals, if Arabs speak truly. I may have to go there first, and down to Tanganyika, if I come out uneaten and find my new squad from Zanzibar. I earnestly hope that you will do what you can to help me with the goods and men."

This letter refers to his discoveries east and west of the southern extremity of Tanganyika, and the unvisited lake is Kamolondo. Comparing this with Livingstone's account of his earlier explorations, in recent letters which have reached us, it helps, it would seem, to establish their authenticity, regarding which some are skeptical.

Then we were startled by the following:

"*To the Editor of the Times, February* 2, 1870:

"SIR: The enclosed letter from my son-in-law, Captain the Hon. Ernest Cochrane, commanding H. M. S. Petrel on the west coast of Africa, is at your service. It gives an account of the awful death which has terminated Livingstone's career. Your obedient servant, RICHARD DOHERTY.

"RED CASTLE, COUNTY OF DONEGAL, *January* 31*st.*"

"MY DEAR SIR: A few lines to tell you Dr. Livingstone has been killed and burnt by the natives ninety days' journey from the Congo. He passed through a native town and was three days on his journey when the king of the town died. The natives declared Livingstone had bewitched him, sent after him and told him he had witched their king, and he must die. They then killed him and burnt him. This news comes by a Portuguese trader travelling that way. Livingstone was on the lakes at the head of the Congo, making his way to the Congo, where he was going to come out. I believe this news to be true."

And so might others, if on consideration they could have persuaded themselves that, after hearing some native rumor, the thoughts in the Portuguese informant's mind had been unconnected with his wish! But time passes; and then we learn how a solitary American most gallantly does that which three Englishmen were going to do—and not doing, did less than might still have been done—and comes home and tells the thrilling tale when and where he found the great Livingstone, and in his sore need helped him.

Mr. Stanley's story is so well known that a brief outline of the work he found accomplished after the meeting at Ujiji, November 3, 1871, will be sufficient to complete this sketch.

Leaving the renegade Johannese to carry home their lie, Livingstone first crosses the Chambézi River in latitude 11° S., which, relying on Portuguese information, he passed unnoticed as the head of his own Zambêsi, but which afterward was to prove such a name of note. In the beginning of 1867, he enters Londa, where he is kindly received by the chief Cazembe, and enters upon the exploration of the regions to the east. Lake Liemba, first visited, he ascertains to be the southern extension of Lake Tanganyika, which covers a latitudinal area of 360 miles. After many and complicated wanderings among the waters of this vast region, he reaches Ujiji in the March of 1869, and it was then the letter was written which has been quoted. Crossing Tanganyika in the following June, he reaches Uguphа on its western side, and, entering Rua (Speke's Ururoa), commences a long series of journeys of which the details are yet his own secret.

But a bird's-eye view is given us. First, a vast water-shed between latitude 10° and 12° S., a tree-covered belt, some 700 miles from east to west. From a plain 4,000 to 5,000 feet above the level of the sea, mountains rise to a height of from 6,000 to 7,000 feet, taking the same level. Countless brooks on this wide upland converge and form broad streams that flow toward the centre of a far-extending trough, which Livingstone supposes to be the valley of the Nile. Three large rivers form primary sources in this great valley; and these unite in what he calls "an enormous lacustrine river." This is the Lualaba—"Webb's Lualaba," as he names it, after his friend, the owner of Newstead, to distinguish it from other streams bearing the same appellation. In the valley are five considerable lakes. First, Bemba, or Bangweolo, into which the Chambézi flows—the most conspicuous among many other river-sources. Out of Bangweolo runs the Luapula, to enter the beautiful lake Moero, from which a stream, "Webb's Lualaba," pours impetuously through a rift in the surrounding mountains, and, spreading out in the plain-country beyond, winds away in a course of confusing tortuousness, till it enters Lake Kamolondo. The Lufira, the second of the three great primary rivers, discharges itself into the Lualaba, north of Kamolondo. Then comes the third, the Lomami, which, flowing from a lake westward of Kamolondo—"Lake Lincoln," as Livingstone styles it—fed by another Lualaba, joins the central drainage-line lower down. The three thus uniting, a mighty stream flows northward toward a lake, which may be that discovered by an Italian explorer, Paggia, but which Livingstone designates as the "Unknown Lake;" for at this point his researches are brought to a stop by the mutiny of his men, and, in a state of mind bordering on despair, and utterly destitute, he wanders back to Ujiji, leaving about 180 miles of country unexplored—the casket containing the crown of his discoveries.

When he first began the journeys which led to them from Lake Moero, he could learn nothing from natives about the central line of drainage, after leaving that lake. It might pass eastward into Tanganyika; and if so, and Tanganyika was found to be connected with the Albert Nyanza, then the Chambézi would be the farthest source of the Nile to the south; but, in this case, the configuration of the country showed that it would have to run up-hill. Or it might flow westward, and be found to be none other than the source of the Congo or Niger. To throw light on this point, Manyuema, or, as the Arabs called it, Manyema, a splendid country, but little known, and whose inhabitants were reported to be cannibals, though Livingstone rather ridicules the idea, had to be visited. Then followed the discovery of Lake Kamolondo, the southern end, in lat. 6° 30′ S., and the great central drain of the Lualaba. But, then, what of the Kamolondo outflow? Here Livingstone is left to himself; the natives know—can tell him nothing; his chronometers are defective, and he cannot depend on his reckonings; but he traces the northeast set of the Lufira and Lomami, and sees that the western, like the eastern boundary of the great valley, is elevated. He observes, too, that the central line of the Lualaba maintains a steady though sinuous northward flow; hence, he is led to the conclusion that this river and lake system has nothing to do with the Congo, but that his tedious wanderings have been to and fro among the head-waters of the Nile.

In the mean time, the question is, and will be, keenly debated. The River Kasai, Livingstone's old friend on the Loando journey, flowing into the Congo, bears another name, Loke, among the natives, and is said by them to wind out of a "Nyanja," or lake. The Lomami, according to Livingstone, is also called the "Loeki." Does this similarity of name warrant the conclusion that the Kasai is only a prolongation of the river, with its source in the Manyema country? The Kasai, with the Quango and Lubilash—the two former rising west of the water-shed in the latitude of Lake Bangweolo—were always presumed, on Portuguese authority, to be the sources of the great western river. Can the Lualaba—proved to be connected with the Loeki or Lomami—take a westward course after its prolonged northing, and, overthrowing Livingstone's assumption, become the Congo feeder? If not, another question arises: What is the course of the Lualaba after leaving the Unknown Lake? Do these great waters find a channel to the eastward, and empty themselves into the Albert Nyanza? If, according to Sir S. Baker's observations, the elevation of that lake is 2,700 feet, the lower level of Kamolondo, which is 2,000 feet above the sea, must necessarily preclude that.

But, further, if unconnected with the eastern branch of the White Nile, of which the Albert Nyanza and the Victoria Nyanza are the feeders, does the Lualaba join the eastern branch either as the upper waters of Petherick's Bahr-el-Ghazel, or as one of its tributary streams? Against the first supposition it is urged that the source of this branch was discovered by the German traveller, Schweinfurth, 5° north of the equator. But it is maintained, in favor of the second, that the Uelle, a large feeder of the Bahr-el-Ghazel, was crossed by the same traveller, which, though certainly, where he saw it, flowing from east to west, was never traced to its source. He supposed it to rise in lat. 2° N., in the range of mountains west of the Albert Nyanza; but it is uncertain. The course of the Uelle may wind in such a manner as to account for the westward setting where Schweinfurth found it. Whether a greater difficulty exists in the fact that the two rivers lie at the same altitude of 2,000 feet, yet awaits the test of accurate observation. In the mean time, it is thought that the Lualaba may prove to be connected with the Uelle tributary, and thus enter the Nile by its western branch.

But even then the old mystery will not be solved. The Chambézi is not to monopolize the glory of giving rise to the great Egyptian river. Dr. Livingstone does not think so. On the 700th mile of the water-shed, are the fountains of the two rivers, Kafue and Leeambye, running south into the Zambési. Near the same spot, the Lufira and Lomami (Lualaba) are said to have their source, flowing, as was seen, to the north. In the stoneless mound, or ant-hill according to some, on which these four fountains are reported to gush out, Livingstone is reminded of the information supplied to Ptolemy by ancient explorers, and of the description of the Nile sources given to Herodotus at Sais in Egypt. Will he be able, as he believes, to substantiate this record of antiquity, and in establishing his own theory of a dividing ridge-line between north and south—where Lake Dilolo (lat. 11° 32′ 1″ S.) may again have to be considered—find, after all, that, instead of a discovery, his labors may simply result in a rediscovery? And then as to Tanganyika and the Albert Nyanza. Dr. Livingstone and Stanley together proved that the first lake has no outlet at its northern end, and that the Rusizi—a river with eighteen tributaries, coming from the small lake Kivo—is an inflowing stream, and not a drain. What will be done in this direction? What may be the result of discovering some other outlet from a lake extending over 360 miles of latitude, and this, too, when the Albert Nyánza to the south shall be no longer, as at present, unexplored?

For the solution of these questions, we must await the return of Dr. Livingstone himself, who is, by this time, we hope, once more among the waters of Rua and Manyema, with ample stores, and well attended. In two years, though probably more, he may be able to give us his own account. But, in prosecuting the researches, whose successful issue will leave him, in the words of his late friend Sir Roderick Murchison, "the most glorious of all explorers in African geography," it is not to be forgotten that he has other, and what must be admitted to be nobler, aims. With his never-relinquished idea of establishing a central trading-mart, and purging Africa from its slave-trade, whether Portuguese or Arab, he exhibits the old steadiness in completing a self-set task, the same tenacity of purpose. He is certainly endeavoring to end as he thought good to begin: "It is better to lessen human woe than to discover the sources of the Nile."—*Fraser's Magazine.*

ARTS IN THE STONE AGE.[1]

WHEN Shakespeare represented his philosophical Duke as finding "sermons in stones," and "books in the running brooks," he was but unconsciously exhibiting the prophetic faculty which has been attributed to all true poets. He could hardly have foreseen that his pretty yet fanciful conceit would one day be found to be sober earnest. But so it is; we have here a goodly volume of more than six hundred pages, illustrated by nearly as many excellent woodcuts, discoursing learnedly of nothing save stones and streams, and finding in them sermons of great and, to many readers, novel interest.

It might have been supposed, when Mr. Evans had published his well-known work on "The Coins of the Ancient Britons," that he had gone back as far as possible in the history of our land and nation; but, in archæological as in other sciences, there is in the lowest known depth one lower still remaining to be fathomed; every chamber opened to the light discloses others lying beyond it. From a people who had no literature, or none of which they have left any trace beyond the rude characters inscribed on their rude coins, we are now carried back to tribes and races which possessed neither coins nor letters; people who have left us neither their sepulchres nor their ashes, nor indeed any trace of their existence, save the rude triangular or subtriangular fragments of worked stone which served them for tools or weapons; and even these are usually found buried beneath the wreck and ruin, it may be, of continents or islands which have long since been worn and wasted away.

The publication of this work is remarkable as an evidence of the quickened pace which characterizes scientific research in our days. Paleontology and geology, vigorous and flourishing as they are, are still hardly "out of their 'teens;" but prehistoric archæology has

[1] "The Ancient Stone Implements, Weapons, and Ornaments of Great Britain." By John Evans, F. R. S., F. S. A. (New York: D. Appleton & Co., 1872.)

made comparatively more rapid progress than either. Not more than fourteen years have passed since the discoveries made by Boucher de Perthes of flint implements in the gravel-beds of Abbeville and Amiens, although at that time discredited and disparaged by the geol-

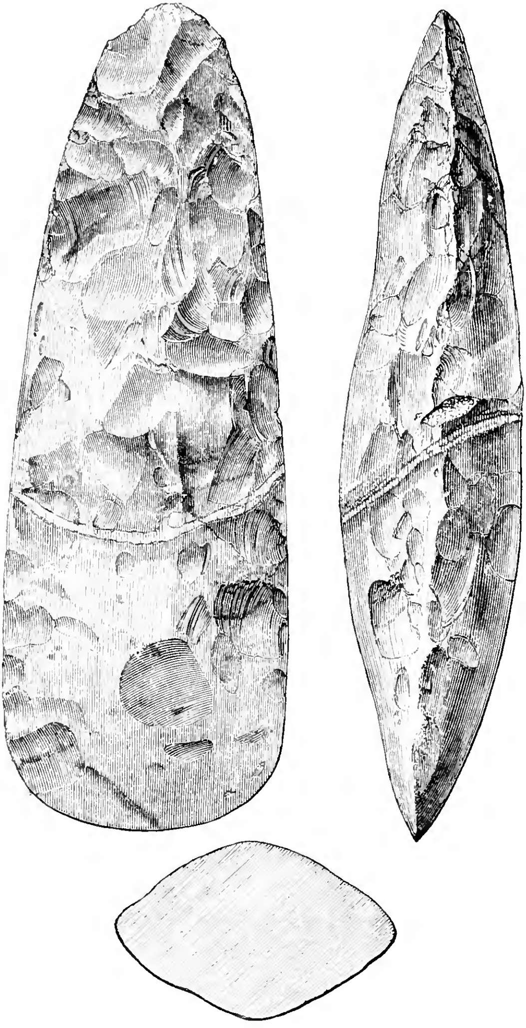


FIG. 1.—Polished Celts, Santon Downham, Suffolk.

ogists of his own country, were confirmed and supplemented by Mr. Prestwich and Mr. Evans. Previously to that time these objects had attracted but little notice; the things were "neither rich nor rare;" men looked at them and wondered, and then forgot them, just as before William Smith's time they gazed with a profitless curiosity on fossil shells and bones, and thought with Dr. Martin Lister, that they might be "the efforts of some plastic power, in the earth, being the regular workings of Nature, whereby she sometimes seems to sport and play, and make little flourishes and imitations of things, to set off and embellish her more useful structures."

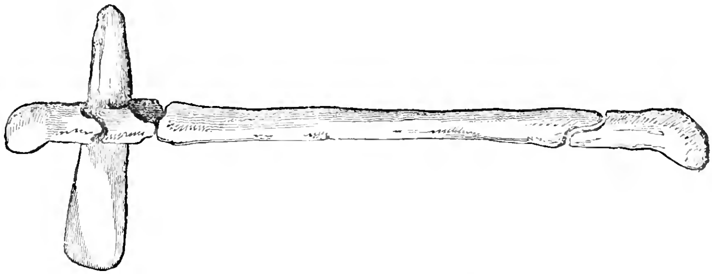


FIG. 2.—Hatchet from the Solway Moss.

But, since the discoveries in the Somme Valley were recognized, a flood of light has been shed upon the subject. These dry bones live, and these rude stones are found to be useful, indeed indispensable, materials for building up the earliest history of the human race. The *savants* of every country in Europe have hastened to take part in an inquiry so novel and so interesting; many volumes of memoirs have been written; our French neighbors, with their usual vivacity, have

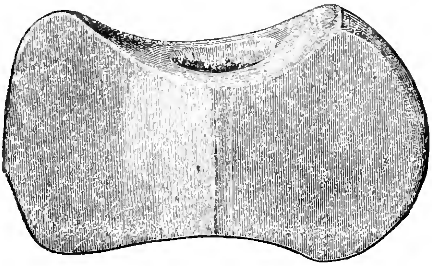


FIG. 3.—Axe-Hammer, Thames, London.

established a journal devoted to prehistoric archæology, as well as an annual *Congrès;* and these researches having been for several years conducted by so many able and eager observers, we need not wonder that Mr. Evans, having studied the whole bibliography of the subject, both ancient and modern, and explored every considerable museum or collection, is now enabled to produce this encyclopædia of the new-born science, which for want of a better word may, perhaps, be called petrology or petro-tomology. He has introduced us into the workshops and armories of our most remote predecessors, it may be of our ancestors, as they existed not at any particular epoch, but in all probability through a long succession of ages; and he has shown us so clearly what were their weapons and tools, of which any vestiges remain, and how they were made and used; and has correlated them so accurately, as far as might be, with similar objects found in all quarters of the globe, as well as with those described by classical writers, or in use by modern savages, that in reading his work we know not which most to admire, the industry shown in the collection and examination of such a vast amount of material, or the skill with which the information thus obtained has been methodized and arranged. The book completely exhausts the subject, and will long continue to serve as a perfect manual for the collector, as well as furnishing most useful materials for archæologists and anthropologists.

Those who are not already somewhat versed in this science will be astonished to learn the infinite variety of uses to which the apparently stubborn and unmanageable rock called flint has been converted. We may, perhaps, doubt if in the very earliest ages it was used for purposes of warfare, and we prefer to give our progenitors the benefit of that doubt, and to believe that those were "golden ages"—times of primitive piety and peace; and that it was only for purposes of husbandry, and the chase, and domestic use, that they worked up the materials found in their plains and valleys. Thus, we find descriptions of celts, or axes for felling trees, or hewing canoes, hoes, threshing-machines—as now used in the East—or perhaps harrows, scrapers for preparing skins, arrows for birds or other "small deer," knives, gouges,

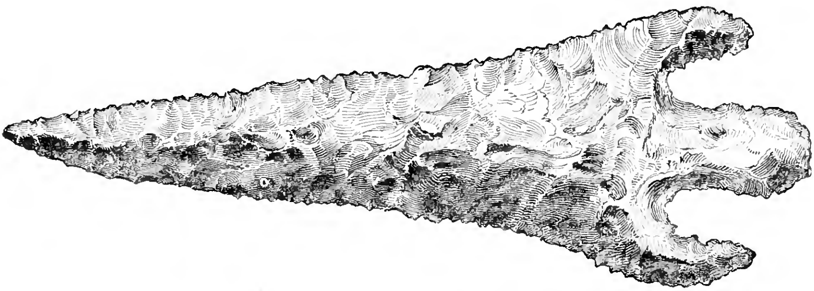


Fig. 4.—Arrow-head, Isle of Skye.

saws, mullers, or pounding-stones, chisels, hammer-axes or picks, and polishing or grinding stones, of which there must have been great need; nor were the women of the period left destitute of their share of the stony spoil; for we find in these pages descriptions and figures of rings, armlets, amulets, spindle-whorls, pestles, and, in the cave-deposits, needles of bone of admirable workmanship, which might have been, and probably were, drilled by flint-flakes.

As these primitive people have left us no record of their progress in arts and manufactures, and the material evidences bearing on the subject are found in a very confused and dislocated condition, it is a work of no small labor to classify and arrange them in order of date, or rather of sequence, and thus none but a rough and wide scheme of classification is possible. The Danish and French authors, as well as many of our own, usually divide the stone-implement period into two principal stages only, the paleolithic and neolithic—unpolished and polished; placing them both before what has been called the Bronze age. This arrangement, however, although found convenient for popular use, and in that sense adopted by Mr. Evans, can hardly be regarded as scientifically accurate; as he has himself observed, there are blanks in the chronology of stone implements, which it is hard to fill up. The classification may be, and indeed is, too wide in one respect, and too limited in another. While, on the one hand, the drift and the cave implement periods, which are usually bracketed together as paleolithic, are characterized by very various conditions, both paleontological and geological, and, indeed, technological also—conditions which may indicate their separation by a vast interval of time; so, on the other hand, as Mr. Evans has shown at the close of the fourth chapter, some of the unpolished stones, chipped or rough-hewn celts, were probably of a date not earlier than some that were ground and polished; and, in Great Britain, at least, there are not wanting indications that the use of bronze was coeval with the polished-stone period, if not, indeed, with one or two exceptions (which were probably imports) anterior to it.

One of the most perplexing questions suggested by the discovery of the drift-implements relates to the means by which they came into their present position. They are often met with at a depth of twenty or even thirty feet, usually at or near the base of thick beds of coarse flint-gravel, which in its turn is overlain by masses, more or less thick, of brick-earth or loess. Occasionally, and indeed not rarely, they occur entirely beneath the gravels, and on the surface of the subjacent rock, whatever it may chance to be. Mr. Evans deals with them merely as constituent portions of the beds of sand, gravel, and clay, in which they occur, and so indeed they now are, but they are something more. Although of the drift, drifty, each has its own separate history; for each has been held and fashioned by hands guided by an intelligent will, and thus we are led irresistibly to inquire when, and why, and how did they come where we now see them, and why are they never found on the surface, nor under any other conditions?

To a certain extent this inquiry is involved in the far larger question of the forces by means of which the superficial gravels, of which the implements are as it were but the accidents, became dispersed—a subject which does not necessarily come within the scope of a work designed to be technological rather than geological. Mr. Evans has, however, very judiciously devoted one of his chapters to it; and, as it is one of great interest, and is still involved in much obscurity, we may gladly welcome any attempt to deal with it, especially by one who has given so much attention to its investigation.

It was the opinion of the late Dr. Buckland, an opinion which was concurred in by Greenough, Conybeare, and other able writers of their time, that the general dispersion of gravel, sand, and loam, over hills and elevated plains, as well as valleys, was the result of a universal deluge, which is described as transient, simultaneous, and of a date not very remote; that the existing system of valleys was mainly due to the same cause, and that thus both valleys and gravels preceded our present river systems. Cuvier, and the French geologists generally, have held the same opinion, but of late years it seems to have been altogether discredited by English authors, with perhaps the exception of the late Sir Roderick Murchison. We may well entertain doubts as to the occurrence of a deluge that should be both universal and simultaneous; and it is probable that it is chiefly on that account that Dr. Buckland's theory has met with so little favor. Still, although we may be unable to adopt his views in their entirety, his statements, as to the diluvial characters of the English drifts, seem entitled to some further consideration before they are set aside altogether, and on this account it is fortunate that the recent discoveries of flint implements have excited so much interest in the gravels in question, as to induce Mr. Evans to devote no inconsiderable portion of his work to the history and antiquity of the river-drift.

In the last chapter he has adduced an elaborate argument in favor of the belief in fluviatile transport as opposed to diluvial, by showing first, hypothetically, the possibility that "deposits now occupying the summits of hills have originally been formed in and about river-beds," and then, by reference to the actual phenomena, the probability that the implement-bearing beds were thus formed. No one can doubt, upon the hypothesis here stated, that rivers may have possessed at one time a far greater power of excavating and deepening their channels than now; but then the author is obliged to assume the prevalence of several conditions, and notably a far more rigorous climate, and a greater amount of rainfall; conditions as to which we have but little evidence, and some of that is of a doubtful tendency. If, as is now supposed, the hippopotamus and elephant and rhinoceros remained here all the winter, they would have fared but badly, had the climate been as severe as is supposed.

But passing by these topics as not bearing very immediately upon the question of transport, it cannot be doubted that submergence, by means of diluvial action, is quite possible, since we have many instances of it within the historical period, and some indeed within the last few years; and, both modes of transport being alike possible, the probabilities of the case have alone to be considered; and, notwithstanding the various reasons so ably stated by Mr. Evans, it does not seem that there are sufficient grounds for rejecting Dr. Buckland's theory, and there are, besides, some inferences to be drawn from the position of the implements, which, so far as they are concerned, are at variance with the theory of fluviatile transport. For instance, when met with in valleys, it appears that the implements are not found along the whole course of those valleys, as well where flint-gravels are wanting as where they abound, as would have been the case had they been carried down promiscuously by the streams from time to time; but, only in certain limited areas, and then usually in large numbers, and at about the same levels; and further, that in several of these deposits the implements are distinguished from those of neighboring deposits by some slight difference in form. From these indications it may be inferred that they were made and left at or near the spots on which they were found, and afterward covered up, and occasionally displaced, by the masses of drifted material which now overlie them; and this seems the more probable, when it is seen that some of them were formed from stones of the same kind as those composing the beds in which they rest, and that some of these appear to have lain exposed upon the surface for long periods before they were worked.

Fig. 5.—Sling-Stone, from Aberdeenshire.

If, indeed, it had happened that these things had never been found elsewhere than in river-valleys, the conclusions arrived at by Mr. Evans would have been irresistible, but, so far from this being the case, it is certain that these implement-bearing gravels are occasionally found on the extreme margin of sea-cliffs, or isolated hills on the verge of far-stretching plains—situations to which no river flowing in the same channels, and draining the same areas as now, could have carried them.

Mr. Evans has noticed several of these deposits as met with at Bournemouth, the Reculvers and the Foreland cliffs in the Isle of Wight (to these probably should be added Southampton and Brandon Down, and some others); and he has also alluded to the remarkable discovery, in the Madras Presidency, of implements of quartzite of true drift-type, found on the cliffs at an elevation of 300 feet above the sea, in a bed of ferruginous clay, which forms the coast-line for several hundred miles, and is intersected at right angles, at various intervals, by the rivers of the country in making their way to the sea.

In all these cases, all traces of the ancient rivers, if indeed they ever existed, have been entirely effaced; neither channels, nor outlets, nor adequate water-sheds, nor a single land or river shell, remaining to testify of them; and not only so, but we find many deposits of quaternary gravel (which Mr. Evans justly concludes to be of the same geological period as those of the implements, and to owe their existence and position to the same causes) on hills which could not have been reached by modern rivers. The whole country would have been a vast lake before such heights could have been submerged; and under such circumstances it may be fairly assumed that the same forces, whatever they were, that covered the hill-tops, may have partially filled up the valleys; the presence of gravel may suggest, but cannot prove, that the river brought it, however much it may have rearranged and sorted it; both valley and gravel may have had an existence before the river began its course. We have many valleys and gravels without rivers, and rivers without gravels; they can very well exist apart, and doubtless have often done so.

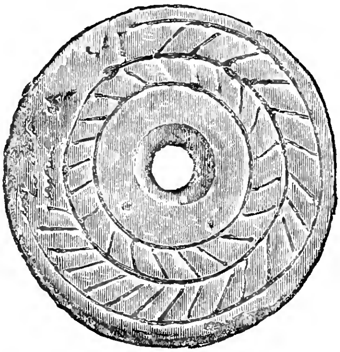


Fig. 6.—Spindle-Whorl, from Holyhead.

One of the arguments usually relied upon, in support of the belief in fluviatile, as opposed to diluvial, agency in the formation of the deposits in which the stone implements are found, is founded on the assumption that the constituents of these quaternary gravels are petrologically such, and only such, as belong to existing river-basins; and this fact, Mr. Evans says, holds good in France and England, and cannot be too often reiterated. Without pausing to consider how far this argument might avail as against those who, like Dr. Buckland, believe in a simultaneous and universal cataclysm, it seems hardly applicable to the conditions under which the implement-bearing drifts are found; for if the term petrological is to be understood as meaning rocks found *in situ* in the river-basins, and thus native to the soil, then it is not the fact that the constituents of the gravels in question belong to those basins; for we know that they are often largely made up—in one instance cited by Mr. Evans, to the extent of 50 per cent.—of the quartzose stones known as Lickey pebbles, and rounded fragments of jasper, quartz, and other foreign rocks. Such rocks certainly do not belong petrologically, in the proper sense of that term, to the river-basins in which they occur, but to strata of a far earlier date. As Dr. Buckland has shown, the quartzite pebbles are derived from the New Red sandstone beds in Warwickshire and Leicestershire, and were at some remote period forced over the escarpment of the Oolite into the south and east of England. Whether they were brought in before or after the present river-valleys were formed is not very clear, nor perhaps very material. It is incontestable that they were transported from a great distance, and possibly by the same forces that brought the flint-gravels; and it is equally certain, in several instances, that their transport cannot be attributed to rivers now in action, because those rivers flow, as at Brandon, toward the quarter from which the stones were brought.

Nor, if it were certain that the intrusion of these rocks dated back to the Glacial epoch, as is usually supposed, or to some other very distant period, and had thus become denizens, if not natives of the soil, could the inference which is drawn from the absence of extraneous rocks be regarded as satisfactory.

The occurrence of alternate elevations and depressions of the land above or below the sea-level, during the post-glacial times, has been suggested by several English writers; and, if we suppose a district comprising the south of England and the north of France, corresponding, or nearly so, with that in which no bowlder-clay is found, to be sufficiently depressed, and then invaded by a deluge, the argument drawn from petrological conditions will cease to apply; for, no rocks are found in the drift-gravels, but such as belong to the supposed deluge-basin. A deluge of short duration would not necessarily introduce any foreign rocks into the submerged area, but would sweep into hollows and valleys those that came in its way; and, even should the submergence be of long continuance, as in some provinces of Holland, it would leave no more traces than those exhibited in our drift-gravels. That such a partial deluge was both possible and probable is evident, when it is considered that a depression of 600 feet would perfectly well effect it; and, as we have evidence that the land has risen in several places 30 feet and more within the historical period, it is not difficult to believe that, in the infinitely longer time that probably intervened after the Glacial epoch, the same process of elevation may have been going on for many ages.

The absence of all traces of a marine fauna, and the occasional presence of land and fresh-water shells in these beds, are circumstances on which much stress is laid by the author; but, when fully considered, they hardly seem to warrant the inferences drawn from them. A marine fauna requires a marine flora for its sustenance, and, unless the submergence had been of long duration, this could not have existed. We find extensive marine deposits of older date, in which no marine organisms are ever seen; and, if marine fossils are wanting in drift-beds, those of the land and fresh water are usually equally wanting. We have, probably, hundreds of square miles of quaternary gravels, in which not a single specimen has ever been discovered. In those instances, comparatively rare, in which they occur in the implement-bearing beds, they are usually lying above the gravel, and may thus be ascribed to a later date; or, if of an earlier date in some instances, their occurrence would not of necessity exclude diluvial action, as regards the gravels.

There is one interesting topic connected with these drifts, which Mr. Evans has not dealt with at any length, as, indeed, it barely came within the design of his work; but he seems to share the general opinion that the men who made and used the drift-implements were contemporary with the hippopotamus, elephant, rhinoceros, and other animals, with whose remains they are often found associated. At present this is but a possibility, and it is an assumption founded on the fact of the bones and implements being often found in close proximity; but, if, as seems probable, the implements were formed from stones found in the gravels in which they now rest, it can hardly be doubted that the bones were already in that gravel, and may have lain there for centuries. From their shattered and way-worn condition, they have evidently been subjected to much rougher usage than that which some of the flint implements have met with. But, however this may have been, there can be no doubt, as Sir Charles Lyell has observed in the "Antiquity of Man," that "the fabrication of the implements must have preceded the reiterated degradation which resulted in the formation of the overlying beds;" a process for which vast periods must be allowed, and one which must have involved important geological changes. Among others we have very strong reasons to believe was the severance of our island from the Continent, an event, indeed, which, however brought about, could hardly have been unattended with important changes in the contour of the adjacent districts, and the courses of their rivers. When we contemplate the vast changes, geological, paleontological, and geographical, which our race seems to have survived, we are surprised to learn how very old we are, or, as Mr. Evans has better expressed it, the mind is almost lost in amazement at the vista of antiquity thus displayed.

It would seem, as might be expected, that, notwithstanding the cosmopolitan character of these objects—for, as Mr. Evans's researches have shown, they are found in one form or other in every country on the face of the globe—certain forms are pretty well confined to certain localities, as if each of the tribes or families who used them had its own manufacture. The half-polished and polished celts of Norfolk,

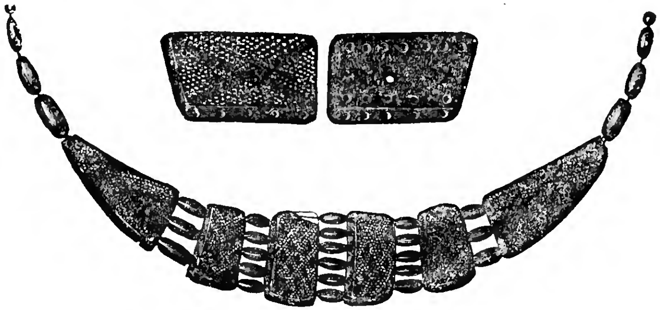


FIG. 7.—Jet Necklace, from Ross-shire.

Suffolk, and Cambridgeshire, vastly outnumber those which have been observed in all other parts of England, from which it would seem that these countries were more populous, or the people more advanced in the arts, than in the rest of the island, or possibly they may have been the manufacturing district of the period. As regards, however, the distribution of the drift-implements, a far more suggestive and important circumstance is to be noticed. As Mr. Evans has observed, the district farthest north of the Thames, in the gravels of which flint implements are at the present time known to have been found, is the basin of the river Ouse and its tributaries. They have, in fact, been found, at one time or other, in every English county lying to the southeast of a line drawn from the Severn to the Great Ouse, corresponding thus far with the great escarpment of the oolite, but they have never been met beyond that line; and it is an interesting subject of speculation to what the dearth of these objects in the country lying to the northwest is to be attributed. If it was habitable and inhabited, it is difficult to imagine a reason for their absence, especially as in Yorkshire and Lincolnshire there is abundance of suitable chalk-flint. This line of demarcation is not very much out of that which separates the bowlder-clay districts from those in which no bowlder-clay is met with. May it not have been the case that, when the implements were fashioned, Scotland and the northwestern parts of England were still submerged beneath the glacial sea, and that on their emergence the southeast became in its turn depressed?

Notwithstanding all that has been written on the subject, there seems to be still much doubt as to the uses for which some, and no inconsiderable number, of these objects were designed. For all useful purposes it would have sufficed that the cutting-edge of a celt should alone be polished and ground; yet it is often, indeed usually, found that the entire surfaces of the faces and the sides exhibit a polish which could only have been obtained by long and apparently profitless labor. And not only so, but many of these are very fragile, being slightly made, and of delicate workmanship, and others are of such small dimensions that, as M. Boucher de Perthes pointed out, they never could have been available for any kind of hard work. Many of these exhibit no signs whatever of fracture or even of scratching, either at the butt or the edge—indications which could not possibly have been wanting, had they ever been used for weapons or tools. Besides which, while many of the districts, in which they are found, contain abundance of rocks suitable for all ordinary purposes, these implements are often made from Asiatic jade, jadeite, tremolite, serpentine, green porphyry, nephrite, and other stones of beautiful colors, and capable of taking a high polish, many of which must have been brought from great distances, and would have been very costly both to import and to work. The museums in Brittany, and particularly that at Vannes, are very rich in jadeite implements of this kind, but they are also found frequently both in England and Scotland.

Fig. 8.—Jet Armlet, from Guernsey.

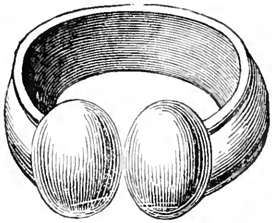


Fig. 9.—Bronze Armlet, from Guernsey.

But, if we conclude, as we must, with the author, that implements, for which such beautiful and intractable materials were selected, could hardly have been in common use, we may indulge in some speculation as to what were the uses they were designed to serve, notwithstanding that, as Mr. Evans says, we have not sufficient ground for arriving at any trustworthy conclusion. M. Boucher de Perthes thought that they were deposited by the survivors in the graves of deceased friends, as useful to them on their resurrection, and he argued from this their belief in a future state. It seems, however, hardly probable that objects, many of which obviously could not be serviceable, should be placed in tombs under the belief that tney would be so at some future date. In the absence of any more satisfactory explanation, it may be suggested that these things were intended by our remote predecessors to represent the deities whom they worshipped, and that, by their varied sizes and shapes, they indicated the ranks and orders of their idols. We may believe that men, not having learned the art of representing the human or animal form, were obliged to content themselves with symbols of their divinities—it may be their Mars and Ceres—under the form of weapons of war, or instruments of agriculture. Nor is this so unlikely as it might otherwise appear, when we know that these celts are still objects of worship in India. Mr. Evans, quoting from the Proceedings of the Asiatic Society of Bengal, says that they are there venerated as sacred, and it is known that, in a certain village in the Shewaroy hills, some hundreds of polished celts, of varying sizes, resembling those found in England and Scotland, are preserved in a temple, arranged in rows. They are guarded with the utmost jealousy by the priests, each representing some particular *swamy* or deity, and each receiving from time to time a dab of red or white paint, as a proof that the priest has performed before it the customary *poojah* or worship.

This being so, the discovery of these implements in Europe may have some bearing upon an important ethnological question. We have good reason to believe that the dolmen-builders came, in the first instance, from India, for we find in Wilts and Berks, and elsewhere, exact counterparts of some megalithic structures, and those of a peculiar construction, which yet remain in the same Shewaroy district in which the celt-worship is still practised. May we not, then, regard it as possible that the fabrication of polished instruments, as well as the practice of dolmen-building, originated in India, where they are still retained, and that these costly polished celts were brought hither by our Aryan ancestors, as the Israelites carried their Teraphim about with them, or as the Trojans, after the fall of their city, are represented in Virgil as carrying with them their household gods:

"Ilium in Italiam portans, victosque penates;"

and that the worship was only abandoned here as men became enlightened, or were subjected to the dominion of some race of a different theology? Since we find abundant traces of the Aryan language in our own, and of their sepulchral architecture in our dolmens, why should we not find in our fields and fens some of their idols? It is quite consistent with, and in a certain sense confirmatory of, such a belief, that, in almost every country in which these things are found, they are regarded by the common people with superstitious reverence, as if the practice of adoration had in the lapse of ages merged in a vague and faint tradition of sanctity.

Nor is it any objection to this hypothesis, but the reverse, that these implements are usually found in and about dolmens, as at Tumiac and Mont St. Michel, where nearly seventy highly-polished celts of imported materials—Asiatic jade and hard tremolite—were found ranged in regular order. It has been usual with almost all people, in all ages, that those things which they most esteemed in life should rest with them in their graves; and as we often find in our own country the priest's paten and chalice placed in his coffin, or the Anglo-

Saxon's sword and shield laid beside him in the earth; so, possibly, these prehistoric men may have wished that the stone idols which, when living, they adored—the lares and penates of their time—should be laid beside them in their tombs.

But, in pursuing the train of thought suggested by our author, we had wellnigh forgotten his book, and we have only space to congratulate all those who are interested in these researches—and they are now many—on the ample and valuable additions which he has made to this new and most interesting chapter in the history of our race.—*Nature.*

CULTIVATING WILD-FLOWERS.

By Prof. SAMUEL LOCKWOOD.

BUT few are aware of the many American wild-flowers which merit and would repay cultivation. The showy scarlet sage (*Salvia coccinea*) is a common sea-coast weed in some of the extreme Southern States. In the North it has deservedly become a favorite; and culture has placed it within the reach of every one, even the poorest. The brilliant, deep-red cardinal-flower (*Lobelia cardinalis*) is highly esteemed abroad as a garden-plant; and yet, to dwellers in our cities, this plant is almost unknown, although it is one of our common wild-flowers, lavishing its bewitching beauty in numberless places, both North and South. Nor is the above word a mere figure of speech. An English scientific gardener lately visited Long Branch. He took a ride among the surroundings of that watering-place. When between Eatontown and Red Bank, he suddenly requested the driver to stop, at the same time uttering an exclamation which caused Jehu to doubt the gentleman's soundness of mind. The carriage was stopped, and away went the well-dressed Englishman over the field-fence, as lithe and agile as a youth. He actually plunged into the half-swampy ground, and made, as nearly as possible, a straight line toward a scarlet speck in the vernal distance. No high-mettled bull in a Spanish arena ever went more intently at the little red banner of the *picador* than went our friend John B., Esq., through that wet New Jersey meadow for that scarlet flower, which drew him like a fascination. It was a pitiable plight that he presented on his return to the carriage, exultant with his prize. To the astonished driver he offered these apologetic words: "This is the splendid *Lobelia cardinalis*, which I have cultivated with so much care at home, and, behold! here it grows wild!" To which Jehu, whose astonishment had now become modified by a shade of contempt, returned an ingenious equivocation: "That *is* worth a gentleman spoiling his clothes for!"

We know of more than one little cottage flower-patch, whose owner has planted in it the cardinal-flower, where it has grown in such decided prominence of beauty as to maintain a sort of pontifical preëminence among the floral dignities of the parterre. This splendid flower, with its racemes like scarlet rods, and the habit of the plant, so upright and graceful, with a sort of queenly bearing, and gorgeous magnificence, very much outshone its gayer but straggling companion, the gaudy scarlet salvia. We know a village blacksmith who thus made this plant the spectacle in his flower-plot ; and it was amusing to see persons, in their admiration, seeking to purchase plants from this little garden, utterly ignorant of the fact that they could be had simply for the going after in the contiguous meadows. As a wild-flower, they had often seen it, but had never observed it. Forsooth, how few obey the æsthetic command: "*Consider* the lilies of the field, how they grow!"

And there is the common spreading dogbane, to which science has given one of its terrible sesquipedalian names, to wit, *Apocynum androsæmifolium*. It is an engaging plant, for all that, with its open, bell-shaped flowers. Its first cousin, the Indian hemp, though very unpretentious as to its flowers, has an upright habit, much more queenly than the loose *abandon* of its beautiful flowered relation. Alas! for its reputation, this plant has fallen into bad hands, and become notorious among the empirics of medicine. Speaking of the spreading dogbane, a correspondent of the Torrey Botanical Club, quoting authorities, describes it as "one of the most charming of our native plants. The beautiful clusters of rosy bells, with their pink bars, and delicate fragrance, claim for it a place in the garden, where, however, we do not meet with it, but on open banks and by the side of roads or cultivated fields. It is well approved, too, by the insect tribe, who are, in general, much more appreciative judges of color and odor than we are. In Europe, where it is not native, it is cultivated in gardens, and, according to Lamarck, is called *gobe-mouche*—fly-trap. If flies alight on this plant, they are frequently entangled by the glutinous matter, and destroyed. Hence, the plant has been called *Herbe à la puce*."

It has surprised me that so little has been done with our starworts, or native asters—plants so prodigal of bloom during the late summer, and almost the entire autumnal months. The number of species is very great, and some are of exquisite beauty. Our favorite is the *Aster concolor*. It abounds South, and comes as far North as the Pines of New Jersey, where it attains perfection in delicacy of structure and prodigality and compactness of bloom. Indeed, this part of New Jersey has seemed to us as the prodigal border-land, where the Southern and the Northern floras terminate and commingle, or overlap each other. Here Michaux and other great men have labored, and carried away many novelties. In these regions, the *Aster concolor* grows up like a simple wand, with its small leaves closely hugging the remarkably small stem, much as if a wire had been dressed with leaves for festal uses. The upper part of the stem is so closely surrounded with the compact flowers, that it is literally a purple raceme or wand. Cultivated in mass, in a dry soil, this aster would glow like a sheet of purple flame.

And why is the very common, yet very stately, gentian overlooked? This plant is positively unique in character. A single stem set amid green leaves, with cerulean gems, is a thyrsus worthy of a god. But there is a quaint, coyish modesty about it—its singular flowers seem to be always in bud, as if too coy to blossom outright.

And what charming terrestrial orchids are found native—but, concerning this, there is but space for a word. These singular indigenous flowers—so lovely, and yet so eccentric—are represented by a large number of species. They may be called pretty, winning little oddities. They would need some skill, perhaps, in their cultivation; and some might come to be regarded as the coquettes of the floral community, jilting the gardener with futile promises. Last summer, we took up with our fingers a pretty specimen of the *Calopogon pulchellus*, which means the Beautiful Little Beard. It had but one tiny scape, growing from a green bulb which lay in the moss, much like a solitary egg in a bird's-nest. The entire plant, with its marvellous flower, was not more than six inches high. Our heart failed us in an attempt to put it in the press as a specimen; so we planted it in a little pot, attached to it a label bearing its scientific name, for popular name it had not, and then put it on the glass case on the counter of the apothecary. It was a pleasant surprise to everybody who saw it. Many were the ejaculatory commendations received by the little stranger with the purple hood, and the quaint little beard of so grotesque dyes of pink, and yellow, and white. The pretty stranger was unanimously voted "charming;" and was by some taken to be a rare exotic, that had grown up under the professor's care. Besides this, we have among our native orchids the equally pretty Pogonia and Arethusa; while, worthy of any conservatory, are the white fringed and the yellow fringed Rein-orchis, both of the genus *Habenaria*. Mention might be made of the Lady's Slipper, the showy and rather ostentatious *Cypredium;* but the list is a long one. These native orchids are all eccentricities, and we have selected the most lovable, and the most easily attainable—in fact, those the nearest to our hands.

Just as the above was written, the usual monthly report of the Department of Agriculture came to hand. The following paragraphs are so much to the purpose, that it would be nothing less than blameworthy not to quote them. Speaking of American plants in Great Britain, it cites an English journal as saying: "The beautiful *Asclepias tuberosa* is, this season, producing freely its showy, bright orange-colored flowers in several collections round London. This fine perennial thrives perfectly well almost anywhere, if planted in sandy peat."

In the same journal we find the following: "One of the best hardy aquatic plants, in flower at the present time, is the North American Pickerel-weed (*Pontederia cordata*), a plant by no means so often met with as it deserves to be. It produces a stout spike of handsome sky-blue flowers from 1½ to 2 feet high. No ornamental water should be without this charming aquatic, which should, however, have a place near its margin." "The American Pitcher-plant (*Sarracenia purpurea*) is thriving as well as any native plant in the bog-garden in Messrs. Backhouse's nurseries at York, and by its side a healthy little specimen of the still more curious *Darlingtonia Californica* is beginning to grow freely."

The Asclepias family in America is very rich in species, but the above-mentioned one is by far the noblest of them all. From the fact that it attracts around it large numbers of these beautiful creatures, it is often called the Butterfly-weed. The plant was formerly held in high repute as a medicine, under the name of Pleurisy-root. But its gorgeously-colored flowers, so intensely orange, and so densely massed in heavy umbels, present a gorgeous richness which is incomparable. There is an African species, with flowers of a similar color, which is carefully cultivated in conservatories; but, when contrasted with our native plant, on every count, the foreigner becomes tame, and mean, if not insignificant, in the comparison. As to the Pickerel-weed, it is of easy culture; and in the margin of garden-ponds, or fountain-basins, it might be pronounced as gracefully genteel. The Pitcher-plant, if set higher up on the banks in a bed of sphagnum, or bog-moss, would be so uniquely elegant as to deserve the epithet *recherché*. This same plant can be grown in a pot, simply by keeping the saucer well supplied with water, while its quaint flowers, and the curious structure of the leaves, would make it the favorite bit of bijoutry in the floral jewels of the window.

This culture of wild-flowers, to some extent, can be indulged in by almost all. Its effect upon a mind of average intelligence is surprising. We have, in our acquaintance, a village bricklayer, a man whose means are of the most slender kind. He has a love for flowers, and shows considerable tact in producing effect by massing the different popular sorts. The imported asters, the improved petunias, and pansies, are severally made to effect a blaze of color. But his chief affection centres in a little spot where he keeps his wild-flowers, among which he pointed out to us, with an amiable pride, his pet pogonias, obtained from the swamp over the way. This man has become quite a systematist in botany, and is deservedly looked upon as the botanical light in his community. And who could possibly indulge in this pleasure of wild-flower culture long without wanting to know the names of his plants? But, as few of them have popular names, he must turn to botany for information. Thus this innocent and elevating pursuit may become a key to the acquisition of scientific knowledge, and the application of scientific methods. Here we stop, with the sense of a child who has picked up a few spangles which have dropped from Flora's rich attire.

THE VELOCITY OF THE WILL.

By R. RADAU.

TRANSLATED BY A. R. MACDONOUGH.

IT is a common idea that the saying "as quick as thought" expresses the *ne plus ultra* of speed—an unapproachable rapidity, instantaneous and lightning-like. The phrase seems used, indeed, as an hyperbole; but in one sense, at least, this is a mistake. Thought, it is true, can transport us afar without taking note of distances, because there is no more difficulty in bringing up, in fancy, a remote object, than one that is close to us, and in this view it may be allowable to say that space creates no obstacle to thought—not impeding nor changing it in the least. But thought never springs instantaneously under the influence of an external cause; an appreciable time elapses, one or two tenths of a second, before an idea is aroused in the mind in consequence of an impression received by the brain, and before it will respond to that idea by the movement of a limb. So the nervous current which transmits sensations to the brain, and bears the commands of the will to the extremities of the body, requires a certain time to finish its course. Impressions coming to us from without are not perceived at the very instant of their production; they travel along the nerves with a speed of from 60 to 90 feet a second, equal to that of the carrier-pigeon, or the hurricane, or of a locomotive under full steam, but very much less than the swiftness of a cannon-ball. For instance, we are conscious of an injury in the feet only after a half-tenth of a second has elapsed. The commands of the will pass from the centre to the circumference with no greater rapidity; the limbs do not instantaneously obey the motive thought. When a movement is provoked by a shock received in any part whatever of the body, the stimulus at first travels as far as the brain; there a thought is developed, the will determines to send out an order; this order runs along the nerves to the limb which is bidden to act, and, at last, the limb begins movement. All this takes place in three times, of quite an appreciable duration.

In the human body, this time lost is a mere trifle, some hundredths of a second; but let us suppose one of a great cetacea, a whale, for instance, in which the telegraphic net-work of the will controls a wider range. A boat attacks it in the rear, the harpoon strikes the monster's tail. Then the pain sets out on its course to demand revenge; but the journey is long—it must travel over 90 feet before reaching the headquarters of the will. Here is one second lost. What takes place then? How much time does reflection need? That depends on circumstances; but it is certain that the will does require a measurable time to make a decision. Then it acts; the order is sent out to the tail to thrash the boat to bits. Another second elapses before the message reaches its destination: total, two seconds gone, during which the boat and sailors get off clear by vigorous rowing.

It will be asked, How have philosophers succeeded in measuring the rapidity of the onward movement of nervous stimulus? Several methods of calculating it have been devised. A doctor of the middle ages, cited by Haller, gave some thought to it long ago. He conceived—a singular notion—that the speed of the nervous fluid might be deduced from that of the blood in the aorta; these two rates, he fancied, must be in the inverse ratio of the sizes of the aorta and the nerve-tubes. That calculation assigned, as the speed of the nervous fluid, 600,000,000,000 of yards a minute—600 times the rapidity of the motion of light.

Haller himself undertook the task in a different way. Reading the "Æneid" aloud, he counted the number of letters he could pronounce in a minute with a very rapid utterance. He found 1,500 the extreme limit, or one fifteen-hundredth part of a minute for each letter. Now the letter *r* requires, Haller says, ten successive contractions of the muscle that gives the tongue vibration, and from that, he adds, we may conclude that in one minute this muscle can contract and relax 15,000 times, which represents 30,000 simple motions. The distance from the brain to the muscle in question is a little over three inches. If the nervous fluid travels it 30,000 times, that makes more than 9,000 feet, and 9,000 feet a minute represents a speed of 154 feet in a second. This reasoning is a mere sequence of mistakes, and the approximation to the right view that Haller gained is the more astonishing because his method was not in the least likely to ascertain it. The "Æneid" justifies, in this instance, its ancient pretensions as a book of oracles.

Not until 1850 were these researches resumed by a new method that led to the solution of the problem. It is due to Helmholtz, the most famous of the German physiologists, who unites, to rare talent as an observer, the profound learning of a consummate mathematician. His first method is founded on the use of the chronoscope of Pouillet. A galvanic current of very brief duration acts at a distance on a magnetized needle, and swings it away from the normal position; the range of the deviation is measured, and the length of the current deduced thence by calculation. A means is thus gained for measuring intervals of time not exceeding a few thousandths of a second. Helmholtz applied this method in the following way: One of the muscles of a frog's leg is fixed at one extremity in a nip, and attached at the other extremity to a little lever forming part of a galvanic circuit. A weight, hung on this lever, serves to give the muscle the required tension. Every thing is so arranged that, at the instant the current is closed, a shock is produced either directly in the muscle, or in a given point of a nerve which is isolated for a length of about an inch, and still adheres by one end to the muscle which it is to stimulate. Under the influence of this excitement, the muscle contracts, stirs the lever, and breaks the electric circuit in which it was a part. The duration of circulation of the current is indicated by the magnetized needle. It is found, then, that contraction occurs later when the nerve is excited than when the muscle is excited directly; the difference discloses the speed of transmission of the nervous agent, which is found equal to very nearly 80 feet a second. Helmholtz has ascertained, moreover, that, in every case, contraction follows the electric shock only after an interval of time equal to $\frac{1}{100}$ of a second, which he calls the time of latent stimulus. The muscular fibres do not, therefore, instantly obey the spur of electricity. Thus the waters of the sea rise under the influence of lunar attraction only after the planet is long past the meridian.

After these beautiful experiments, which revealed for the first time the knowledge of the way in which a stimulus is transmitted along the nerves, Helmholtz devised another method, permitting the analysis of the phenomenon in its minutest details. In this, also, the contraction of the muscle lifts a light lever, but the lever carries a point which leaves a white mark on a revolving cylinder covered with lamp-black. A peculiar arrangement causes the same point to mark the instant of production of the stimulus, and, from that instant to the moment of the muscular contraction, the point traces a straight line in the lamp-black. When it is afterward lifted by the tension of the muscle, it draws a curve which at once represents to sight, by its appearance, all the different phases of the movement of contraction. By this method, Helmholtz discovered that the speed of the nerve-current was a fraction over 83 feet. He proved, moreover, that the tension of the muscles gradually increases from the first moment of movement, that it reaches a maximum after about $\frac{5}{100}$ of a second, and diminishes again until the muscle returns to its natural state.

This second instrument of Helmholtz received the name of a myographe. It has been perfected or rather modified by several physiologists. The great difficulty was, to measure precisely the time corresponding to the different points of the tracing drawn by the point on the cylinder. Helmholtz communicated motion to the cylinder of his apparatus by a clock-work arrangement which pointed out to the eye the length of its revolution. For this method, the use of the diapason has been advantageously substituted. Dr. Marey, in his course of medical physiology, employed for this purpose a diapason which made 500 simple vibrations every second; those vibrations noted themselves on the cylinder alongside the curve traced by the extremity of the muscle; it was sufficient to count the number of vibrations inscribed parallel to a part of the tracing by the muscle, to arrive directly at the time corresponding to the tracing. Marey detected, by this method, degrees of speed in transmission varying from 30 to 61 feet.

Moreover, the nerve-current travels more slowly at low temperatures than at high ones. Dr. Munk discovered, besides, that the speed is not alike in the different parts of a nerve; in the motor nerves it seems to increase toward the point of attachment of the muscle. And, according to De Bézold, this speed decreases when the nerve is under the influence of an electric current.

The point was now to repeat these experiments on the human subject. It was found possible to conduct them in this manner: An electric current produces a slight sensation of pain on one point in the skin; the instant of action by the current is marked on the revolving cylinder of a chronoscope. As soon as the person experimented on feels the shock, he gives a signal by touching an electric key, and a second mark is produced on the same cylinder. Measuring the interval comprised between these two marks, we have the time that elapses between the two signals. This time, which is from one to two-tenths of a second, is made up of several parts; transmission of external impression to the brain, perception, reflection, transmission of the will to the fingers, muscular contraction, which is the result; but, if the stimulus is applied successively to different points on the skin, these delays are always the same, except that which is due to the transmission of sensations. If, for instance, a point on the great-toe is first excited, and afterward a point in the inguinal region, the difference in the delays remarked will represent the time employed by sensation in ascending from the foot to the middle of the body.

These experiments were first made in 1861 by Hirsch, director of the Neufchâtel Observatory, by means of an apparatus which it would take too long to describe here. The person experimented on touched an electric key with the right hand at the instant of feeling that slight pain, not unlike a pin-prick, which the knob of an induction apparatus produces on touching the skin. The knob was applied in succession to the cheek, then to the left hand, then last to the left foot. The time lost in the transmission of this stimulus from the point touched to the right hand was found equal, in the three cases respectively, to $\frac{11}{100}$, $\frac{14}{100}$, and $\frac{17}{100}$ of a second; it required, therefore, $\frac{3}{100}$ of a second for sensation to arrive from the left hand at the head, and $\frac{6}{100}$ for its passage from the foot to the head. Hirsch inferred from this that the nerve-current travels over a distance of six feet and a fraction in $\frac{6}{100}$ of a second, or about 104 feet in a second. Dr. Schelske repeated these experiments in a more thorough way at the Utrecht Observatory. He arrived at 91 feet as the speed of transmission of sensation in the human body. The same experimenter proved that the passage takes place with the same rapidity in the spinal marrow as in the nerves. This result is the more remarkable, as the nerve-tubes undergo great changes at their entrance into the spinal marrow, where, according to Van Deen, they cease to be sensitive to the action of electricity, of chemical substances, mechanical injuries, etc.

It follows, from all these experiments, that the nerve-current makes its way with a speed that is relatively inconsiderable. The hand in thowing a stone parts the air with the quickness of nearly 68 feet a second, which is quite comparable with that of the nervous fluid; and the race-horse, the hare, and the leveret, move quite as rapidly. The arterial wave, which passes through $27\frac{3}{4}$ feet in a second, moves only three times more slowly.

When the sensation transmitted to the spinal marrow occasions a reflex action, that is, an involuntary movement determined by the intervention of the ganglionic cells, the reflex motion always proceeds more slowly than that produced by the direct action of the exciting current on the muscles; the retarding varies from a thirtieth to a tenth of a second. It may be inferred from this that reflex action in the spinal marrow takes twelve times longer than the transmission of a stimulus through nerves of sensation or motion.

The time employed in the brain's operations is also some tenths of a second. Dr. Jaeger measured it in the following way: The subject of the experiment was made to touch the electric key with the left hand as soon as he received an electric shock on the right side, and with the right hand when the shock came from the left side. The interval between the shock and the signal was found to be $\frac{20}{100}$ of a second when the person knew beforehand, which side the shock would come from, and $\frac{27}{100}$ when he was not forewarned; thus $\frac{7}{100}$ of a second were used in reflection. Hirsch found that at least two-tenths of a second elapse before an observer marks by signal the preception of a luminous spark or a sudden sound. In other experiments it was arranged that the observer should touch the key with the left hand for a white spark, and with the right for a red one, and he lost, in that case, from three to four-tenths of a second. Therefore reflection took from one to two-tenths of a second. Donders and Jaeger made the experiment a little differently. One pronounced some syllable, which the other repeated as soon as he heard it, while a phonontograph registered the vibrations of the word. When the syllable to be repeated was agreed on beforehand, the delay observed was two-tenths of a second; when not, it was three-tenths.

As we see, then, thought does not spring instantaneously; it is a phenomenon subject to natural laws of time and space. In different observers the time lost is not alike; one perceives, reflects, and acts, more briskly than another; it is a matter of temperament and of accidental circumstance. This explains the differences always remarked between astronomers busied in observing the same phenomenon. Two persons never saw at the same instant the passage of a star across a thread: besides, the difference between the instants noted, or what is termed the "personal equation," of two astronomers, varies more or less according to circumstances, and may increase or diminish with time. The observer's training has a great deal to do with it, Wolf having demonstrated that, by practice, the time lost may be reduced to a minimum, with the employment of a special apparatus.

An important conclusion follows irresistibly from these experiments: it is, that the nerve-fluid is not identical with the electric fluid. Electricity darts through telegraphic wires with inconceivable rapidity, far outspeeding light, and moving 20,000,000 times faster than the nerve-agent. There exists another important difference between these two forces. Any alteration in the structure of the nerves checks the transmission of the nerve-current; crushing or partial burning is enough to interrupt its passage; once cut, they do not regain their conductive power when the separated ends are brought together again. Metallic wires, on the contrary, conduct electricity in spite of all the injuries that may be inflicted on them. Yet the well-known labors of Prof. Dubois-Reymond clearly prove that electricity plays a part of some kind in nervous phenomena. Electric currents exist naturally in nerves, and these currents are influenced and modified by the action of the nerve-currents. It may be admitted, then, that nervous phenomena are the result of a secondary action of electricity, producing certain changes, chemical or otherwise, in the nerve-substance; these manifest themselves only after the lapse of a certain time, during which the action increases in a slow and gradual manner till it becomes sensible, and produces mechanical effects. This side of the question is still enveloped in profound darkness, and we are driven to more or less plausible hypotheses. Still, we can say that a great step has been taken toward the solution of the problem of life: the experiments of which this account is given have thrown light upon its approaches, and placed the question on the ground of exact science. No doubt a long time will pass before the progress of methods of observation shall permit us to make one step nearer to the goal, and nothing authorizes the belief that we can ever fully reach it; but we may take pride in what has already been done, since the exactness of the results gained surpasses all expectation.—*Revue des Deux Mondes.*

ASTRONOMICAL AND PHYSICAL OBSERVATORIES.

IT has been said that "dirt is but matter out of place," and we may likewise take for an axiom that error is force misapplied. It cannot be complained that the age in which we live is one which demands the most careful economy of our forces of all kinds, nor are we intellectually in the position which geologists are fond of predicting for the material world—"nearly out of our store of force." But it were wisdom in us to husband the forces we have, that we may hand down to our successors a thoroughly well-ordered system in all things. And in nothing should we be so careful and scrupulous as in our schemes of education, which affect, in a very direct way, the judgment of the generation which follows us.

Sooner or later there is created in most American colleges what is thereafter known as its astronomical observatory, and in respect to this portion of the college we are frequently called on to lament over some glaring instances of wasted force—force misapplied. One of the forms of these prevalent errors is a mania for "instruments of the largest size," which are not unfrequently bought at large cost, and used perhaps a dozen times a year to allow the senior class, and perchance a few ladies, to view such objects as Jupiter, Saturn, the moon, *perhaps* a double star, and, more unlikely yet, a nebula. Its kindred error is an immense and vague desire for the multiplication of apparatus, so that one walks amid a labyrinth of chronographs, transits, meridian circles, and equatorials, upon each of which the rust of long inaction lies. We must remember that each of these instruments represents a large outlay of money, and also an expenditure of faith in the giver of them. It is bad enough to allow so much mere capital to lie idle, but it is worse not to return to the benefactor of a college something which may be the sign of a good investment, something which shall encourage him and others to believe that their gifts are doing real, practical educational good. It is here intended to speak only of the college observatory as a *means of education*, and a distinct difference is made between the ordinary institution of this kind, and the working observatories of such colleges as Dartmouth, Harvard, the University of Michigan, and others.

It is taken for granted that the ordinarily-constituted observatory is for the purpose of teaching certain specific things and certain important methods to the average class of college pupils, and it will be the endeavor of this paper to point out a remedy for some of the abuses that undoubtedly exist in this respect.

Most certainly there are but few subjects which have a greater educational value than Astronomy. As a continuation of the most advanced mathematical course, Theoretical Astronomy is of immense importance and of endless extent. The effect of its study upon the mind is of a much higher order, most of us will agree nowadays, whatever Pythagoras might have said, than the study of even the most abstract relations of number and space. It is supplementary to these last-named subjects, which are, so to say, its raw material, which it elaborates into more complex and higher forms. But let us remember, it is the boast of Theoretical Astronomy that it is *purely* a science of the closet, dependent upon observation only for its data. Its greatest master, Laplace, thus speaks in the "Système du Monde:" "Il est très remarquable qu'un Astronome, sans sortir de son observatoire, en comparant seulement ses observations à l'analyse, eût pu déterminer exactement la grandeur et l'aplatissement de la terre, et sa distance au soleil et à la lune, élémens dont la connaissance a été le fruit de longs et sensibles voyages dans les deux hémisphères,"[1] etc. (6me édition, p. 232).

It is evidently not the purpose of Theoretical Astronomy, then, to train faculties other than those employed in the higher mathematical investigations, and for this purpose no observatory is strictly necessary. But Physical Astronomy, as usually taught, confines itself to Descriptive Astronomy, and for that study it is undoubtedly necessary that students should have access (and a far freer access than they usually have) to instruments. To supply this want, "instruments of the largest size" have been too frequently supplied, so that it is possible that the student may contemplate the features of the moon, or the components of a coarse double star, through a 15-inch, nay, perhaps, a 20-inch object-glass, when perhaps a 4-inch telescope of Alvan Clark's make would serve the student's and the college's purposes fully. It used to be a saying of a celebrated American astronomer that "the price of telescopes increased directly as the cubes of the diameters of their object-glasses." If no higher ratio be the true one, it is evident that in the case supposed we have force misapplied, or not applied at all. It has become almost a reproach for a college not to own an equatorial of at least eight inches clear aperture; yet only consider how much of the best work of astronomy has been done with less apertures! Sir John Herschel and Sir James South executed a long and very refined series of measures of double stars with a much smaller instrument than the ordinary college equatorial, and much of Struve's best work is recorded as done with "the smaller instruments," and so on. It is not intended to advocate the use of poor instruments, nor specially of small ones, but to point out that the means should be adjusted to the object in view, and that no waste of power should be permitted. Again, Spherical Astronomy is taught in some colleges; and, in considering this branch of the subject, we are touching on its most useful portion. In nothing is a student's habit of accuracy more trained than in astronomical observation. There are minor points to be attended to each moment, and it is not until he ceases to be a pupil that he begins to be thoroughly at ease with even the simplest instrument. He has a running commentary of reasoning to make constantly, which is of the greatest value to him. He must constantly ask himself, while using his instruments, "If I do this or that, what will happen, and why?" Now, it is presumably to forward this

[1] It is a very noteworthy fact that an astronomer, without quitting his observatory, but by merely submitting his observations to analysis, could have determined exactly the dimensions of the earth, its oblate form, and its distance from sun and moon—data which have been obtained as the fruit of long and arduous voyages in both hemispheres.

branch of Astronomy—Spherical Astronomy—that the college observatory was founded, and, if it does this in the right way, it is of great value. To do this properly, requires but a small outlay. A small equatorial of, say, four inches aperture, with circles divided to one minute, will serve to exhibit every thing of interest to the general observer, and will give a student much more opportunity for work than he can possibly find time to improve. A Pistor & Martin's portable meridian circle, two good clocks or chronometers, and, if one wishes luxury, a chronograph, will fit up a small observatory in the most complete way, and give both student and professor excellent means for observation. All this could easily be bought for the price of one of the unwieldy equatorials which lie idle in so many college-towers.

We must remember, too, that the professor of astronomy in most colleges is a busy individual. I have before me the condensed catalogues of 157 American colleges, with an aggregate number of pupils so great as 34,515, and, on running over the lists of college-officers, I find such entries as the following: "—— ——, Professor of Mechanics, Astronomy, and Engineering:" or "Professor of Mathematics, Astronomy, Physics, and Geology:" or of "Astronomy and Physiology;" or, again, of "Latin, Astronomy, and History of American Literature," and many other similar mixtures.

All this indicates that very little time is given by the average student to any proper study of the subject, and the expensive and ill-considered observatories in the country certainly show that a great deal of money and time is wasted in their construction. The writer of this article is familiar with several of such ill-proportioned sets of apparatus. In one case, the observatory contains a fair equatorial of six inches aperture, mounted on a brick arch let into the walls of its tower a few feet below the floor of the dome, which arch receives every tremor of the adjacent building, which is full of students; also a fine portable transit by Würdemann, *no clock*, and a mean solar chronometer. In another a fine clock is thrown away on a zenith telescope, which is used only as a transit, and so on.

The moral would seem to be to have few instruments, to have them of the best possible workmanship for their size, and to have no one so large and expensive as to prevent the purchase of others which are necessary.

But it is proposed further to give a few reasons why, as a means of education, the astronomical observatory might well, in ordinary cases, be superseded by the physical observatory, or at least why in most cases it would be better to divert some of the funds, which would otherwise be spent on little-used apparatus, to establishing a physical observatory, on a modest basis.

And first let us remember that, to properly educate, we must not only give knowledge, but also the power to acquire knowledge; that, although facts are of great importance, the mental grasp which will connect isolated facts is much more valuable. Viewed in this light, the study of astronomy will be readily seen to be less efficient for training the mind than the study of physics. Physics, indeed, includes astronomy as one of its parts, but, as the termph ysics is com monly used, it denotes the science of the changes and conditions of terrestrial matter, and peculiarly of the laws relating to the various emanations of celestial bodies, heat, light, etc. The subjects here referred to are such that their study requires in the very highest degree just those faculties which it is the province of modern education to train. Physics, too, is eminently a practical science; it gives the *rationale* of what we see all around us, and is, so to say, of progressive difficulty. Its elements may be taught to the young lad, and he may go on for his life in their development. Every special method which is useful educationally, that we have referred to in astronomical study, has its analogue here.

Thermo-dynamics and optics certainly present as wide fields for pure analysis as even celestial mechanics. In the cultivation of the powers of observation, the study of physics stands preëminent; and in the physical laboratory the student has an immense advantage, for in many cases it is within his power to produce by experiment, and on a small scale and under favorable conditions, the same appearances that he observes in Nature. There is thus opened to the mind a vast field for that "scientific use of the imagination" which is so important an element in culture.

Perhaps it is more than time that the exact nature of a physical laboratory or observatory should be explained, and we are fortunate in having a succinct account of its main purpose from the hand of Prof. Henry, of the Smithsonian Institution.

Prof. Henry says (Report, 1870, p. 141) the principal object of a physical observatory is, "to investigate the nature and changes of the constitution of the heavenly bodies; to study the various emanations from these, in comparison with the results of experiments, and to record and investigate the different phenomena which are included under the name of terrestrial physics."

The study of the nature and constitution of the sun, by means of photographs, by experiments on its heat, by the spectroscope, and the comparison of these results with similar observations of the stars, is also pointed out by Prof. Henry, as among the legitimate and necessary works of such an institution as he describes. Climatology, meteorology, magnetics, and electrics, equally belong to its scope.

To completely equip such an observatory as we imagine, would require a great outlay, but, considered only in its relation to a college, an equipment becomes much more simple and less expensive. The apparatus required is simple in its nature, and but few of the single instruments are of great cost, and the true policy of a college would be to allow its laboratory to grow slowly with it, enlarging its scope as occasion demanded. In such an observatory the student would acquire every habit of nice adjustment, delicate manipulation, accurate judgment, which would be acquired in the best astronomical observatory, and the field for the mathematical discussion of his results is simply limitless.

In another aspect, too, does the foundation of such observatories hold out important promises. It must be remembered that many of our physical constants rest unfortunately upon too uncertain a basis. The velocity of electricity and the density of the earth are examples. We have to look, then, to scientific men for the establishment of these and other facts as they truly are, and besides, for the discovery of the vast number of unknown physical laws, some of which we must believe are entirely within our reach, and but waiting continued effort to declare themselves. The laws of terrestrial magnetism, the connection of the aurora borealis with other appearances, and like subjects, seem upon the point of being elucidated. It must be remembered, too, that one astronomical observatory can do the routine work for an entire country, and that, once done, it is done forever, and that any repetition of it, however useful it may be to the person making it, is yet of no original value in the world. But the vast number of unclassified facts in the domain of physics, and the almost infinite variety of its unknown laws, will supply ample work for many more physical observatories than could possibly be established. It seems decidedly to the advantage of the student and of the college that each should have the benefit of a well-appointed physical observatory, and it is certain that the class of American gentlemen who found and sustain departments of this kind in our colleges (and it is a very large class, to our honor be it said), will find, in the establishment of such an observatory as we have advocated, the pleasure which comes from effort wisely made. They will see (as they have a most undoubted right to expect to see) the immediate usefulness and benefit of their gift, and can hardly fail to have aided in the discovery of some one of the many laws of physics which lie so close to us, almost demanding discovery.

The wisest plan for the foundation of such an observatory may be found in the form of a letter in the Smithsonian Report for 1870, already referred to, and it is as an introduction to that letter that the present paper may claim to have any value.

EDITOR'S TABLE.

OBSERVATION IN EDUCATION.

AN excellent article in the *Tribune* urges the need of more and better-educated observers to carry on the work of science. Prof. Agassiz is quoted as urging the establishment, in San Francisco, of a college for the training of skilled scientific observers. It is stated that the Signal-Service Bureau is engaged in training a large number of students in the use of instruments of observation, with a view to taking charge of signal-stations for the promotion of meteorological science. We publish an able and interesting paper on the claims of physical laboratories, in connection with institutions of learning, which shall afford the necessary opportunity of training in physical observation. Of the importance of this work the writer in the *Tribune* observes: "We think the day is coming when it will be generally recognized that careful scientific observation is the most valuable labor performed in the world." And regarding its delicacy and difficulty, he further observes:

> "Of the nicety of observation which science requires, it is difficult to convey to the uninitiated any idea. A man who has never before looked through a telescope would not probably be able to see Biela's comet, upon whose vagaries hang so much speculation, if he gazed through any of the instruments by which the observations on it have been obtained. The best microscopists, in approaching the more difficult class of investigations, prepare their physical systems by fasting and rest, so that even their skilled eyesight may give a purer service. Already men are training themselves in certain specialties of observation, with reference to the few minutes of work they expect to perform, two years hence, at the transit of Venus."

Now all this is most true. Excepting that higher intellectual work by which, from the facts of observation, laws are arrived at, so that general principles can be substituted for ever-accumulating details, there is no labor performed in the world so valuable as that of careful scientific observation, and it is also true that its difficulty equals its importance.

But there is a vital consideration connected with the subject, which the writer seems to have overlooked: it is that the capacity of educated observation is just as necessary for people generally as for men of science. Facts bear the same relation to principles, in common life, that they do in the higher departments of technical science. The question is, at last, simply one of evidence: what is fact, and what is not fact? Imperfect observations vitiate reasoning, and lead to erroneous conclusions in the workshop, on the farm, in the counting-room, the church, and the legislative hall, just as much as in the laboratory or the observatory. The objects are different; the mental procedure is the same. But that which is a universal necessity should be provided for by universal means, and systematic training in observation should therefore be a recognized part of our common education. Even for purposes of the higher science, this truth is not to be neglected; for you can no more make first-class observers out of young men who first take up the business in college, than you can make first-class musicians by beginning with adults. Skill in doing the most important work in the world is not to be so cheaply and readily acquired. For the sake of science itself, training in observation should begin in childhood, and become an early mental habit. There are native aptitudes here as in all other departments of intellectual exertion; and only by beginning with the young can we find those whose natural bent is in this direction, and who, by early preparation and life-long discipline in this difficult field, can reach that standard of perfection which science now requires, and which it will continue more and more to exact. But when we take the larger view of the value of observational training, which regards it as nothing less than bringing the general mind into right relations with Nature, art, man, and all the objects and interests around us, of which we are compelled to form judgments, the claims of special science are at once subordinated to the grander requirements of humanity. Or perhaps it would be more correct to say that science is itself to be so widened and enlarged as to take control of this fundamental work of education. Until scientific education recognizes this as its first and great task, it will assuredly fall short of its highest duty.

DEATH OF MR. GREELEY.

One of the greatest personalities of our country has just passed away. We have little to add to the strain of eulogy that has been heard in all parts of the land, concerning the life and character of the late Mr. Greeley. That he has filled a large space in public attention for the past generation, is of little moment; that he has exerted an extensive influence for good upon the American people during that long period, entitles his name to be written high in the rolls of public honor. He is to be gratefully remembered, not because of his large capacities and extensive influence, but because he used his powers in the best service of his fellowmen. He ever worked in the direction of social amelioration and public improvement. Believing in the power of ideas, the value of knowledge, and the vital need of general education, and that the progress of society is an internal constructive work of its citizens, depending upon virtue, industry, and intelligence, he established a journal dedicated to these objects, and developed it into a great and powerful institution for moulding the public mind, and elevating the public character. For thousands of families scattered all over this land, the newspaper founded by Mr. Greeley has played the part of a people's university—arousing and stimulating multitudes of the young to enter upon the work of self-improvement, or to seek instruction in academies, high-schools, or colleges. Of all this it is superfluous to speak, as its living witnesses may be everywhere met, while the public press has done full justice to the magnitude and salutary influence of Mr. Greeley's work. But, there is one point in regard to his mental character upon which a few words may not be here out of place. Mr. Greeley made the most of his opportunities of self-education. He read widely in critical literature, and attained a mastership of his own language which but few of the largest opportunities of culture have equalled. It has been customary, with many, to lament that Mr. Greeley was without the advantages of a regular collegiate course of study. But he was never much troubled by this alleged deficiency. He saw too much of the influence of our colleges in turning out waste acquisitions, unavailable faculty, and capacities unadapted to the times, to regret very deeply that he had not been exposed to the same peril. This has been often attributed to the ignorant egotism of the self-made man, but, we think, very erroneously; for Mr. Greeley did have his profound regrets at his own mental shortcomings and defective culture. He deplored the circumstances of his early life, which gave him no chance to acquire the rudiments of science. We have often heard him express deep and painful regret that there was no one to guide his childhood in the direction of observing and studying the familiar phenomena of Nature. He keenly felt that his life had been made less enjoyable to himself and less valuable to the public for want of that early cultivation of the observing powers by natural objects, of which we have just been speaking, as the great defect of our common education. He knew nothing of science, but he never despised it, as is too common with the devotees of literature and politics, who are generally ignorant of it; and he was always strong in his condemnation of our educational system, because of its culpable neglect of scientific studies. He was emphatic in insisting that the study of natural things should be commenced in childhood, so as to maintain a place in after-development, for he saw how difficult it is, when the mind becomes engrossed with other knowledge, to give proper attention to the study of science. Mr. Greeley's love of Nature was a profound and genuine feeling, and his interest in rural affairs was very far from being an affectation. All who are familiar with the course of the *Tribune* in its early days will remember the prominence given to science in its columns—the copious illustrated reports of the lectures of Lardner and Agassiz, and the fulness and ability of its treatment of scientific agriculture. Had it not been for the all-disturbing influence of the antislavery convulsions which distracted the country for twenty years, this early policy of the *Tribune* would undoubtedly have been carried out in a systematic way, and with the most salutary public results. If Mr. Greeley did not understand science, and was therefore unable to assist in its direct development, he, nevertheless, appreciated the noble part it is to play in the world's affairs, and the great service the press can render in promoting it; and, in the card announcing his return to the editorial control of the *Tribune*, he stated that this would be among the great objects to which he proposed to dedicate the remainder of his life. It is to be hoped that the managers of that journal will share in the discernment of its founder, and, as its history is indissolubly linked with the diffusion of ideas among the American people, that they will see to it that its future shall, in this respect, be worthy of its past.

TYNDALL AND FROUDE.

In the same ship came two wise men from the East, at the urgent solicitation of our people, to instruct them by public lectures. But it turns out that there are different kinds of wisdom, and our illustrious teachers represent very diverse sorts of it. Prof. Tyndall accepts, as the problem of his life-study, the universe as it is. By the help of all that has been hitherto revealed concerning the order and harmony of Nature, he engages with the living phenomena of the world as it exists around us, and is accessible to all. To understand the present ongoings of the universe, the course and polity of Nature, and the living laws by what we are all enmeshed, is his supreme and immediate task. Not what men have thought in past times, nor what they may happen to think now, but what can be demonstrated, and what all can actually know to be true, is his great concern. Asking no man to take his bare word, he shows us facts that can be recognized, principles that can be proved, laws that can be verified, truths that can no more be resisted than the physical forces themselves. He speaks to us of the order of Nature in its latest and grandest interpretations, and with such force of proof that his crowded listeners are convinced, and assent to his utterances as one man. Multitudes in our leading cities have heard him with eager attention; but there has not been a ripple of criticism or dissent even sufficient to indicate his presence among us. This results from the quality of the knowledge he imparts, which is science, or knowledge that can be shown to be true. It is felt that so much, at all events, is gained. So far we can all agree.

The question now arises, How far can this platform of solid and irresistible truth be widened? The discovery and organization of this certain knowledge have been the work of the past three centuries, and its further expansion is the great work of the present time. Is it to be equally the task of the future, and is science indefinitely progressive? Is law universal and ascertainable, and are we to go on creating new knowledge of this kind, and reconstructing the older knowledges, until they shall take on the form and character of science? Or, are there limits, and have we reached them? The question, as all must see, is simply one of the extent of the order of natural law, for, wherever there are method and law, there is possibility of science. Prof. Tyndall represents, first of all, our sure ground of knowledge and then its certain and safe extension.

Mr. Froude, on the other hand, represents opposite ideas and modes of thought. He deals with the past rather than the present—with human events in their variable, obscure, and uncertain course, rather than with that side of the world in which law and order can be clearly shown. He represents the debatable and unsettled in human affairs, and that which will be forever debated, and can never be settled. Hence, no sooner does he open his mouth, than dispute arises, and a hubbub of contradiction and contention has followed him whithersoever he has gone. Mr. Froude gives lessons in what he calls "history," but his teachings do not enforce assent. At this we cannot complain, for he himself believes that there is neither law, order, nor science in his chosen field of labor. He belongs to the antiquated, historical school, which was in the ascendant long before science arose, and is contented to delve in the rubbish of the past, with no guiding light from principles that science has disclosed, and which even scouts all possibility of such guidance. Mr. Froude gave a lecture upon this subject before the Royal Institution, in 1864, attacking the views of those who hold that there is such a thing as a science of history and of social polity, which, although still in an indefinite stage, is yet as certain in the future as the progress of knowledge itself. The reader, who will turn to the June number of the MONTHLY, will find a convincing refutation, by Herbert Spencer, of Mr. Froude's position; and, as the subject is just now one of public interest, we reproduce some passages from an able lecture of Mr. John Fiske, of Cambridge, upon the same subject:

"Mr. Froude begins by dogmatically denying that there is or can be such a thing as a science of history. There is something incongruous, he says, in the very connection of the two words. 'It is as if we were to talk of the color of sound, or the longitude of the rule of three.' But he carries on the thought in a way that shows plainly his reluctance to grapple fairly with the problem. In his next sentence he says: 'Where it is so difficult to make out the truth on the commonest disputed facts in matters passing under our very eyes, how can we talk of a science in things long past, which come to us only through books?' Now, to reason like this is merely to shrink from the encounter. For the question is, not whether the science is difficult, but whether it is possible. Mr. Froude sets out to show that there can be no such science, and his first bit of proof is that, if there is such a science, it must be far more difficult than any other; a position which we may contentedly grant. Let us follow him a step further. 'It often seems to me as if history were like a child's box of letters, with which we can spell any word we please. We have only to pick out such letters as we want, arrange them as we like, and say nothing about those which do not suit our purpose.' And what does all this amount to? Is this Mr. Froude's idea of historical investigation? Why, the same thing may be done in any science. We have only to pick out all the facts on one side, and blink all the facts on the other side, to prove the veracity of every oracle, soothsayer, and clairvoyant, that ever existed, the validity of every paltry omen, the credibility of every crazy notion of alchemy or judicial astrology. In this way we may prove that the homœopathist always saves his patient, while the allopathist always kills him; or *vice versa*. And it was in this way that the phrenologists erected their pseudo-science. It is in this way that every charlatanry, as well as every incorrect or inadequate hypothesis in physical or mental science, has arisen and gained temporary recognition. Mr. Froude ought to know that, in history as in every thing else, our only road to a safe conclusion lies through the impartial examination of all relevant facts. Supposing Tycho Brahe had said to his Copernican antagonists: 'Astronomy is like a child's box of letters; if we take out what we want and let the rest go, we can spell whatever we please; I spell out the Ptolemaic theory, and will therefore abide by it;' he would have been talking much after the manner of Mr. Froude. It is true, as Mr. Froude says, that one philosopher believes in progress, a second in retrogression, and a third, like Vico, in ever-recurring cycles. But is this because the facts are undecipherable, or because the investigation is one-sided? Because Prof. Agassiz believes species to be fixed, while the majority of naturalists believe them to be transmutable, are we to infer that there is no science of biology? In such unworthy plight does Mr. Froude retreat before the problem he has encountered. He starts to show us that a science of history is as ridiculous an impossibility as a scarlet B flat or a westerly proportion, and he ends by mildly observing that history is a difficult subject, in which a series of partial examinations may bring forth contradictory conclusions!

"The next bit of inference concerns us more intimately: 'Will a time ever be when the lost secret of the foundation of Rome can be recovered by historic laws? If not, where is our science?' Just where it was before. The science of history has nothing to do with dates, except to take them, so far as they can be determined, from the hands of historical criticism. They are its data, not its conclusions. As Mr. Morley reminds us, we do not dispute the possibility of a science of meteorology, because such a science cannot tell us whether it was a dry day or a wet day at Jericho two thousand years ago. Facts like these show us that sciences dealing with phenomena, which are the products of many and complex factors, cannot hope to attain that minute precision which is attained by sciences dealing with phenomena which are the products of few and simple factors. They show that sociology cannot, like astronomy, be brought under the control of mathematical deduction. But it was not necessary for Mr. Froude to write an essay to prove that.

"But, continues Mr. Froude, 'can you imagine a science which would have *foretold* such movements as' Mohammedanism, or Christianity, or Buddhism? To the question as thus presented, we must answer, certainly not. Neither can any man foretell any such movement as the typhoid fever which six months hence is to strike him down. If the latter case does not prove that there are no physiologic laws, neither does the former prove that there are no laws of history. In both instances the antecedents of the phenomenon are irresistibly working out their results; though, in both cases, they are so complicated that no human skill can accurately anticipate their course. But to a different presentment of Mr. Froude's question we might return a different answer. There is a sense in which movements like Mohammedanism and Buddhism, or Christianity, could not have been predicted, and there is a sense in which they could have been. What could not have been predicted was the peculiar character impressed upon these movements by the gigantic personalities of such men as Mohammed and Omar, Sakyamuni, Jesus, and Paul. What could have been predicted was the general character and direction of the movements. For example, as I shall show in a future lecture, Christianity as a universal religion was not possible until Rome had united in a single commonwealth the progressive nations of the world. And, when Rome had accomplished this task, it might well have been predicted that before long a religion would arise which should substitute monotheism for polytheism, proclaiming the universal fatherhood of God and the universal brotherhood of men. I admit that such a prediction could have been made only by a person familiar with scientific modes of thought not then in existence; but, could such a person have been present to contemplate the phenomena, he might have foreseen such a revolution in its main features, as being an inevitable result of the interaction of Jewish

Hellenic, and Roman ideas. I am inclined to think he might have foreseen that it would arise in Palestine, that its spread would be confined to the area covered by Roman civilization, and that its work would be most thorough in the most thoroughly Romanized regions.

"I would not, however, insist upon this point; nor is it necessary to do so. In none of the concrete sciences is there any thing like thorough and systematic prevision, save in astronomy; and even in astronomy our foresight becomes precarious as soon as we pass beyond the solar system and begin to inquire into the mutual gravitation of the innumerable stellar bodies. We know that our sun is rushing with immense velocity toward the constellation Hercules; but we cannot yet trace his orbit as Kepler traced the orbit of Mars. When we come to biology and psychology, the power of accurate prevision is very small; yet no one denies that the phenomena of life and intelligence conform to fixed and ascertainable laws. In sociology we must expect to find still less ability to predict. The truth is, as Comte acutely pointed out, that while in the simpler sciences our object is gained if we can foretell the course of phenomema so as to be able to regulate our actions by it, in the more complex sciences our object is gained when we have generalized the conditions under which phenomena occur so as to be able to make our volitions count for something in modifying them. We cannot modify astronomic phenomena, but we can predict them. We cannot predict, save to a limited extent, biologic phenomena; but, knowing more and more thoroughly the conditions under which they occur, we can more and more skilfully modify them so as to insure health or overcome disease. And obviously even this limited ability to modify the phenomena implies a certain amount of prevision, enough to justify us in asserting that the phenomena conform to law. The case is similar in sociology. Though we may not be able definitely to predict a given political revolution, we may, nevertheless, understand the general movement of affairs, and the effects which certain kinds of legislation are likely to produce, so as to hasten a desired result or avert social mischief. Upon this possibility are based all our methods of government and of education. And, as in biology, this ability to modify the phenomena proves that the phenomena occur in some fixed order of sequence. For, where there is no definite order of sequence among phenomena, we can neither predict nor modify them; and, where there is a definite order of sequence, there is, or may be, a science.

"Now, in denying that there is or can be a science of history, Mr. Froude, if he means any thing, means that social affairs have no fixed order of sequence, but are the sport of chance. Either Law or Chance—these are the only alternatives, unless we have recourse, like the Mussulman, to Destiny, an illegitimate third idea, made up of the other two, misconceived and mutilated in order to fit together. But for the modern thinker there is no middle course. It is either symmetry or confusion, law or chance, and between the two antagonist conceptions there can be no compromise. If the law of causation is universal, we must accept the theory of law. If it has ever, in any one instance, been violated, we may be excused for taking up with the theory of chance. Now, we know that all the vast bodies in this sidereal universe move on for untold ages in their orbits in strict conformity to law. In conformity to law the solar system in all its complexity has grown out of a homogeneous nebula; and the crust of the cooling earth has condensed into a rigid surface fit for the maintenance of organic life. Out of plastic materials furnished by this surface, and the air and moisture by which it is enveloped, organic life has arisen and been multiplied in countless differing forms, all in accordance with law. Of this aggregate of organic existence, man, the most complex and perfect type, lives and moves and has his being in strict conformity to law. His periods of activity and repose are limited by cosmic rotations. His achievements, physical and mental, are determined by the rate of his nutrition, and by the molecular structure and relative weight of the nervous matter contained in him. His very thoughts must chase each other along definite paths and contiguous channels marked out by the laws of association. Throughout these various phenomena, already generalized for us by astronomers, geologists, biologists, and psychologists, we know that neither at any time nor in any place is law interfered with—that yesterday, to-day, and forever, the effect follows the cause with inevitable and inexorable certainty. And yet we are asked to believe that in one particular corner of the universe, upon the surface of our little planet, in a portion of the organism of one particular creature, there is one special phenomenon, called volition, in which the law of causation ceases to operate, and every thing goes helter-skelter!"

LITERARY NOTICES.

Faraday as a Discoverer: By John Tyndall. New York: D. Appleton & Co., 1868.

Michael Faraday: By Dr. J. H. Gladstone, F. R. S. London: 1872.

Notice sur Michel Faraday, sa Vie et ses Travaux: A. de la Rive. Geneva: 1867.

The name of Faraday has been a familiar one to all of us for many years. As students, it was in our class-books, occurring on page after page, with others nearly as familiar; and it is almost ludicrous to remember the notion we had, as boys, of the men whose works were before us. Their names were the only realities to us; their real existence was a vague concession to authority; the possibility of knowing any thing of their true life and character was too remote to be considered.

Their work was before us, and the hand that did it unknown. Liebig was a myth, Regnault a shadow, the double-headed Dulong et Petit a visionary Cerberus who barked at error. Afterward we began to know more of them as lecturers, or by their portraits, and, to some of us, Herschel, Faraday, Tyndall, are as real as our friends. And how delightful it was, this making friends of our shadowy acquaintances; how grateful we were to Arago for his long series of *éloges* of great men! The curious steel portrait of Laplace prefixed to the French editions of his "Système du Monde" told us much of him, but how much more we knew from Arago's anecdote of this towering genius, who could and did pronounce an opinion on the probable duration of the solar system; how one day he, sitting in his study, was timidly approached by Madame de Laplace, with the request that he might "intrust" to her "the key of the sugar." He, a "peer of France; Grand-officer of the Legion of Honor; one of the forty of the French Academy; of the Academy of Sciences; member of the Bureau of Longitude of France; of the Royal Societies of London and Göttingen; of the Academies of Science of Russia, Denmark, Sweden, Prussia, the Low Countries, Italy," etc., *he* with the "key of the sugar!"

So, we first began to know Faraday as a man, through a steel engraving of him published by the Society for the Diffusion of Useful Knowledge; and the promise in his youthful, tender face we may read fulfilled in the books before us. Prof. Tyndall's book contains two engravings of Faraday, with the fire of his young face subdued to a peaceful light; and, if this volume should pass to a second edition, it would add to its value as an exponent of Faraday's *inner* life, to include in it a copy of one of his early portraits. Its title is "Faraday as a Discoverer," but in spite of its title we cannot but know of the sweetness and light of his character; as if, indeed, it were impossible to conceive of his place as a philosopher, without knowing somewhat of the man.

His "Life and Letters," by Dr. Bence Jones, gives best a conception of his development as a man and as a scientist, for it is shown by his own hand. And yet these tributes of his three friends must be read to understand him; and, in reading these, you cannot fail to be struck with one thing, which is in itself a key to his character.

Dr. Gladstone proposes to treat of his "life and noble character" so as to be appreciated by those who "cannot follow his scientific researches," and yet one gathers from this life his scientific methods and a knowledge of his principal results: De la Rive and Tyndall mean to speak chiefly of his work, and yet they *must* turn aside to tell of his loveliness of disposition. The truth is that, in his life, science was not a thing apart; he lived in it; his house and his laboratory joined, and his thoughts knew no difference as to place.

In reading these books you are not struck with the wonderful facts of his life; that he should be born a smith's son, and die a member of seventy-three scientific bodies; it requires an effort to remember this, for from the first you feel, with De la Rive, that he had that condition which exists but rarely, "*c'est le génie.*" E. S. H.

Quarterly German Magazine. (Berlin, 1872, Carl Habel.) This appears to be intended for English readers, but a slight acquaintance with German will be found of great use for whoever wishes to find out what the writers are driving at. Not having seen the original German of the two papers which make up the second number of this serial, we are not prepared to say whether they contain any thing novel or interesting about the matters they treat of. On the whole, it were better to convey scientific instruction to English-speaking people in the English language.

Proceedings at the Inauguration of the Building for the Departments of Arts and of Science in the University of Pennsylvania; also Special Announcement of the Organization and Course of Study of the New Department of Science, same University.

The Appendix to the "Proceedings" contains two very brief notices of the life and labors of the late John F. Frazer, LL. D., Professor of Natural Philosophy and Chemistry, and editor of the *Journal of the Franklin Institute.* The new Department of Science, established in the university, allows the student to make his choice of a professional training between the following four courses: Chemistry and Mineralogy; Geology and Mining; Civil Engineering; and Mechanical Engineering.

A Popular Treatise on Gems, by Dr. L. Feuchtwanger. New York, 1872. Published by the author, No. 55 Cedar St.

This useful work, now in its fourth edition, is intended as a guide for the teacher of natural science, the lapidary, jeweller, and amateur. It is, in the best sense of the term, a *popular* treatise, explaining the chemical constitution and properties, and the geological character, of all the substances known as gems, in such a manner as to be understood by the untechnical student. The first part, which treats of mineralogy in general, is based on Nichols's "Elements," and treats of the forms, physical and chemical properties, and classification, of minerals. The second part treats of gems in general, their composition and geographical distribution, and describes the various ways of grinding, polishing, and setting them, as also the methods of producing gems artificially. The third and last part is devoted to the consideration of the various species of gems, in the order of their commercial value. The Appendix contains a full chronological list of works on gems, which will be of great service to the student who desires to form an acquaintance with the literature of this branch of mineralogy.

BOOKS RECEIVED.

Annual Report of the Board of Health, to the General Assembly of Louisiana. New Orleans, 1872.

Proceedings of the Agassiz Institute, Sacramento, Cal. With the Constitution and By-Laws. Sacramento, 1872.

Fourth Annual Report of the Secretary of State, of the State of Michigan, relating to the Registry and Return of Births, Marriages, and Deaths. For the Year 1860. Lansing, Mich., 1872.

Popular Address on Organic Reform, delivered before the Illinois State Medical Society, at Rock Island, for the Session of 1872. By A. L. McArthur, M. D. Chicago, 1872.

New Theory of the Origin of Species. By B. G. Ferris. New Haven, 1872.

On a Method of detecting the Phases of Vibration in the Air surrounding a Sounding Body. By Alfred M. Mayer, Ph. D.

MISCELLANY.

Experiments on Sound.—Prof. Mayer, of the Hoboken Technological Institute, N. J., has made some rare and remarkable researches on sound, of which he lately gave an account before the Lyceum of Natural History, New York. The following is a summary of the views he presented: That sound reaches the ear by a series of waves or undulations, is a generally-accepted fact. But, although so accepted, it may well be doubted whether many persons, even among those of considerable general culture, are possessed of a clear view of the nature of these waves. To obtain this, it is necessary to bear in mind that the waves of sound which take place within a gaseous medium are in no wise similar to those waves which undulate on the surface of water or other liquids. The latter form around their point of origin in concentric *circles;* the former are generated around that point in concentric *spheres;* all deviations from these forms being in both cases due to mere special disturbing influences. This conception having been fixed in the mind, it is readily seen that sound-waves consist of alternate swellings (involving a rarefaction) and contractions (involving a condensation) of the air, propagated from the point of origin, and that the thickness (length) of each wave is measured by the distance between the curved surfaces corresponding to the periods of maximum swelling (rarefaction) and contraction (condensation). Within the wave-limits, the progress of sound-motion is by no means uniform; and, could we accurately trace the steps in variation, we could readily delineate the march of sound within the wave.

This result may be obtained approximately by attaching a small piece of copper-foil to one of the prongs of a tuning-fork, and quickly drawing this (while vibrating) across a plate of smoked glass. A very beautiful representation of this march of sound may also be obtained by operating with an organ-pipe, having a hole at the middle (nodal-point), which is covered by a thin elastic membrane, offering no impediment to the transmission of the undulations. Directly over this membrane a little box or capsule is placed, through which a current of illuminating gas is conducted to a jet burning in front of a revolving mirror. The sound-waves being communicated to the gas, give rise to a series of flame-pulsations. When the mirror revolves, the quiet flame is reflected as a continuous, the pulsating flame as a serrated, band of light.

If, at this point of the experiment, the aid of one of Helmholz's resonance-spheres be called in—the resonance-waves being conducted by a pipe through a box and membrane (like those already described), to a second gas-jet placed exactly under the first—the image in the mirror will be duplicated. The resonance-spheres (resonators) here mentioned are thin, hollow, brass globes, with two openings opposite to each other; one being furnished with a neck for attaching a pipe, the other serving as a mouth for receiving sound-impulses. They act by sympathy, as it were, taking up and resounding with a special note, and that only, the special character of the note depending upon the relative capacity of the sphere, and the size of the mouth.

As the waves of sound, propagated through a uniform medium, travel with uniform velocity, it follows that, when the pulsations transmitted to the first jet from the organ-pipe, and the pulsations transmitted to the second jet from the resonance-sphere, pass through equal lengths of air, they will be reflected from the revolving-mirror as coincident serrations. When, however, the pulsations from the organ-pipe are transmitted through a depth of air equal to one wave-thickness or length, and the pulsations from the resonance-sphere are transmitted through a depth, either less or more (and not an exact multiple) than the wave-thickness or length, the two serrated bands of light, reflected from the revolving-mirror, will not be coincident. If, starting with equal distances of the organ-pipe and resonance-sphere from the jets, that of the latter be gradually increased, the serrations of the two images will be at first coincident, then non-coincident; then, when a distance of two wave-thicknesses is reached, again coincident, then again non-coincident; each coincident corresponding to a distance equal to a simple multiple of the wave-length of the note. And if, on the other hand, the resonance-sphere be moved in such a manner that the coincidence of the serrations is not disturbed, it is evident that the motion must be in lines traced upon the curved surface of a body of air—exactly similar in size and form to one, two, three, etc., pulsations sent forth by the organ-pipe. Prof. Mayer was the first to trace the surface of sound-waves by this beautiful and ingenious method. It is highly probable that, by this arrangement, some hitherto unapproachable acoustic problems may meet with a solution.

The velocity of sound is not influenced by variations in the density of a uniform gaseous medium, provided the temperature of this medium remain stationary. But, when the temperature changes, the velocity is at once affected. Hence, a gradual rise in the temperature of the air, passing from the resonance-sphere to the gas-jet, will be productive of a successive alternation of coincidences and non-coincidences of serrated images, analogous to the alternations produced by increase of distance. This remarkable fact Prof. Mayer proposes to employ in measuring temperatures, and particularly the high temperatures of furnaces. This is to be accomplished by interposing a coil of porcelain or other fire-proof pipe between the resonance-sphere and the jet, and introducing it slowly into the furnace. By this method, Prof. Mayer expects to be able to measure temperatures with an accuracy equal to about twenty-five degrees of the Centigrade thermometer, or even less.

A New Species of Rhinoceros.—A writer in *Nature* is disposed to see, in the hairy-eared, two-horned rhinoceros at present in the menagerie of the London Zoological Society, a new species, which he proposes to call *R. casiotis*, the hairy-eared rhinoceros. When this animal arrived in England, it was taken to be the Sumatran rhinoceros, though naturalists were surprised that a Sumatran rhinoceros should be taken so far north as was this specimen—Chittagong, the northern extremity of the Bay of Bengal. There is a fringe of long hairs on the posterior rim of the otherwise naked ears, and the tail is long, and tufted at the extremity. The head is very broad, and the skin comparatively smooth.

Nothing new under the Sun.—Humboldt, in his "Cosmos," states that the Chinese had magnetic carriages with which to guide themselves across the great plains of Tartary, one thousand years before our era, on the principle of the compass. The prototype of the steam-engine has been traced to the eolipyle of Hero of Alexandria. The Romans used movable types to mark their pottery, and indorse their books. Mr. Layard found in Nineveh a magnifying lens of rock-crystal, which Sir D. Brewster considers a true optical lens, and the origin of the microscope. The principle of the stereoscope, invented by Prof. Wheatstone, was known to Euclid, described by Galen fifteen hundred years ago, and more fully in 1599 A. D., in the works of Baptista Porta. The Thames Tunnel, thought such a novelty, was anticipated by that under the Euphrates at Babylon; and the ancient Egyptians had a Suez Canal. Such examples might be indefinitely multiplied, but we turn to photography. M. Jobard, in his "Nouvelles Inventions aux Expositions Universelles," 1857, says a translation from German was discovered in Russia, three hundred years old, which contains a clear explanation of photography. The old alchemists understood the properties of chloride of silver in relation to light, and its photographic action is explained by Fabricius in "De Rebus Metallicis," 1566. The daguerreotype process was anticipated by De la Roche in his "Giphantie," 1760, though it was only the statement of a dreamer.

The Sun as a Borer of Mountains.—1. The universe is filled with rays of heat and light, which vibrate among the heavenly bodies perpetually without loss or gain, and which, on alighting upon a heavenly body, pass first into common sensible heat, to be reflected afterward as cold, invisible rays.

2. Of the inexhaustible supply of these rays, our sun receives at every instant of time as much as he radiates back again.

3. A portion of his rays fall upon our earth, where they are converted into sensible heat.

4. By means of this sensible heat, water is converted into aqueous vapor; the sensible heat being at the same time changed into so-called *latent* heat, or chemical motion.

5. Aqueous vapor having less specific gravity than air, it ascends and represents a lifted weight. In this process, heat is converted into motion—the ascent of the weight.

6. The expansion of the air (during which heat is converted into mass-motion) causes the aqueous vapor to be spread over the surface of the earth.

7. By the condensation of the aqueous vapor, chemical motion escapes as common heat, and the resulting water is deposited on the mountain-heights in the form of snow; thus, again, representing a lifted weight.

8. The warm winds from the Mediterranean melt the snow and glacier-ice; sensible heat is thus converted again into insensible chemical motion.

9. The downward current of the Alpine streams generates motion in virtue of their mass, and of the space passed over during their descent.

10. This mass-motion, when temporarily checked by any resisting object, is converted back into heat.

11. Man arrests a portion of this motion by means of a large water-wheel, and, by the aid of a crank and a connecting-rod, transmits the motion to the piston-rod of an air-compressor.

12. In compressing air, we accumulate motion as a force or tension; and the compressed air yields this force again without loss (exception made of the loss occasioned by the friction of the piston, which reappears as heat).

13. Compressed air — a storehouse of motion—is made to pass into a contrivance similar to the steam-chest of a steam-engine, where a sliding-valve forces the air to enter alternately above and below the piston to which it thus imparts common mass-motion. The process is the same as the one operating in the steam-engine, with the difference that the motor agent is compressed air in place of steam, and that the motion is ultimately obtained, not from the combustion of fuel, but from the descent of water.

14. The mass-motion of the water, now transferred to a drilling-machine, is modified by means of mechanical contrivances in a manner such that powerful blows are dealt in rapid succession upon the cutting-tool which drills the hole; mass-motion is thus converted back into heat.

15. The drill-hole is filled with a mixture of substances containing chemical motion, which, at any time, may be given out as heat and mechanical motion. By the ignition of the mixture, new combinations of substances occur, which, owing to the new distribution of chemical motion, take up a much greater space, and thereby split the rocks.

16. Mont Cenis Tunnel (as will be the future one of St. Gothard) was bored by the sun's heat.—*Mohr, translated by Hotze.*

Cinchona in Bengal.—In 1862 Dr. T. Anderson began the cultivation of cinchona (the tree that yields the Peruvian bark) in Sikkin, Bengal. The venture has proved profitable; and at the present time he has under cultivation cinchona-trees of three species, to the number of 1,707,115, yielding about 300 pounds of bark per acre. Besides these, he has 480,000 young plants in nursery.

Bulb-Culture in Holland.—Although one-fifth of the entire land in the Netherlands is worthless for cultivation, and another fifth is meadow-land, yet 47,500 acres of the remainder are devoted to tobacco, 35,000 to hemp, and 500 acres to raising tulips, hyacinths, and other flowering bulbs. Holland has ever excelled in this sort of horticulture.

Antiseptic Properties of Borax.—A paper by M. Jacquez on the preservative action of borax and the sub-borate of ammonia, on animal matter, read before the French Academy of Sciences, gives an account of some important experiments made by the author during a period of five years, with a view to ascertain the antiseptic properties of the substances named. In June, 1853, he dissolved 25 grammes (about 387 grains) of gelatine in 100 grammes (a little over 3 ozs. of water) with 4.50 grammes—nearly 70 grains—of borax. The mixture remained in an open flask all through the summer, without any sign of mould or putrefaction. In August of the same year, pieces of meat dropped into a solution of borax and water (5 parts of the former to 100 of the latter) were there preserved unchanged for a month—being then taken out of the solution and exposed to the air, they dried slowly, and did not undergo decomposition. The next series of experiments was with a mixture of borax, sub-borate of ammonia, and tepid water, in the proportion of 5 or 6 parts of borax, and 10 or 12 of sub-borate of ammonia, to 100 of rain or pure river water. By injecting this mixture into the bodies of rabbits killed two days previously, the water kept them without sign of decomposition for several months. M. Jacquez is of opinion that this process is of high importance for the dissecting-room, as it does not alter either the coloring or the firmness of the tissues, and at the same time imports no poisonous element into the subject. Futhermore, the edge of cutting-instruments is not at all affected by the presence of the antiseptic. Probably, if 6 per cent. or even 8 per cent. of borax were used with the liquid at about 40° C. at the moment of injection, the *cadaver* itself having been previously kept for some hours in some warm medium, the borate of ammonia might be omitted. Then an adult *cadaver* might be prepared at the trifling expense of two francs. For purposes of embalming, the writer recommends a concentrated solution of both salts, injected two or three times into the blood-vessels at intervals of a few days. Pulverized borax would also be of service in preserving the skins of stuffed animals and birds; and the solution might be used instead of alcohol in cases where the latter is now employed to preserve specimens.

Disintegration of Tin.—Two cases of the disintegration of tin are given in the *American Artisan*, the phenomenon being in the one case traceable to the action of intense cold and long-continued vibration, while in the other the cause of the disintegration is unknown. A certain quantity of tin in ingots was shipped from Rotterdam to Moscow by rail during extremely cold weather. On reaching its destination it was found to have been reduced to a powder, with coarse crystalline grains. When fused, instead of forming a solid mass, it gave only oxide of tin, a gray powder. The second case was that of two pigs of "Banca tin," purchased by the United States Ordnance Bureau. They had lain in store for several years; and, when at length they were taken from their resting-place, one was found almost entirely reduced to a gray powder, while the process of disintegration in the other was as yet confined to the edges. Dr. I. Walz, who communicates to the *Artisan* this piece of information, tried in vain to learn the previous history of these two pigs of tin. It is his belief that the instances here recorded are the only ones known of tin assuming a granular condition.

A Squirrel-Pest.—In some parts of Arkansas the squirrels were so numerous the past season that they destroyed entire fields of corn. As many as 125 have been killed by one person in a day.

Welding Copper.—According to the *Journal of the Franklin Institute*, Mr. Rust has succeeded in perfecting a method by which he accomplishes a perfect welding of copper. He mixes together 358 parts of phosphate of soda and 124 parts of boracic acid. This powder is applied when the metal is at a low red heat; it is then brought to a cherry-red, and at once hammered with a wooden hammer.

Effect of Atmospheric Pressure.—Mr. Paul Best, in a very interesting memoir, shows that the destruction of life by diminished barometric pressure is chiefly to be attributed to deficiency of oxygen. An animal that will die with the pressure reduced to 18 centimetres (7 inches) of mercury, will endure a reduction to 6 centimetres (2.4 inches) if an additional supply of oxygen be furnished. And the converse is also true, that the danger of too great pressure is from the increased amount of oxygen in a given volume of air inhaled.

Relations of Local Diseases to the Nature of the Soil.—Dr. Moffat read before the British Association a paper on the above subject, in which he shows that the nature of the soil exercises considerable influence on the character of endemic disease. His district lies on the carboniferous and red, or Cheshire, sandstone formation. Anæmia is the prevailing condition of the inhabitants of the carboniferous land, who are both miners and farmers, while it is almost unknown on the red sandstone. Consumption is also more prevalent in the first-named district. Since anæmia is a want of iron in the blood, Dr. Moffat examined the constitution of wheat grown on the Cheshire sandstone, and found it produced much more ash, and hence a larger proportion of mineral constituents, including oxide of iron, than that grown on the carboniferous soil. He estimates that a pound of wheat from the first furnishes five grains more of oxide of iron to the consumer than a pound of wheat from the second soil, which accounts for the comparative poverty of the blood of the miners in iron and phosphoric acid. An examination of the blood of the animals kept in the two districts confirme the above observations.

Sensitive Streams.—Prof. Edwin J. Houston, while spending a summer's vacation in Pike County, Pa., had the good fortune to discover the sensitiveness of water to sound-waves. Among the many beautiful water-falls of that section he found one scantily supplied with water, which dripped in small streams from the ends of the moss covering the rocks of the precipice; the air being still and the stream free from ventral segments. And it was found that, on sounding a shrill *falsetto* note, the streams would instantly respond, and change the grouping of the drops and the position of the ventral segments. A heavy rain, however, flooded the stream, and prevented further investigation.

Vegetable Caprice.—It would almost seem that too much can be asserted as to the uniformity of habitat, or natural location, of a given species of plant. The Bunch-flower (*Melanthium Virginicum*) has been set down as invariably occupying moist meadows and damp borders. A correspondent of the Torrey Botanical Club reports seeing, "when crossing the Alleghanies by carriage-road to the Peaks of Otter, and frequent, high and dry, on the rocks, tall and stout *Melanthium Virginicum*," and adds: "I was unprepared for that, as with us it grows along the margins of marshes, as at Bergen, N. J."

The Tails of Comets.—Prof. Zöllner, in his book "On the Nature of Comets," accounts for some of the phenomena by showing that water, mercury, and many other substances, even in the solid state, always give off vapor; hence, a mass of matter in space will ultimately surround itself with its own vapor, and present the appearance of a comet. It is quite probable that some of the masses moving in space may be fluid, in which case, on approaching the sun, the development of vapor would be very rapid, as is well exemplified by some of the smaller comets. And, as regards the swift growth of the tail, Prof. Zöllner demonstrates that if the free electricity of the sun be not greater in amount than that observed at the surface of the earth, it would be sufficient to communicate an impulse which, as exemplified by the comet of 1680, would produce a train or tail 60,000,000 miles long in two days. Having proved this mathematically, he does not think it necessary to seek further for a theory of repulsive force by which to account for the tails of comets.—*Chambers's Journal.*

Phosphoric Acid.—The occurrence of phosphorus in combination with the ores of iron has long been an annoyance to iron-manufacturers, and many rich ores are worthless from the presence of phosphorus, which makes the iron brittle and useless. Julius Jacobi proposes a method of freeing iron-ores from phosphorus, and at the same time saving the phosphoric products for agricultural purposes. His process consists in roasting the ore and crushing it, and, after placing it in a proper receiver, submitting it to the action of water charged with sulphurous acid under pressure. The ore is then washed with water to remove all the soluble products, and the phosphoric acid precipitated from the water with fresh-burnt lime is obtained as a neutral phosphate of lime. If effectual, and not too expensive, the proposed method is very important, as rendering many ores available which are now regarded as worthless, and at the same time supplying a demand in agriculture which has heretofore been but imperfectly met.

The Osage Orange.—The *Maclura aurantica*, a familiar shrub from its general use as a hedge-plant, it is now proposed to utilize for other purposes. A decoction of the wood is said to yield a beautiful and very permanent yellow dye. This decoction, carefully evaporated, forms a bright-yellow extract, called *aurantine*, which may be used in imparting its color to fabrics. In addition to this coloring-matter, the wood of the Osage orange is rich in tannin. Experiments made in Texas represent that hides are tanned quicker with the wood of this tree than with oak-bark. The seeds yield a bland, limpid oil, resembling olive-oil, and which may, in general use, be substituted for it.

Test for Silk Goods.—In the present methods of silk manufacture the amount of adulteration to which the fabric is subjected is enormous. Although linen is often used, the favorite adulterator is jute, which is cheaper, is heavy, and so easily takes the dye, and in other ways is made to simulate the silk, that it is the more difficult of detection by an unpracticed eye. If a sample of the "goods suspected to contain other kinds of fibre be treated with hydrochloric acid of 1.13 specific gravity, the silk will be dissolved, while other kinds of fibres, such as jute and linen, will remain undissolved."

Opium-poppy in France.—The cultivation of the opium-poppy in France is steadily increasing. It now occupies 50,000 acres, of the value of 4,500,000 francs, yielding opium to the value of 2,000,000 francs a year. Different samples of opium, raised in various parts of Europe, are said to have yielded from 8 to 13 per cent. of morphine.

NOTES.

The Volcano of Santorin, when last visited, in October, 1871, had ceased giving the small eruptions which had been common almost without intermission since the great eruption of 1866, and the summit of the crater, covered with great blocks of lava, presented the same appearance as in 1707. A little steam was still escaping, but this seemed due almost entirely to the vapor of water condensing on the cinders covering the cone. In the north the fumerolles were still active, and all around the stones were covered with sulphur. At the southeast point the volcanic activity had not completely ceased, but had greatly diminished. All this would show that the eruption had entered on its last stage, and after a period of great central activity in 1866–'67, accompanied by a diminution of activity in 1869–'70, it is now again assuming a condition of rest and quietude.—*Nature.*

Colonel Weitzel, of the Brussels Congress, tells of a village on piles, still inhabited, on the island of Noessa Kimbaugan, off the south coast of Java. Its inhabitants live by fishing. On being asked by Colonel Weitzel why the village was built out into the water, one of the inhabitants said that it was in order to be secure against the attacks of tigers.

English Sparrows in Australia.—Complaints are received by the Royal Horticultural Society that fruit-crops in Australia have been seriously injured by the English sparrows imported into that country.

The dolmens, or cromlechs, of Algeria, was the subject of an address by General Faidherbe before the Brussels International Congress. He considers the cromlech to be a monument indicating a place of interment, and thinks it has no other purpose. According to him, the area in which cromlechs are to be found extends from Pomerania to Africa. That none exist in Belgium he accounts for by the great density of the population, the cromlechs having been there cleared away.

We take from the *Journal of the Franklin Institute* the following facts in microscopic photography, contributed by L. Erckmann: Thin sections of plant preparations laid overnight in aniline red solution came out thoroughly colored. When washed in water, the nitrogenous parts retain the red, the non-nitrogenous giving it up. But, if the solution is too concentrated, the image, seen through the microscope, will be red throughout. As the red rays have but little action upon silver iodide, a positive print will show very dark in the nitrogenous, and lighter in the other portions.

In Great Britain and Ireland there are about 30,000 coal-mines, yielding 120,000,000 tons per annum. The depths from which this coal is raised vary widely—the deepest workings being the Dunkinfield and the Rosebridge collieries, near Wigan. The depth of the latter is 2,418 feet, and the average temperature 95° Fahr.

We have in the *Gardener's Chronicle* a remarkable instance of the luminosity of fungi. The spawn of some unknown species of fungus, growing on a trunk of spruce or larch, was found to give a perfect blaze of white light along the track where the trunk had been dragged. The light was enough to read the face of a watch, and it continued for three days.

Attention has lately been directed to a new method for printing on cloth, the invention of Mr. E. Vial. The fabric to be printed is first impregnated with a solution of nitrate of silver, or other metallic salt, which, when brought in contact with zinc or copper, will be reduced to the metallic state. The patterns are designed on zinc or copper, and, wherever contact is made between the metal plate and the cloth, a metallic precipitate is firmly fixed upon the tissue. If nitrate of silver is used, the color of the precipitate, and therefore of the cloth, may be varied by varying the strength of the solution, from a brilliant gray to a deep black. The color withstands acids, alkalies, or soaps.

The sewage of Tunstall, in Staffordshire, England, is to be converted into cement by precipitation, by the process of Major-General Scott. This system is already in operation in Birmingham, West Ham, and Ealing.

THE

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FEBRUARY, 1873.

THE LAW OF STORMS DEVELOPED.

By PROFESSOR THOMPSON B. MAURY,

OF THE SIGNAL-OFFICE, WASHINGTON.

METEOROLOGISTS tell us that their science is as old as Aristotle. If we should judge by its progress up to the middle of the present century, its antiquity furnishes little to boast of; for, in the long lapse of centuries, it must have proved an incorrigibly dull scholar. Within the past few years, however, it has greatly improved, and, especially since it became identified with the popular and important systems of storm-warnings and weather-forecasts, it has been rapidly developed. This is peculiarly the case in America, and it is not wonderful, when we consider the comprehensive observations of our meteorological bureau, and the many beautiful phenomena which its publications disclose.

If Vasco Nunez, the discoverer of the great South Sea, was so awed by the grandeur and expanse of its waters, as seen with the naked eye, how much more may we be impressed as telegraphic meteorology enables us to discover, at a glance, the tossings and undulations of the aërial ocean over the larger part of the hemisphere!

It is to some of the deductions, that may be justly made from the extensive and synchronous observations of the modern weather-systems, as they bear upon those weather-problems, which, from time immemorial, have interested mankind, that we now ask attention.

Until the year 1821, "the law of storms," simple as it is, was unknown to the most profound meteorologists and expert seamen of the world. It was then first discovered and announced by Mr. William C. Redfield, of New York, and established by the labors of that great mind, against the constant perversions and opposition of the scientific empirics of his day. It can be easily comprehended in its great outlines, and as far as our present purposes require. It assumes nothing, supposes nothing; but, from thousands of actual and actually recorded observations, presents the phenomena of spiral currents of air seeking a common centre of depression, and, in the attempt to find that centre, acquiring a vorticose or rotatory motion. The direction of this rotation Mr. Redfield found to be uniformly, in our hemisphere, contrary to that of the hands of a watch, with its face turned upward; and, in the Southern Hemisphere, the rotation is with those hands, or with the sun in its diurnal round. It is easy to see that, if the atmospheric column, resting over any given area of the earth's surface, should, for any cause, be suddenly diminished, or its pressure and intensity be reduced, the gaseous fluid would rush in from all surrounding regions to restore the disturbed equilibrium; and, if the earth was not whirling around on its axis, every particle of the centre-seeking air would endeavor to move on the shortest, or the straight line. It is known, from the principles of mechanics, that this endeavor can never strictly be executed, because the axial rotation of the globe incessantly so acts as to throw every body, while in motion, in our hemisphere, to the *right* of the line on which it is moving, no matter whether that line be from east to west, north to south, or at any conceivable angle with the meridians or the equator. Obeying, in part, this tangential impulse, every particle of wind must take up a resultant motion. If it begins to blow toward the depressed centre of the storm as a north wind, it trends to the west, and is felt as a northeaster; if it begins as a south wind, it diverges as a southwester; if as an east wind, it becomes a southeaster; and, if as a west wind, it soon changes into the boreal northwest wind.

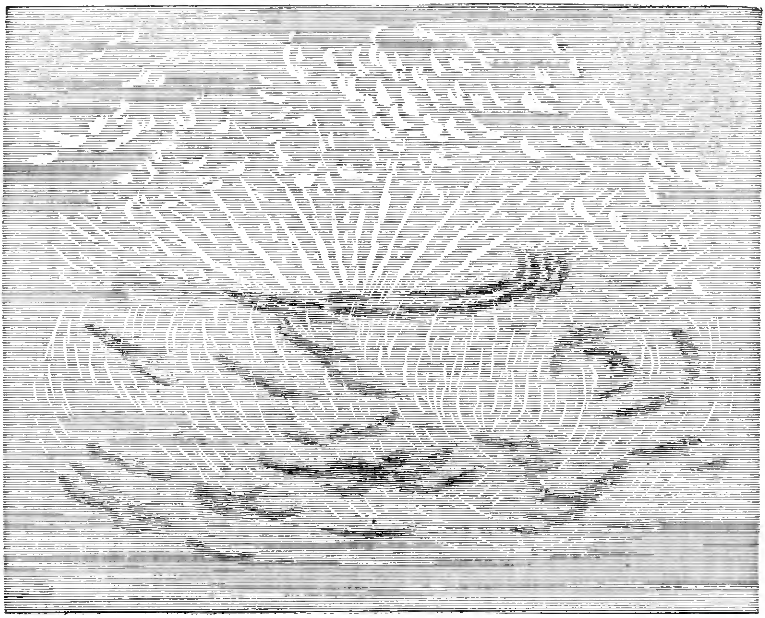
It has often been asked whether the storms of our latitudes attain the immense size formerly attributed to them; and many eminent writers have denied the possibility of their reaching a diameter of more than two or three hundred miles. Mr. J. K. Laughton, in his recently-published "Physical Geography," would have us believe that cyclones "do not attain the enormous magnitudes which have been assigned them." But this opinion rests merely upon conjecture, not yet upon a correct physical theory.

It is a well-known fact that the monsoons generated on the central plateau north of the Himalaya Mountains, and the whole system of Asiatic wet monsoons, may be regarded as an immense and prolonged cyclone; and extend their "backing" influence into the Indian Ocean, and reach far to the south, through more than forty degrees of latitude (a radius of 2,500 geographical miles), and from the 60th to the 140th meridian of east longitude, far out into the Pacific, beyond the Bonin and Ladrone Islands, southeast of Japan. The whole system of wet monsoons may also be justly regarded as a grand cyclone, whose centre is stationary over the heated plains of Central Asia, whose intro-moving winds, bearing the evaporations of the Asiatic seas and oceans, feed it with meteoric fuel for six months in the year, and whose periphery may be regarded as embracing nearly one-third of the entire Eastern Hemisphere. Analogy, therefore, warrants the idea of a great cyclone. But, apart from all this, actual observations in different parts of the globe prove the frequency of storms of enormous magnitude. Thus, in the celebrated Gulf-Stream storm of 1839, as Sir David Brewster long ago pointed out, several stanch merchantmen were foundering off the coast of Georgia, near Savannah, in the very heart of the gale, at the same hour that the winds in its northwest quadrant were taking the roofs off houses in New York and Boston, more than 800 miles distant—clearly revealing a cyclone whose formation was symmetrical, and whose diameter must have been nearly 1,300 miles. But, not to go back to old data, the West-Indian storm of the 18th of August, 1871, before its centre had moved north of Florida, had begun to draw upon the regions of high barometer in the northern States, had exerted its influence as far north as New London, Connecticut, and gave us the northeasterly cyclonic winds in the northwest quadrant of the whirl, on the entire Atlantic coast. The more furious cyclone of the 24th of August, discovered to be then southeast of Florida, and telegraphically foreannounced as likely to endanger the coasts of the Southern States in less than forty-eight hours, appeared on the 26th in full force in Northern Florida, but not until some eight or ten hours after it had set the atmosphere all around it (as far north as Boston) in cyclonic motion, and had caused the storm-cloud to spread itself over the entire region of the United States on the eastern slopes of the Alleghanies, and as far westward as Knoxville, Tennessee. It is no uncommon thing, as Redfield, Espy, Henry, Loomis, and others, long ago showed, for an area of depression on the upper lakes to make itself simultaneously felt as far south as the Gulf of Mexico, and as far east as New England.

If it fell within the scope of the present design in this paper to consider the final cause of storms, it would be easy to show that, unless the law of storms ordained a large area, and a far extended path for the meteor, in some degree commensurate with the area of our immense continent, the meteor could not fulfil its office in the terrestrial economy—an office which, apparently, imposes upon it the task of gathering to its centre, through the agency of its intro-moving winds, the idle and inappreciable moisture scattered over the surface of the earth, condensing it into rain and snow, and diffusing it, in these forms, over immense districts of country.

It is of incalculable importance to observe, and carefully digest the fact, that, when a storm-centre or area of low barometer is once formed, it is the *nucleus* for a vast aggregation and marshalling of meteoric forces. No matter how small at first, under favorable atmospheric conditions, the *courant ascendant* is formed, condensation aloft sets in, and the precipitation only serves to add "fuel to the flames" of the cyclonic engine. This process widens in geographical area, and, after a few hours have elapsed, the storm may so develop as to cover a continent with its portentous canopy of cloud, while simultaneously strewing an ocean with wrecks, and throwing out, in the upper sky, more than a thousand miles in its front, the fine filaments of the premonitory cirrus and cirronus.

Fig. 1.

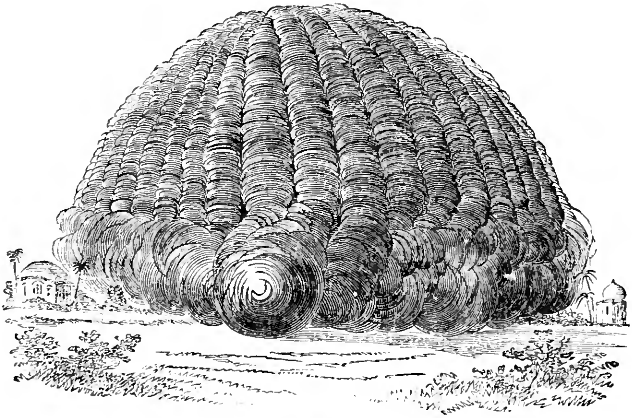


CIRRUS-CIRRONUS CLOUDS.

In close connection with the size and magnitude of cyclones must be considered the distance over which they pass from their initial point. Much has been said on this part of our subject, and not a few writers have accepted the doctrine of Admiral Fitzroy that they progress over but comparatively short distances. For such a view, however, it is impossible to find, either in the nature or physical office of the cyclone, any support whatever. The storm once engendered, no matter in what part of the world, may be stationary or progressive. There are well-authenticated instances of almost stationary cyclones and almost stationary typhoons, of which latter will be remembered the famous gale of the ship Charles Heddle — an Indiaman, carried round and round the storm-centre for five days — which progressed not more than ninety miles a day. Indeed, we may, as has been said, regard every wet-monsoon region as a stationary and semi-perennial cyclone.

Such a meteor has been shown to resemble an eddy moving in the current of a rapid river. The latter may be large or small, while it does not determine, but is determined by, the course of the on-flowing stream. It is true the centre of an eddy or water-hollow may soon be filled up and the whirl disappear; but it is because the depression is not maintained. If the depression could be maintained, it is easy to see that the eddy would continue, and pursue its way, as long as the current in which it is embodied continues to flow: it might be through the length of an Amazon or a Mississippi River. In the case of a cyclonic eddy or whirl, we know the atmospheric depression is maintained as long as the centre moves in a region sufficiently supplied with aqueous vapor to feed it. It is a physical impossibility, as has been often shown, that any storm, however vast or however violent, can prolong its advance or sustain its fury over a dry and desiccated surface. The most extended typhoons of the East, upon entering the dry and rainless continental regions, dwindle into the well-known and diminutive dust-whirlwind, such as Sir S. W. Baker describes as witnessed in Nubia, and as here illustrated. The Sahara is a more formidable barrier to the

Fig. 2.



THE DUST-WHIRLWIND.

passage of a storm than the majestic mountain-wall of the Alps, and the simoom is, notwithstanding the stories of travellers and the legend of swallowing up of the army of Cambyses on the African desert, a wasted and worn-out cyclone. In his "Desert World," Mangin, compiling the more accurate observations of the phenomenon says: "It never prevails over any considerable area, and beyond its limits the atmosphere remains serene and calm; the phenomenon is of brief duration, the atmospheric equilibrium is speedily restored; the heavens recover their serenity; the atmosphere grows clear, and the sand-columns, falling in upon themselves, form a number of little hills or cones, apparently constructed with great care, like those mimic edifices of sand made by children in their pastimes." The same writer also mentions a severe simoom which was "over in a couple of hours."

Embedded in the great aërial currents, however, and supplied with abundance of moisture, there is nothing to arrest either the rotatory or progressive movements of the storm. Like the drift-bottles cast upon the current of the ocean, and found after months to have been carried thousands of miles, from the equatorial to the polar parallels, there is every reason to suppose the tropic-cradled gale, and the minor storms also, are borne in the great atmospheric currents through quite as great distances. There is an authentic and well-attested account of a Japanese junk, lost or deserted off Osaka, drifting through the immense arc of the Kuro Siwo's recurvation, and encountered (in latitude 37°, by the brig Forrester, March 24, 1815) off the coast of California. That tiny craft must have followed in the bands of westerly winds and warm waters for seventeen months. Why, upon theoretical grounds, should we reject the hypothesis which represents the movement of storm-areas as prolonged for many thousands of leagues, or indeed that which represents them perpetually in motion around given centres of cyclonic or anti-cyclonic areas, keeping pace with the great winds in their eternal circuit?

As a striking corroboration of all this we find—what might have been assumed on theoretical grounds—that the logs and special observations of the Cunard steamships show that a vessel bound from Liverpool westward encounters frequent advancing areas of low pressure, indicating a number of rapidly-succeeding barometric hollows or depressions, "each with its own cyclonic wind-system, moving across the Atlantic as eddies chasing each other down a river-current."

The word *cyclone* has frequently, but incorrectly, been used as significant of an enormous or very violent meteor, as if its application was to be confined to the devastating hurricane of the West Indies or the terrific typhoon of the China seas. It simply means a storm which acts in a circular direction, and whose winds converge, by radials or sinuous spirals, toward a centre, moving in our hemisphere in the opposite direction to that of the hands of a clock, and in the Southern Hemisphere in a contrary direction. Taking this as the definition of a cyclone, it seems clear, from observation alone, that all storms are to be regarded as cyclonic. Volumes have been written to prove that this is not the case. But we have only to examine a few series of weather-maps from week to week to see that, wherever you have an area of low barometer, into its central hollow the exterior atmosphere from all sides will pour, and that in so doing a rotatory spiral or vorticose storm is generated. The tornado, the simooms, the dust-whirlwind, the fire-storm, even the slow and sluggish storm which moves on our Western plains as the laboring wheel of the steamship buried in a heavy sea, all attest that a body cannot move on the earth's surface in a straight line. It is not more true with us that the Gulf Stream turns to the eastward, the Polar Stream to the westward, and the equatorial currents to the northward, than that every air-current, in obedience to the same law, should turn to the *right* of the line along which from any cause it is called to move. The meteorist has therefore only to ascertain by observation where the barometer is lowest, to know at once the direction of the winds from the circumjacent districts, far and near, or at least to test the mathematical law by a grand experiment.

The tangential and centripetal forces, acting at the same time on any particle of air in the storm, may be equal or very unequal, and the cyclonic character of the gale may be well marked or partly concealed. In the tornado, with a diameter of only a few hundred feet, the tangential force may not be appreciable to an observer, but it is present, and intensely assists in communicating vorticose motion to the storm, whose roar is heard with awe by the stoutest heart, as it crashes through the forest and even ploughs up the soil of the earth. If the cyclonic or spiral feature should fail to manifest itself in any storm, we ought to look for such failure in the tornado. It is true that no barometric readings have ever been taken in the narrow heart of a tornado, but abundant evidence exists of the fearful rarefaction in the centre. While the meteor, once set in motion, may move forward with great velocity and destructiveness, the danger is clearly due to the intro-rushing and gyratory winds. There is not an instance, it is believed, recorded in which a tornado moved as much as 100 miles an hour; probably one-half that velocity would be too high an estimate for its usual and ordinary motion. But the wind, moving straightforward at the rate of 60 or 80 miles an hour, never worked any thing like the disaster of a tornado. In the West-Indian hurricane, blowing at the rate of 100 miles an hour, houses have been blown down, ships inumerable stranded; but all this is mere child's-play compared to the suction and whirl of the tornado. The conclusion forced upon us is, that the ravages of the latter are due, not to the weight of the atmosphere, moving as a river-torrent in a straight line, nor to the rush of air behind the travelling vacuum, but to the torsive, racking motion—imparted to every object in its path—due to its gyration. To prove that this gyration is *always* from right to left, or against the hands of a watch, is, of course, practically impossible; but such a direction has often been observed in tornadoes.

It may, therefore, be safely concluded that, for all processes of meteorologic calculation, the disturbance, if not such at first, will soon become cyclonic. All daily weather-charts demonstrate this, not by a laboratory or lecture-room experiment, but on an infinitely wider and grander scale, and in a manner far more conclusive than any merely manual experiment could possibly make to appear. As one has happily said, "Nature makes no distinction between small and great; the drop of mist that lights gently down on a delicate flower, and the avalanche that sweeps away a village, fall in obedience to one universal law."

It has been asserted lately that the Gulf Stream has no influence upon storms; that they have no tendency to run toward it or to run upon it; and that what geographers and seamen have always said about the Gulf Stream as a "weather-breeder" and "storm-king" is absurd. I think it can be demonstrated that this well-known popular belief is not absurd.

It is an observation, as old as Aristotle, that the storms of the middle latitudes in the Northern Hemisphere advance from west to east. This is obviously partly due to the fact that the winds on their eastern sides are southerly, that they come from the equatorial regions, and hence are highly charged with aqueous vapor. This vapor is absolutely essential to the sustenance of the storm. Moreover, the law of storms requires that the southerly winds should enter the storm-vortex on the eastern side, and as this is the side on which the greatest quantity of vapor is found, and the side of greatest condensation, of the greatest evolution of latent heat, hence of the greatest aërial rarefaction and barometric fall, to this side the heavier air from the west will push as into a great hollow. Thus do we actually find that all storms, formed west of the Gulf Stream, are actually propagated toward it. It may be argued from the above facts that the anti-trade winds are thus maintained by storms incessantly making the circuit of the globe within the temperate zone. But in reality, instead of being the effect of storm-influence, the anti-trades are originated by independent solar agency, as are the trades, and they are potential and causal in producing the eastward progression of all cyclones. It must be conceded that the pressure of vast aërial currents does serve to force the meteor along with them as the river-eddy is carried down stream with the water-current; otherwise it is impossible to explain the westward progression of tropical hurricanes. While yet in the band of easterly trade-winds the storm will invariably work its way or be propagated toward *the most humid region*, unless mechanically borne in another direction by the great atmospheric current in which it is often embedded as an eddy in a river. The cyclone-tracks over all the oceans lie in the central bands of the great ocean-currents of high temperature and great evaporation, and the band of cyclonic violence is often beautifully coterminous with the sharply-marked edge of the Gulf Stream. Thus, in the Pacific, the Loochoo Islands lie just in the path of the Kuro Siwo, the great Pacific Gulf Stream of the Japanese, and are visited by the most fearful typhoons; but the Bonin Islands, in the same parellel, but on the extreme margin of the Kuro Siwo, have very mild and moderate storms.[1] "If a storm commences anywhere in the vicinity of the Gulf Stream, it naturally tends toward that stream, because," as Loomis says, "here is the greatest amount of vapor to be precipitated, and, when a storm has once encountered the Gulf Stream, it continues to follow that stream in its progress eastward." Vessels and Japanese junks, dismasted in gales off the Asiatic coast, have been drifted for many days in the current of the Kuro Siwo, to the coast of California, just as West-India beans, cocoa-nuts, and vegetables, have been drifted to Iceland, Greenland, and Spitzbergen, on the extension of the Gulf Stream. According to all meteorological observations of the tracks of storms, we are warranted in believing that cyclones and hurricanes do, as a matter of fact and of atmospheric law, run on the hot currents of the sea as naturally as the water-course clings to its bed. Practical seamen, though unable to explain the fact, are always on the lookout for these furious gales when sailing on the axial lines of the Gulf Stream, on the hot Mozambique current (the Gulf Stream of the Indian Ocean), and on the dark superheated waters of the Kuro Siwo of the Pacific.

So dangerous and disastrous are the storms which course along the Gulf Stream that sailors avoid it, and the American Sailing Directions and those of the British Admiralty advise all vessels, sailing from the West Indies to New York or Liverpool, to beware of taking advantage of its current, although it would help them along from three to four miles an hour. Close observation has traced these storms continuously from the Florida coast to New York, through Redfield's labors, and thence to England, through the record of the Cunard steamships, and thousands of detached observations.

We have now reached a point where we can properly and intelligently consider a question that has always baffled meteorologists — the *origin* of cyclones. The diagnosis of the phenomenon necessarily precedes its explanation. This subject has engrossed many minds, and various have been the ingenious devices for unravelling its mystery. Mr. Redfield — the father of storm physics — in his modesty and diffidence, so distrusted himself and in his day so keenly felt the need of a more enlarged induction of facts, that he has scarcely left us his opinion. The theories of other writers have all long since been abandoned by themselves or suffered to drop from the notice of the scientific world as evidently incapable of explaining the phenomena of cyclones. This has been the fate of them all, unless possibly we except the theory advanced by the great meteorologist, M. Dové, of Berlin. Briefly stated, the latter hypothesis is this (at least in its application to West-India hurricanes), viz., that "they owe their origin to the intrusion of the upper counter trade-wind into the lower trade-wind current" (Dové's "Law of Storms," p. 264).

[1] *See* Redfield's Report.

Without pausing here to examine this theory upon its merits and upon the facts, we hasten to mention a different hypothesis advanced, nearly two years ago, as a substitute for that of M. Dové, and as affording an entirely original and satisfactory explanation of the origin of cyclones.

The hypothesis was likewise based upon the agency of the trade-winds, but in a manner wholly different from that elaborated by the German meteorologist. In the original paper in which my views were published, the following statement was made: "It can be demonstrated that the origin of cyclones is found in the tendency of *the southeast trade-winds to invade the territory of the southeast trades, by sweeping over the equator into our hemisphere.*"

The hypothesis advanced, in lieu of another seemingly less satisfactory, claimed to rest upon observations conducted in the very region most notorious for the generation of cyclones.

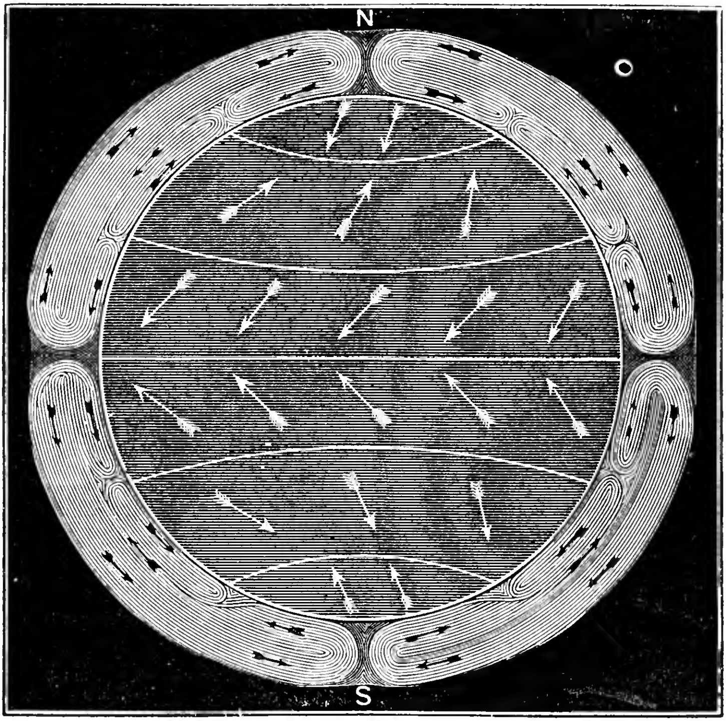
To test this, we need only to examine the Atlantic trade-winds.

Theoretically, physicial geography has generally represented the motions of the atmosphere somewhat as is represented in the accompanying diagram of the winds, as projected by Prof. William Ferrel, of Cambridge. The elaborate pages of Prof. Coffin, in his invaluable volume on the "Winds of the Northern Hemisphere," as deduced from myriads of observations, show that the graphic illustration furnished by the following diagram is approximately correct.

The region of the trade-winds, it will be seen, more than covers the torrid zone of the earth, and all seasons of the year overlaps both the northern and southern tropics. While this is theoretically true, and is usually put forth as fact, it must be accompanied with one or two important qualifications and additions.

Let us see what these are: The well-known oscillation or swinging of the belts of winds to and fro on the meridians, which is kept up in never-ceasing response to the apparent annual motion of the sun as he crosses and recrosses the equator, must ever underlie the conception we form of the trade-winds and be perpetually present to the mind's eye. This oscillation has never yet received the popular attention it needs. The sun traverses (apparently) an arc of 23½° on either side of the line; and we might, *a priori*, suppose that the thermal or meteorological equator, the thermal or meteorological Tropics of Cancer and Capricorn, and all those phenomena which lie between them and beyond them, move over an arc of as many degrees as they traverse. Such an inference, however, is not borne out by observation, and we propose to confine ourselves strictly to what may be proved by observation. It is clear that the trade-wind belt does traverse or vibrate over a wider zone than any physicist has yet assigned to it, which is not more than ten degrees of latitude north and south respectively of the Tropic of Cancer and that of Capricorn. These winds, when first experienced by Spanish sailors, gave, to that portion of the

FIG. 3.



THE ATMOSPHERIC MOVEMENTS.

Atlantic over which they blew, the name *el Golfo de las Damas* (the Ladies' Sea) because they rendered navigation so easy that a girl might take the helm. But, "gentle" as they are, they have a wide sweep, and, in the summer of the Northern Hemisphere, extend far beyond the Tropic of Cancer. They have often been distinctly felt at Madeira and the Azores (near the 40th parallel) in summer, and it is highly reasonable to suppose that they then fully reach the latitude of 40° N. The equatorial side of the northeast trade-wind belt, of course, vibrates with the sun. In summer it stretches along between the 10th and 12th parallels of north latitude, verging in August on the 13th parallel, and, according to one writer, occasionally the northeast trades at that season do not extend south of the 15th parallel of north latitude. Dampier, "the prince of navigation," as the English call him, gives the direction of the wind in the summer months, between the equator and 12° north, as south-southeast, south-southwest, and southwest.

The equatorial side of the northeast trade-wind belt in winter approaches very nearly to the equator, and may be located in January at least as far south as the latitude of 2° north.

The freshest trade-winds in the North Atlantic are generally found between the parallels of 10° and 25°, and by long-protracted experiment in seamanship they have been found to have an average propelling power, when the wind is taken just abaft the beam, of about six knots an hour. But, of course, the northern boundary of the southeast trade-wind likewise varies and vibrates with the seasons. So, also, and under the same condition, does the southern boundary of this trade vary and vibrate with the seasons. Its normal and mean position is a little south of the parallel of 25° south, but in the winter of our hemisphere it is pushed much farther south, and in the vicinity of 35° south latitude. The charts of Captain Wilkes give easterly winds for the east coast of Australia, and also for the south coast of Africa. Sir John Herschel, speaking from knowledge gained by his long residence at the Cape of Good Hope, tells us that there "the southeasterly wind which sweeps over the Southern Ocean, infringing upon the long range of rocks which terminates in the Table Mountain, is thrown up by them, makes a clean sweep over the flat table-land which forms the summit of that mountain (about 3,850 feet high), and thence plunges down with the violence of a cataract" ("Meteorology," p. 96).

From these high southern latitudes, we must conceive the motion of the southeast trades, extending northward in summer to the neighborhood of the parallel of 10°.

From the Cape of Good Hope, in a straight line toward the projecting eastern coasts of Brazil, mariners have found a peculiar streak of southeasterly winds. Between the island of Tristan da Cunha and the Cape, and northward and westward to the island of Fernando Noronha, this streak of powerful winds, with which nothing in the trade-wind region of the North Atlantic can compare, has its atmospheric current as sharply marked as the dark blue and rapid current of the Gulf Stream in the Narrows of Bemini. It is, doubtless, the region or band of most intensely acting southeast trades, and is probably due to the peculiar configuration of the shores of the South Atlantic, and to the wall of the South American Andes. It is a well-known fact that the volcanic cone of Teneriffe, which lies in the zone of northeast trades, intercepts the wind and gives it a lateral deflection; so that, while the trades are blowing strongly on the northeast side of the island, on the opposite side there is a distinctly-marked and carefully-measured calm shadow. Now, the chain of the Andes endeavors to exert on the southeastern trades just such an influence as is exerted by the Canary Islands on the northeast trades. This influence, in the former case, suffices to throw off from the Continent of South America a large body of the southeast trades, and to deflect it to the eastward, giving it the character of a south-southwest wind, and, at the same time, by forcing a greater or more concentrated body of air into the regions northeast of Brazil, imparting an increased velocity and violence to the air-current. It is, therefore, in the air-current that the homeward-bound vessel from the Cape of Good Hope aims to steer, because she is sure of being wafted happily and swiftly to her destination.

It has long ago been demonstrated by meteorologic observations, taken both at sea and on land, that there is very much *less* atmosphere in the Southern Hemisphere than in the northern, and for a long time physicists were at a loss to account for the difference. It has been, however, very satisfactorily explained by the eminent American mathematician, Ferrel, in his work on the "Motions of Fluids and Solids, relative to the Earth's Surface," where he proves at length, and states in detail (p. 39): "As there is much more land, with higher mountain-ranges, in the Northern Hemisphere than in the southern, the resistances are greater, and consequently the eastward motion of the air, upon which the deflecting force depends, is much less; and the consequence is, that the more rapid motions of the Southern Hemisphere cause a greater depression there, and a *greater part of the atmosphere to be thrown into the Northern Hemisphere.*" It is, doubtless, to this tendency of the Southern Hemisphere to throw off much of its atmosphere north of the equator that we may attribute in part the superior force and power of the southeast trades, and their well-known ability to battle with the northeast trades, and drive them from their own territory, at least all summer, and even in winter, as far back across the line as 3° or 4° north latitude. Mr. Ferrel, speaking of the principle just enunciated, well says: "This also accounts for the mean position of the equatorial calm-belt being, in general, a little north of the equator. But, in the Pacific Ocean, where there is nearly as much water north of the equator as south (and the resistances are usually equal), its position nearly coincides with the equator." In other words, just as a bucket full of water set to revolving on a perpendicular axis would show a depression in the centre, and the fluid be thrown from all sides of its rim, the Southern Hemisphere throws its water and its atmosphere into the Northern Hemisphere, all along the equator.

It is, therefore, a mathematical and mechanical certainty that there is an invasion of the northeast trade-wind belt from the southeast trades, and observation powerfully bears out the deduction of the mathematician. Auste states, in his cautiously-written "Physical Geography:" "The southern trade-wind region is much larger than the northern in the Atlantic Ocean. In this sea, the southeast trades are fresher, and blow stronger, than the others, and often reach to the 10th or 15th parallel of north latitude; whereas, the northern trade-wind seldom gets south of the equator, and usually ranges from 9° to 29° north latitude" (p. 253). It is easy to see how easily it happens that a very small atmospheric eddy found in the tropical Atlantic by the conflictory northeast and overleaping southeast trade-winds may soon become a hurricane of wide extent and of tremendous energy. All that is necessary, as we have before seen, is that an INITIAL IMPULSE of gyration be given to a body of air. The moment that this takes place by mechanical influence, and, centrifugal force creates the smallest eddy or vortex, the surrounding air, already highly charged with moisture, begins the process of convergence and ascensional motion, followed rapidly by condensation aloft, small, centrical, and upright.

The storm-cylinder—the nucleus of the hurricane—originally very small, is instantly enlarged and expanded by the evolution of latent heat stored away in the vesicles of aqueous vapor. For some hours, as all observations show to be actually the case, the incipient cyclone scarcely moves, while gathering in its energies and laying tributes upon all contiguous regions. The process continues with momentarily increasing intensity, and, before the sun has made his daily circuit, the meteor is formed.

If it be asked along what parallels of latitude in our hemisphere this formation takes place, the intelligent reader will at once answer, Near the terrestrial circle of trade-wind interference. This, we have already seen, is in summer, from the 10th to the 12th parallels of north latitude.

This slender zone of debatable ground is the battle-ground of the two opposing bands of the trades. There is really no need of observations to tell us as much. But millions of observations attest the fact. Every seaman knows it. Every meteorological writer tells the same story. You have only to examine physical charts from the time of Columbus and Magellan to this, to see the absolute unanimity of testimony, and to discover that the hypothesis now advanced, and the known facts of the case, are in perfect and minute accord.

If it be asked whether the origin of the West-Indian gales is *solely* due to mechanical interference, the proper reply, it would clearly appear, should be in the negative. As the southeast trade-wind comes laden with the vapor of the southern or water hemisphere, which Dové well called "the boiler" of the globe, it is met by the cold northeast trade from the northern, or land hemisphere. There must be a great difference in their temperatures, and consequently extensive condensation, which, by the reasoning of Mr. Clement Ley, would, of itself, explain the formation of the storm. That condensation greatly assists in producing and intensifying it, cannot be doubted. In the high latitudes, where the polar air-current is sometimes forced by barometric pressure into the southerly or equatorial current moving over the warm waters of the ocean, and thus heavily vapor-laden, the consequence is illustrated by such terrific and sudden tempests as that of the Royal Charter, distinctly proved by Admiral Fitzroy to have been generated between the opposite polar and equatorial currents off the coast of Wales.

But that the origin of great depression systems is solely due to

FIG. 4.

WEATHER-CHART OF GREAT BRITAIN, BEFORE ROYAL CHARTER STORM.

Full-feathered arrows show Polar current; half-feathered arrows show Equatorial current; dark-colored surface not reported by vessels or land-observers.

condensation, can hardly be sustained, and seems entirely overthrown if we regard the single fact that, on the great equatorial belt—the belt of perennial precipitation—no hurricane or typhoon has ever been experienced by the mariner. It has long been, and is now, the universally-accepted theory of meteorologists, that the reason no cyclones have ever been known to occur on the equator is, that there the earth's rotation exerts a deflecting influence on the winds, amounting to zero, and hence the formation of a whirl is impossible. This view is not satisfactory, because the nucleus of a depression once formed on the equator, there would be intro-moving masses of air proportioned in violence to the amount of the depression and the steepness of the barometric gradient, down which they rush to reach the point of lowest barometer. The true reason that no great cyclone has ever been formed nearer the equator than the third parallels of latitude appears to be, that the equatorial belt is a belt of *calms*.

HEAT AND LIFE.

By FERNAND PAPILLON.

TRANSLATED FROM THE FRENCH BY A. R. MACDONOUGH, ESQ.

THE full solution of the question of heat and life could only be reached by simultaneous concurrence of physics, chemistry, and biology. Ancient physiology treated of animal heat empirically, but was unable to explain its origin. That result required the discoveries of Lavoisier and the more modern researches of thermo-chemistry. After revealing the source of that heat, it was important to show how it was disposed of; and this is taught us by thermo-dynamics. And, in conclusion, only the most delicate physiological experiments could settle the modifications that take place in living beings, when subjected to the influence of a temperature either above or below that they possess normally. Medicine and hygiene already benefit by the indications yielded by pure science upon this subject. It is admitted that the study of the variations of animal heat in diseases is of the highest consequence for their comprehension, and that both diagnosis and prognosis receive unexpected light from it.

An inquiry into calorific phenomena, undertaken from various separate and independent points of view, for the solution of questions that seemed at first sight to have no mutual connection whatever, has thus obtained a body of truths which enter into combination almost of their own accord at the present time, and are found to contain the secret of a great problem in natural philosophy. A minute and extended analysis has thus resulted in an instructive synthesis, which is one of the most signal acquisitions of the experimental method.

I.

All animals have a temperature above that of the gaseous or fluid media in which they live; that is to say, they all possess the faculty of producing heat. Warm-blooded animals maintain an almost constant temperature in all latitudes and all climates. Thus, in polar regions, man, mammals, and birds, mark only one or two degrees less than they do at the tropics. The mean temperature of birds is 41° (cent.), and that of mammals 37°. Those animals called cold-blooded produce heat also, though in a less degree; but their temperature follows the variations of that of the surrounding medium, keeping, however, a temperature a few degrees higher than it. In reptiles, this excess varies from 5° to half a degree; in fish and insects, it is still smaller; and, in the wholly inferior species, it rarely reaches half a degree. In fine, with animals that vary in temperature, the power of resistance to external causes of refrigeration increases in proportion to the perfection of the organization. It is observed, too, that in these beings vital activity and the force of respiration have a direct relation to the thermometric state; thus, in a medium of 7°, lizards consume eight times less oxygen than at 23°. With animals of constant temperature, the reverse is the case; the colder it is, the more active is their respiration: a man, for instance, who, in summer, consumes only a fraction over an ounce of oxygen an hour, in winter consumes more than an ounce and a half. Apart from the state of the surrounding medium, many different circumstances exert a perceptible influence on animal heat, and produce tolerably regular variations in it. The seasons, the times of day, sleep, digestion, mode of nourishment, age, etc., are thus constant modifiers of intensity of combustion in breathing; but there are such order and harmony, such foresight, one may say, in the organization of the system, that its temperature continues definitively nearly the same in the physiological state.

The temperature of the human body, at the root of the tongue or under the armpit, is about 37° (cent.); this figure expresses the mean found in taking the temperatures of different points of the body, for there are certain slight variations in this respect in passing from one organ to another. The skin is the coolest part, and the more so the nearer we come to the extremities. The temperature rises, on the contrary, with increasing depth of penetration into the organism; cavities are much warmer than surfaces. The brain is cooler than the viscera of the trunk, and the cellular tissue cooler than the muscles. Nor does the blood have the same temperature in all parts of the body. The labors of Davy and Becquerel established the fact that the blood is warmer the nearer to the heart examinations are made. Claude Bernard measured, by methods of equal ingenuity and exactness, the temperature of deep vessels and the cavities of the heart. He showed that blood, in passing out from the kidneys, is warmer than when it enters, and the same is true of blood passing through the liver. He ascertained, too, that the vital fluid is chilled in going through the lungs, and consequently the temperature of the left cavities of the heart is lower than that of the right, by an average of two-tenths of a degree. The last fact clearly proves that the lungs are not the furnace of animal heat, and that the blood, in the act of revivification, grows cool instead of warm.

Ancient physiologists supposed that life has the power of producing heat; they conceived of a kind of calorific force in organized beings. Galen imagined that heat is innate in the heart—the chemic-physicians attributed it to fermentations, the mechanic-physicians to frictions. Time has dispelled these errors of supposition, and it is proved now that the heat of animals proceeds from chemical reactions taking place in the interior of the system. Lavoisier must be credited with the demonstration of this truth by experiment. As early as 1777 he discovered that air, passing through the lungs, undergoes a decomposition identical with that which takes place in the combustion of coal. Now, in the latter phenomenon, heat is thrown off; "therefore," says Lavoisier, "there must be a like release of heat in the interior of the lungs, during the interval between inspiration and expiration, and it is doubtless this caloric, diffusing itself with the blood throughout the animal economy, which keeps up a constant heat in it. There is, then, a constant relation between the heat of the living being and the quantity of air introduced into the lungs, to be there converted into carbonic acid." Such is the first capital fact brought to light by the creator of modern chemistry; but he did not rest there. He undertook to examine whether the heat theoretically produced in a given time by the formation of a certain amount of carbonic acid, that is to say, by the combustion of a certain quantity of carbon in the organism, is exactly equal to the amount of heat developed by the animal in a corresponding time. This quantity was estimated by the weight of ice melted by the animal placed in a calorimeter. Lavoisier ascertained in this way that such equality does not exist, nor was he long surprised at this, for he soon discovered that, of 100 parts of atmospheric oxygen absorbed, only 81 are thrown off by the breath in the form of carbonic acid. He concluded then, from this observation, that the phenomenon is not a simple one, that a part of the oxygen (nine per cent.) is consumed in burning hydrogen, to form the vapor of water contained in the expired air. Animal heat must be accounted for, then, by a double combustion: of carbon first, then of hydrogen; and respiration regarded as throwing off out of the animal carbonic acid and vapor of water.

Lavoisier's experiments have been repeated and varied, and his conclusions discussed in many ways for nearly a hundred years.

Several experimenters have corrected or perfected some points, but the general doctrine has not been shaken by the recognition of its secondary and very subtle difficulties, several of which still puzzle physiologists. It is, indeed, undeniable that the greater part of the reactions which occur in the system, with the production of heat, do bring out, as a result, the exhalation of watery vapor and carbonic acid from the lungs; but these two gases cannot arise from a direct combustion of hydrogen and carbon, because the system does not contain such substances in a free state. They represent really only the close of a succession of transformations, often distinct from combustions, properly so called. On the other hand, these are not the only residue of the chemical operations performed in the vital furnace. Besides the water and carbonic acid thrown off by animals in breathing, which are like the smoke of this elaboration of nutrition, they excrete by other channels certain principles which are, as it were, the scoriæ. Now, these principles of disassimilation, among which should be noted urea, uric acid, creatine, cholesterine, etc., could not be results of pure combustion, and they denote that the circulating current is the seat of extremely manifold reactions, the laws of which we are only beginning to gain a glimpse of.

The latest advances of chemistry allow us, indeed, to follow the linked sequence of the gradual transformations of nutritive substances into the cycle of vital operations. It is well, at the outset, to fix exactly the seat of these phenomena. They take place in all the points of the system traversed by the capillary vessels. The glands, the muscles, the viscera, in brief, all the organs, are in a state of constant burning—they are every instant receiving oxygen, which brings about alterations of various kinds in the depth of their substance. In a word, every organ breathes at all its points at once, and breathes in its special way. Certain physiologists of the present day are wrong in localizing the phenomena of breathing in the capillary vessels. They are merely the channels of transfer for oxygen, which, by exosmosis, penetrates their thin walls, and then effects, by direct contact with the smallest particles of the organized mass, the chemical action which keeps up the fire of life. It is easy to prove this by placing any tissue, lately detached from the body, in an oxygenated medium. We remark in this case an escape of carbonic acid, together with a development of heat, and this possibility of breathing outside the system proves clearly that such act can be accurately compared, as Lavoisier thought, to the combustion of any substance. The only difference is with regard to intensity. While a candle or a bit of wood burns rapidly, with a flame, the combustible materials of organic pulp unite with oxygen in a more slow and quiet manner, less violently and manifestly.

The blood, which flows and reflows incessantly in the most slender vessels of our bodies, and charges itself full with oxygen every time the chest heaves, is composed of very various substances. It contains mineral salts, such as chlorures, sulphates, phosphates of potassium, soda, lime, magnesia, coloring-matters, fatty particles, neutral substances of the nature of starch, and nitrogenized products, such as albumen and fibrin. The salts undergo slight changes in the torrent of circulation; they are eliminated by the chief emunctories. The neutral matters of the nature of starch are converted into glycogene and fat. The fatty particles undergo in the blood only such oxidizations as produce certain derivatives of the same order. And, last, the nitrogenized products are made over into fibrin, musculin, ossëin, pepsin, pancreatin, compounds all differing very slightly. It is the first portion of the chemical process which is effected in the principal fluid of the body. All these materials, elaborated at different points of the circulating current, and designed to be assimilated, are destroyed in the very organs in which they had been fixed. The glycogene is transformed into sugar, which is burned, yielding water and carbonic acid; the fatty acids are partly eliminated by the skin, and partly burned. As to the plastic matters which form the web of the tissues, we know little about the chemical relation which connects these with their products of destruction—urea, creatine, cholesterine, uric acid, and xanthine. Such is a rapid sketch of the principal chemical phenomena which, taking place throughout the entire system, kindle everywhere an evolution of more or less intense heat. There is no central organ, then, for feeding the vital fire—every anatomical element performs its share; and, if a nearly uniform temperature exists throughout the body, it is because the blood diffuses heat regularly into the various parts it bathes.

Now, how can the amount of heat to which these reactions may give rise be ascertained? Lavoisier arrived at it in a very simple manner. After comparing the oxygen absorbed by the animal with the carbonic acid and watery vapor thrown off, he deduced the weight of the carbon and hydrogen burned, by assuming that the formation of carbonic acid and of water produces in the system the same amount of heat that it would produce if taking place by means of free carbon and hydrogen. This is very nearly the result he obtained: A man weighing 132 pounds burns in 24 hours, at the average temperature of Paris, very nearly 11 ounces of carbon, and $\frac{1}{14}$ of an ounce of hydrogen, and thus develops 3,297 heat units. During the same period he loses through his lungs and skin $2\frac{3}{4}$ pounds of watery vapor, which take from him 697 heat-units. There remain, then, nearly 2,600 heat-units to account for. Other analogous estimates have been made, and physiologists have deduced from them the conclusion that a man of average weight produces in our climate 3,250 heat-units every day; that is to say, a sufficient amount of heat to raise seven gallons of water to the boiling-point. These figures, though approximations, give a sufficiently clear notion of the power of the animal economy to generate heat.

Of late years, the question has been taken up again with more exactness, thanks to the views of a new science called "heat-chemistry," which occupies itself with chemical phenomena in their relations to heat. Heat-chemistry, by the aid of very delicate apparatus for measuring heat, ascertains the number of heat-units developed or absorbed by bodies entering into combination, beginning with the noted experiments of Favre and Silbermann. Berthelot, who had made profound researches into this subject, reduces the sources of animal heat to five varieties of transformation: first, the effects resulting from the fixation of oxygen with different organic principles; then the production of carbonic acid by oxidization; then the production of water; in the fourth place, the formation of carbonic acid by decomposition; and, last, hydrations and dehydrations. The learned chemist attempted to show how the numbers obtained in the study of the heat of combustion of the different organic acids, alcohols, etc., might be applied to the compounds burned in the animal organism; but, while admitting the theoretic verity of the analogies he establishes, we cannot refrain from remarking that their practical verification is exceedingly delicate and difficult. How can we measure, at any one point of the system, the heat produced by a fleeting reaction occurring in the inmost depths of a tissue that must be lacerated to be examined?

If thermo-chemistry seems not to throw much light on physiology on this side, it reveals to it on another sources of heat that had hitherto escaped notice. Berthelot shows that carbonic acid in the system is not always formed by oxidization of carbon, but sometimes proceeds from decomposition absorbing heat. We know that alimentary substances are reducible to three fundamental types—fats, hydrates of carbon (sugars, fecula, starch), and the albuminoids. Now, the fats, in decomposing and combining with water, as it occurs under the influence of the pancreatic juice, evolve heat; and so it is with the hydrates of carbon, independent of any oxidization. And albuminous substances, too, produce very clear calorific phenomena, when their combination with water takes place with its consequent various decompositions. These facts, noted by Berthelot, must have their place in the minute and exact calculation of animal heat, which it is perhaps as yet too early to undertake. At any rate, this heat originates in the totality of those chemical transformations which are going on unceasingly in the depths of the animal organs, and are bringing about the continual renovation of the whole organized substance; in other words, nutrition; but why that nutrition—why that perpetual production of heat in the living machine?

We have now the means of answering this question, which involves the secret of one of Nature's most beautiful arrangements. The heat produced by animals is the source of all their movements; in other words, the mechanical labor they perform is a mere simple transformation of the activity of heat they develop. They do not create motive force by any voluntary operation, which would be one of the prerogatives of life; they draw it from the calorific energy stored up in the organs traversed by the blood. Besides, there is a fixed relation between the quantity of heat that disappears and the mechanical labor that appears. Yet, it is to be remarked that, if all motion by living beings is a transformation of animal heat, that heat is not wholly transformed into motion. It is partly wasted by transpiration through the skin, by touch, and especially by radiation; it is used in keeping up to a constant point the temperature of the animal, subjected to many causes of refrigeration.

The mechanical labor performed by an animal is very complex. Independently of visible muscular motions, there are all the changes of place in the interior organs, the continual passage of the blood, the contractions and dilatations of a great number of parts. Now, these actions are only possible in so far as the phenomena of breathing are taking place in the active region. Prevent arterial blood from coming to the muscle, that is to say, prevent combustion taking place, and consequent heat evolving in it, and, although the structure of the organ suffers no harm, it loses its contractile power. Mere compression of the supplying artery of the muscle, so as to check the flow of blood in it, causes the organ to grow cool, and lose its power. The labors of Hirn and Béclard have clearly established the relations between heat and muscular motion. Later experiments by Onimus have fixed, with equal precision, the efficiency of heat through the movements of circulation.

We have said that the heat-producing power of aliments will be the more considerable in proportion as they contain a greater quantity of elements that need a large supply of oxygen for their combustion. Therefore, meat and fats repair the losses of the system much more speedily than vegetable substances. The latter are suitable for the inhabitants of warm countries who do not require to produce heat, which the atmosphere supplies them with abundantly. The inhabitants of cold regions, on the contrary, whose accessions of heat ought to be as continual as energetic, are urged by instinct to use meats and fats, which throw out great heat in their combustion. For instance, it is a physiological necessity that the Lapps should feed on the oil of cetacea, as it is a necessity for men of the tropics to consume only very light food. The activity of respiratory combustion and the kind of alimentation thus vary with climate, so that there is always a certain proportion maintained between the thermic state of the surrounding medium and that of the animal furnace. In like manner, in the same climate, persons who perform great mechanical labor must eat more than those who put forth but little movement. This fact, long ago observed, has received of late the clearest and surest demonstration. Yet, perhaps, it is not kept sufficiently in view in the management of public alimentation. Many examples prove the benefit that industry would derive from increasing, in all possible ways, the amount of meat used in laborers' meals. Quite recently, at a manufacturing establishment of the Tarn, M. Talabot has improved the strength and sanitary condition of his workmen by giving them meat in abundance. Under the influence of a diet almost wholly vegetable, each laborer lost on an average fifteen days work a year through fatigue or sickness. As soon as the use of meat was adopted, the average loss for each man per year was not over three days. Often enough, it must be owned, alcohol is only the workman's means of remedying the want of heat-producing elements in his food; a deceitful remedy, which buoys up the system for a time, only to sap it afterward with alarming subtlety. One of the best preventives of the abuse of alcohol would certainly be the lessening of the cost of meat.

From the point of view of the relation between heat and motion, the living being may thus be compared to an inanimate motor, as a steam-engine. In both cases, heat is engendered by combustion, and transformed into mechanical work by a system of organs more or less complex. In both cases it is at first in a state of tension, and yields motion in proportion as it is demanded for the performance of certain work. Only the living being is the far more perfect machine. While the best-made steam-engines only utilize $\frac{12}{100}$ of the disposable force, the muscular system of man, according to Hirn, accounts for $\frac{18}{100}$. On the other hand, the animated motor has this peculiarity, that its sources of heat and its mechanical arrangements are intimately commingled, that its heat is produced by organs in motion with a sort of general diffusion, and that the machine itself becomes in turn transformed within itself into heat; an incredible complication, of which science has succeeded in unravelling the simple laws only by dint of the united efforts and resources of physics, chemistry, and biology.

As some physiologists hold, heat must not only be the source of motion in the system, but must also undergo transformation into nervous activity. The functional action of the brain must be a labor, exactly like that of the biceps. Mind itself should be regarded as engendered by heat. Late experiments by Valentin, Lombard, Byasson, and especially Schiff, would seem to prove, it is thought, that there is a proportional and constant relation between the energy of nervous functions and the heat of the parts in which they are effected. Gavarret boldly concludes, from his researches, that heat has the same relations to the nervous system that it has to the muscular system; only, in the case of the muscles, the force produced exhibits itself externally by visible phenomena, while in that of the nerves it is exhausted internally in profound molecular action, which eludes any exact measurement. A given sum of heat developed in the system would thus be on one side a mechanical equivalent, and on the other a psychological equivalent. Gavarret, who is a cautious *savant* and true to experimental methods, doubtless does not go so far as to maintain that thought and feeling can be estimated in heat-units; he even asserts that there is no common measure between intelligence and heat; but less timid physiologists are not wanting who reduce every kind of vital manifestation to the strict laws of thermo-dynamics. A few succinct remarks may perhaps show that such physiologists err.

A comparison between the muscular and the nervous systems from the point of view of their connection with heat is a bold one for many reasons. Between nerve and muscle there exists this enormous difference—that the former is endowed with a spontaneity denied to the latter. Muscular fibre never contracts of its own accord; it needs a stimulus—its energy is borrowed. The nerve-cell, on the contrary, has in itself an ever-present, never-exhausted power of action, of which the energy is its peculiar property. Both evidently derive the principle of the activity that marks them from the same external and internal media; but, while the muscle, a mechanical organ, is limited to the obedient transformation of the force assigned to it, under the form of heat, into a measurable amount of work, the nerve, a vital organ, remains impenetrable and inaccessible to our calculations, and exerts its characteristic and sovereign powers in its own way, through a series of operations that escape all estimates of their force and heat. On the part of the muscular system, every thing can be measured; on the part of the nervous system, nothing. Impressions, sensations, affections, thoughts, desires, pleasures, and pains, make up a world withdrawn from the common conditions of determination. That superior force which, ruling all the highest animal activities, decides, suspends, checks, and governs the very transformation of heat into movement; which, asserting its independence within us, call it by what oldest name we may—soul, will, or freedom—remains the most undeniable, though the most mysterious certainty of our consciousness, this force protests against the degradation of cerebral life to mechanism. Such is the conviction, moreover, of Claude Bernard and of Helmholtz.

II.

Independently of the slight and usual variations that heat may present in the same species, and those it exhibits in passing from one zoological group to another, we may consider the changes it undergoes in the same individual, influenced by the various disturbances of the system. Although it remains almost insensible to modifications of the surrounding temperature, it is not the same when the complete equilibrium of the organs is affected. The concord between the different parts of the organism and the functions they discharge is so perfect that the least trouble is reflected among them, and sends disorder everywhere. The nervous system, charged with keeping up harmonious communication between all points of the living being, first takes note of the change befalling, and transmits its abnormal impression into all quarters. It is not the generator, but it is the regulator, of animal heat; that is to say, it directs and in a manner oversees its production and diffusion according to the varying needs of the system. Every lesion or affection of this system reacts on the physiological processes, and particularly on the evolution of heat. By cutting the filament of the great sympathetic nerve on only one side of a rabbit's neck, Claude Bernard produced an elevation of temperature of several degrees on that side. The blood flows toward the point where the action of the nervous system is suspended under any influence whatever, bringing with it an increase of heating force. At a point where the reverse occurs, the vessels contract, and the temperature falls.

Imperfect nutrition and fasting act on the animal heat, but not directly. The organism keeps up to its normal degree of temperature till it has exhausted its reserved store of combustible substances. Then it cools slowly down to a much lower degree. Thus, a rabbit, starved by Chassat, showed the first day a warmth of 38° 4′ (cent.); two days before its death, 38° 1′; the evening before, 37° 5′; and at the moment of death, 27°. By placing it in a warm medium the moment it was about to die, the apparent activity of its functions was restored for a little while; but the renewal is of brief duration: the anatomical elements have absolutely lost their spring.

The hand of an invalid, suffering from inflammation of the chest, or from an attack of fever, is burning; that of one affected by serious asthma, or by emphysema, is as cold to the touch as marble. This is because animal heat varies greatly in different pathological states. Sometimes it rises, sometimes it falls; and the morbid influence is scarcely ever compatible with the body's degree of normal temperature. In Hippocrates's time, when examination of the pulse was not yet practised, the increase of temperature was the only element in the commonest of maladies, fever. Galen defines it quite simply as an extraordinary heat (*calor præternaturalis substantia febrium*). The ancients did not err. It has been admitted and proved in our days, that the elevation of the animal heat is just the specific character of the febrile condition. On the one hand, there is never any fever when the temperature continues at the normal degree; on the other, the rapidity of the pulse may reach the utmost limits, without any febrile movement, as is seen in hysteria. Whenever the bodily heat exceeds 38° (cent.), it may be affirmed that there is fever; and, whenever it falls below 36°, there is what is termed algidity. So that the normal heat varies within the narrow range of scarcely two degrees. Beyond these limits, that is, above 38° and below 36°, the temperature points out some morbid trouble. In common intermittent fever, it rises two or three hours before the chill, reaches a maximum at the close of it, and then falls. Acute and decided inflammations, such as pneumonia, pleurisy, bronchitis, erysipelas, etc., are marked by a period of thirty-six hours, or about two days, during which the heat rises slowly to 41°. Toward the third day, this heat decreases, ready to reappear in exacerbations of from half a degree to a degree, during three or seven days, at the end of which time the disorder has run its course. When the temperature gradually rises after the third day, a fatal result may be expected. Persistent heat in that case is the precursor of death. Eruptive fevers, like small-pox, scarlatina, and measles, present very important phenomena of heat. In these heat begins with the attack of the malady, and increases till the cutaneous eruption occurs. It keeps up at a maximum, which reaches $42\frac{1}{2}°$ (in scarlatina), till the eruption is complete, then it begins a declining course, variable with the phases of the eruption, which finishes either with scaling off as in scarlatina, or suppuration as in small-pox. And the temperature rises also in several surgical affections, bringing on a more or less inflamed and feverish condition. This is observed in wounds, and generally in every kind of traumatism, in tetanus, aneurisms, etc. In the case of strangulated hernia and of burns, and in most cases of poisoning, on the other hand, it declines in a remarkable way.

Very plainly this rising and falling of animal warmth in diseases can only be attributed to a corresponding state occurring in the energy of respiratory combustion. We do not yet exactly know the cause of these variations; that is, the mechanism by which the morbid influences stimulate or check the active production of heat. Some physicians see in it the effect of fermentations occasioned in the blood by certain microscopic beings, such as bacteria and vibriones, which may perhaps be supposed to be the fact in most febrile maladies. Others assume that, in local inflammations, it is the inflamed organ which communicates heat to the whole body, as a furnace does in a confined space. To others the disturbance seems rather to have a nervous origin, since the nerves, as we have seen, are the regulators of thermic action.

The use of the thermometer is the only exact method of measuring the temperature in diseases. Swammerdam, in the middle of the seventeenth century, seems to have been the first to have the idea of it. De Haën and Hunter, in the last century, used it in their medical practice, but its employment at the sick-bed has really only come into importance in our own day, thanks to the labors of Bouilland, Gavarret, Roger, Hirtz, and Charcot, in France; Bärensprung, Traube, and especially Wunderlich, in Germany. These physicians were not content with proving that the temperature in illness rises several degrees; they followed the variations of the thermometer day by day, hour by hour, in the different phases of the pathologic movements. They discovered that the curves of these oscillations furnish constant types for each disease, which are modified in a regular manner, according as the disease has been left to itself or treated by one or another medicine. By the study of these pathologic curves of heat the course of diseases may be followed, and valuable indications noted in diagnosis or prognosis. In hæmorrhage of the brain, for instance, the temperature falls suddenly to 36° or even 35°, while, in the attack that takes the form of apoplexy, it continues nearly at 38°. These two disorders, quite distinct in their treatment and cure, yet often give rise to a confusion, which the thermometer will hereafter allow to be avoided. Granular meningitis is distinguished from simple meningitis by the same method; in the former the temperature does not rise, notwithstanding the extreme rapidity of the pulse, but in the latter the thermometer marks 40° or 41°.

In every case we see what advantage practical medicine may gain from the physical sciences, what precision and safety it attains by the employment of its means, in proportion to the morbid symptoms. We may add that the future of diagnosis is to be found partly here. By the banishment from medical examination of the often-uncertain judgment of the senses, by substituting as far as possible for personal and arbitrary conclusions, as well as for the feeling, always more or less confused, of the physician, the plain and impassive indications of an exact instrument, we do away with the causes that impede the methodical interpretation of the evil in question. Moreover, these instruments often reveal peculiarities that elude direct observation. They repair the omissions, correct the mistakes, guide the activity, multiply the power of our imperfect senses. From this point of view, the study, by the thermometer, of variations of animal heat in diseases, thermometric clinic, as it is called, is one of the most indisputable onward steps in medicine.

III.

After having seen how internal heat is produced in animals, how it expends itself in them, and undergoes change into mechanical work, in fine, what spontaneous or occasional changes it passes through in them, we should study the influence of external heat on the same animals, and the various phenomena resulting from the rise or fall of temperature in the medium they live in. Quite recent researches have thrown light on these questions. Boerhaave had made some experiments, not sufficiently exact, however, on the subject. Berger and Delaroche, at the beginning of this century, undertook new ones, which gained celebrity in the schools of physiology. They placed animals in stoves containing air heated to different degrees of temperature, and noted the effects produced on life by thermic influences. The conclusion from their researches was, that all animals have the power of resisting heat for a certain length of time, and that the duration of resistance varies with the species. Small animals yield after a moderate time to a temperature of 45° to 50° (cent.). Larger ones endure heat better. Cold-blooded animals and the larvæ of insects resist more energetically than warm-blooded animals; but the reverse is the case with fully-developed insects.

Delaroche and Berger studied the human subject, too, from the same point of view, and ascertained that the effect produced varies with individuals. Thus from 49° to 58° the stove grew insupportable to Delaroche himself, who became ill from the experiment, while Berger was scarcely fatigued by it. On the other hand, Berger could remain only seven minutes in a medium heated to 87°, while Blagden stayed 12 minutes in it. In tropical countries the heat often rises during the day above 40° without troubling the natives. At the Cape of Good Hope the thermometer marks 43°. Yet sometimes such a heat is murderous. It is related, among other cases, that in the month of June, 1738, in the streets of Charleston, several persons died under the influence of 41°. In Africa our soldiers are often known to be attacked with madness and to die in making a long march, under the rays of a burning sun, but here the influence of light is combined with that of heat. Duhamel mentions the account of several servant-girls of a baker, who could remain without any inconvenience at all for nearly ten minutes in an oven heated to the necessary degree for baking bread. The experiment has since been repeated. There is nothing contradictory in these facts. An animal can endure for some time a temperature much higher than its own, because the very profuse transpiration which occurs in such a case prevents the heating of the organs; yet, as we shall see, so soon as the internal heat really rises a few degrees above the normal figure, life is no longer possible.

The study of these phenomena had scarcely been carried further, when in 1842 Claude Bernard devoted to it certain researches, which he resumed and finished last year, and of which he has just published the results. This physiologist used a pine box, divided into two parts by a grating, on which the animal subjected to the experiment is placed. The box rests on a cast-iron plate, and the whole is arranged on a furnace which warms the air of the apparatus more or less. A window, placed in the side of the box, allows the head of the animal to be fixed outside of it at will. Examining animals, subjected under these conditions to the influence of air more or less warm, Bernard verified the first observations of Berger and Delaroche, and made new and more important ones. Boerhaave had given as the cause of death the application of hot air to the lungs, preventing the cooling of the blood. Bernard showed by experiments that hot air, acting on the skin, creates a rise of temperature more rapidly fatal than when this fluid is merely introduced into the pulmonary vessels. He proved also that, when the hot air is damp, the phenomena take a more rapid course, and death occurs much more quickly and at a lower temperature than in dry air. This difference must result from the fact that dampness promotes a rise in temperature.

When an animal is subjected to the poisoning effects of heat, it presents a series of uniform and characteristic phenomena. It is at first a little disturbed, then panting, its movements of respiration and circulation accelerate, it grows slowly hotter through the circulation, which, carrying the blood continually from the surface to the centre, bears heat also along with it, then at a given moment it falls into convulsions, the beating of its heart ceases, and it dies uttering a cry. By means of the thermometer it is noted that the temperature of the animal, in every case, is higher by four or five degrees (cent.) than the figure which represents the normal warmth. Thus at first the animal is excited, its functions seem to be performed with fresh vigor, very much as, in the first rays of April sunshine, the pulsations of life in all beings become more rapid; but this stimulus is only fleeting, and soon, when it reaches a certain degree, this heat gives place to the cold of death. Bernard carefully examined animals dying under these conditions, and the first phenomenon that struck him was the rapidity with which corpse-like rigidity came on. The heart grew suddenly insensible to any stimulus; effused spots appeared at several points on the skin. The heat fixed in coagulation the soft matter that composes the muscular fibres. These had the look of being struck with lightning. On the other hand, the arterial blood of the animal grew black, ill-supplied with oxygen, overloaded with carbonic acid, and assumed the look of venous blood. Yet in this state the blood has not lost its physiological properties, and under the influence of a new supply of oxygen can regain its normal state, and grow ruddy again. The heat, provided the degree be not too elevated, only promotes activity in sanguine combustion, without changing the blood. Nor does the nervous system either appear to suffer much. The element most deeply affected is muscle; *heat is a poison of the muscular system*, like sulpho-cyanuret of potassium, and the upas-antiar. It is the loss of the vital properties of this system, which, by bringing about rigidity of the muscles, then the stoppage of circulation, and consequently of respiration, is a necessary cause of death. This destruction of the contractile muscular fibre occurs toward 37° or 39° in cold-blooded animals, toward 43° or 44° in mammals, toward 46° or 48° in birds, that is, speaking generally, at a temperature five or six degrees higher than the natural temperature of the animal. Bernard calls attention to the fact that in no case is it allowable to suppose that life opposes a kind of resistance to the excessive heating; on the contrary, vital movement tends to quicken it, and that may be readily understood. The internal heat produced by the animal unites with the acquired heat, and the renewal of the blood, which is the condition of the heating, then occurs with much greater activity. Let us add that quite lately Demarquay applied this toxic action of heat on the muscles in the happiest manner, and without suspecting it. He cured patients suffering from those frightful muscular contractions which characterize tetanus, by subjecting them to the influence of caloric, and making them take very hot air-baths. The rise of temperature in the tetanized muscles was sufficient to modify them, and restore them to a healthy state. Here the poison worked a cure.

Such are the effects on animals of the elevation of temperature. Let us now see what becomes of them when immersed in cold media. Some curious facts with respect to the freezing of certain animals have long been known. During his voyage to Iceland, in 1828 or 1829, Gaimard, having exposed in the open air a box filled with earth in which toads were put, opening it after a certain time, found the reptiles frozen, hard and brittle; but they could be restored to life when put in warm water. Many ancient authors cite similar cases, and we can almost bring ourselves to understand how a great English physiologist might for a moment have given them the whimsical interpretation that he did. John Hunter fancied it might be possible to prolong life indefinitely by placing a man in a very cold climate, and there subjecting him to periodical freezing. The man, he said, would perhaps live a thousand years, if, at the end of every ten years, he were frozen for a hundred, then thawed out at the end of the term for ten years more, and so continuously. "Like all inventors," Hunter adds, "I expected to make my fortune by this scheme, but an experiment completely undeceived me." Putting carp into a freezing mixture, he observed, in fact, that, after being entirely frozen, they were dead, past recovery. The case is the same with all other animals, as the late and very remarkable experiments of F. A. Pouchet have proved.

The influence of cold on organized beings varies, according as we regard superior animals or the inferior species. In general, it may be said that it requires a very low surrounding temperature to chill many animals, because the vital heat they develop resists the process with energy. Yet the mammals of arctic regions, in spite of their thick coat of fur, can only brave the temperature of the pole (sometimes equal to 40° (cent.) below zero, the freezing point of mercury) by living under the snow where they make their lair. The Esquimaux, too, dig huts in it, where they pass their wretched days. When the organism can neither react nor protect itself against temperatures so low, death by freezing quickly overtakes it. The body is stiffened, and retains afterward a state of remarkable incorruptibility. Every one knows the story of the antediluvian mammoths, discovered in the polar ice, where they had been buried, as fresh as animals just dead. While heat destroys the tissues, cold preserves them.

Through what mechanical means does cold become mortal? It seems to act on the nervous system. Travellers relate that in polar regions an unconquerable disposition to sleep overcomes men attacked by very low temperatures. On the icy shores of Terra del Fuego, Solander said to his companions, "Whoever sits down falls asleep, and whoever falls asleep never wakes again." This inclination is so overpowering that many of his attendants gave up to it, and he himself sank down for a moment on the snow. It is said that, during the winter of 1700, two thousand soldiers of Charles XII.'s army perished in the sleep to which they surrendered, under the influence of cold. Its action on the nervous centres, however, is only secondary and consequent on another phenomenon, studied by Pouchet, which reveals this as the secret of death. When the temperature of the interior of the body sinks to 10° or 12° below zero (cent.) the cold freezes the blood more or less, thoroughly disorganizing its globules, and it is this alteration which, either at once or when the blood becomes fluid again, destroys all the vital functions. Larrey relates the case of Sureau, chief apothecary of the French army in Russia, who, when chilled to freezing by a painful march in the snow, did not die until the moment they began to restore warmth. Experiments on animals show that they keep themselves alive as long as they are maintained in a state of half congelation, and die whenever their temperature and circulation are so far restored as to permit the blood-globules, disorganized by cold, to be diffused throughout the vessels. Death occurs, therefore, whenever the quantity of these globules is sufficient to produce a considerable disturbance in the system, that is, whenever the frozen part is at all extensive. An animal entirely frozen, and consequently containing in its congealed blood no globules but those unfit for life, is dead, without possibility of resurrection. Thawing it only restores a soft flaccid, discolored body, with opaque eyes. If freezing only attacks a limb, it becomes gangrenous, and is destroyed. Pouchet deduced from these examinations a judicious, practical conclusion. If it is true that, in cases of partial freezing, the death of the individual is due to the disorganized globules reëntering the circulation and corrupting the blood, it is plain that, the more sudden the invasion of these globules is, the more rapidly death will supervene. It follows, that, by resisting this invasion, by means of ligatures, or extremely slow thawing, we might succeed in preventing the poisoning. The diseased globules which, pouring in a flood into the heart and lungs, would imperil life by the sudden alteration of the blood, will apparently disturb it merely in an unimportant way, if they are dropped into the blood by slow degrees.

Thus the late researches of experimental physiology explain for us the effects of heat and cold, regarded as toxic agents. The former is a poison of the muscular fibre, the latter a poison of the blood-globules. The case is the same with heat as with the other elements of the cosmic medium, in which the animated being lives. It enfolds the most contradictory powers, like the tender flower, spoken of by Friar Lawrence, in "Romeo and Juliet," from which may be distilled both safety and danger. It can by turns support health, heal disease, or inflict death.

Man is, then, the weak plaything of all those silent forces that surround and press upon him. In vain he enslaves them; he cannot escape the inflexible laws that subject the equilibrium of life to that of the lowest physico-chemical conditions. He has at least the consolation of knowing these laws, and guiding his existence so as to soften their severity as far as possible. When Nature crushes him, she is unconscious of it, unconscious of herself: man, so small, is greater than these blind greatnesses, because his peculiar greatness is consciousness. The subject we have been studying is a grand proof of this; but its full, imposing interest would not be understood were we to end without giving the answer to the last question it suggests. Whence comes this heat developed by chemical phenomena in the living system? It comes from aliments which, in the last resort, are all drawn from plants, and they have borrowed it from the sun. When the vegetables, whose combustion takes place within the animal, there throw off a certain amount of potential energy, as heat, they do but transmit to it the force which the sun has supplied them with. It is, then, a portion of solar radiation, stored up at first by the plant, which the animal makes disposable and converts to use, whether for resisting cold or for securing the regular play of his motive functions. Thus we may say, with exact truth, the sun is the inexhaustible source, as it is the perpetual spring of life. From this point of view, science confirms the intuitions of oldest date, and man's poetic dreams in the childhood of the race. Reason completes the instructions of its long experience by harmonious agreement with the simple and natural sentiment felt by the first of men, when for the first time they looked on the splendor of day.—*Revue des Deux Mondes.*

NERVOUS HEALTH AND MORAL HEALTH.

An able article in the *Times* some weeks ago on "Brain-work and Longevity," which has since been discussed and rediscussed in all sections of the press, was remarkable for several characteristics, especially for a curious thesis apparently indorsed by the *Lancet* of a subsequent week, that overwork of the brain, through late hours and the like, is a physiological impossibility. The argument was something of this kind: All brain-work means the destruction of nervous tissue or brain-tissue; all such tissue, when destroyed, must be repaired by food and sleep before it can be drawn upon again; therefore, overwork is impossible. A man may try to steal hours from sleep; but, if he does, he will only find how hopeless the attempt is the moment he passes the bounds of what the existing amount of tissue permits. He will struggle feebly against sleep, drop asleep, find he is doing no good, and be compelled, in the interests of his work, to shorten the hours of his work. The argument is full of fallacies, as any one might tell who applied a parallel argument to prove the impossibility of overwalking; and we are astonished at the sort of sanction given to it by the *Lancet.* It is quite as easy to prove that no man can overwalk himself. He cannot walk except by the destruction of muscular tissue, and, when as much has been destroyed as makes him weary, he ought to drop down and go to sleep on the high-road, if the argument be worth much! As a matter of fact, of course, a man may destroy a great deal more of the supply of either brain or muscular tissue than he ought to destroy, before the process of reparation begins, just as he may live for days of comparative starvation on a great deal less food than he needs to keep his system in health, or even on the flesh he has made in past days. The brain-work done under such conditions may not be quite as sound, but yet it may draw a certain hectic fire from the glow of anxiety, which, to many a taste, would more than replace the defective soundness of thought. Indeed, the writer of the *Times* article admits anxiety as one of the causes of ill-health, through its effect in preventing sleep and proper nutrition; and why, if it prevents sleep, should it not prevent the sleepiness which alone prevents the destruction of more nervous tissue than is desirable at any one time? The writer is hardly consistent with himself; but we mention his argument, not for its own sake, but because his able paper represents the rise of a physiological school of ethics, which is, as we believe, gaining rapid ground and doing a great deal to supplant a true ethical doctrine. The real drift of all this skilful argument, partly indorsed by the *Lancet*, against the possibility of overworking the brain, is to strike a blow at the root of all ethics—the limited freedom of the human will. The physiologists want to identify moral action so completely with the physiological conditions of moral action, as to represent all life as the mere result of the growth and destruction of tissue, and as containing no provision for any real alternative choice at all. If a man can't overwork, as this writer says, but can very easily underwork, and can be overworried by any *involuntary* spring of care, the natural inference would seem to be that the secret of what looks like "*will*" in life is really not "will" at all, but some involuntary emotion which plays our actions as we play chessmen; and hence the rules of right action will have more and more to be sought in the manipulation of the influences to which our bodies and tastes are subjected, rather than in useless appeals to the will to do what the will has no power to do.

What would be the kind of ethics which would spring out of such a theory? We find traces of it in plenty of medical journals, and pretty distinct traces in the able paper on "Brain-work and Longevity" itself. "One who is insulted or offended," said the writer, "feels an instantaneous impulse to attack the offender. A mere brute, whether human or bestial, acts upon the impulse without reflection. A man may either act upon it after reflection, or restrain himself, and perhaps go peacefully away. If so, he will probably bang the door after him; *and will feel better for doing it.* A child or a woman will obtain the same relief from a gush of tears. In either case, the imprisoned force is discharged, is gone out from the system. Whatever may be the nature of an emotion, its repression is hurtful; but the repression of the depressing emotions is far more hurtful than that of the pleasurable. Grief, disappointment, or envy, when restrained from external display, has a marked tendency to exert a very hurtful influence upon the nervous system of organic life, which governs the processes of secretion and of repair." Now, if we take this doctrine along with the other, which denies to man all power over the physiological conditions of life, most men will infer that physiology is a far better source of guidance than any considerations of right and wrong. If the will has no power over the physiological conditions of life, while the physiological conditions of life have great power over the will, naturally we shall seek the guidance of the latter, and not try to find rules for the guidance of the former. Here, for instance, is a new rule of the physiological sort at once: "The suppression of all emotions, but especially of depressing emotions, is injurious." Therefore, in place of attempting to repress and conquer selfish anger by an inward effort, one ought, in deference to one's nervous physiology, to go and bang the door of some empty room at least, or indulge in a flood of tears with the women and children. Or, if envy—one of the most depressing of passions, as the exponent of the physiological rules for long life justly remarks—preys upon an ambitious or vain spirit, the depressing effect ought, we suppose, to be guarded against by inventing some similar safety-valve. If the sufferer rom that passion be literary or artistic, an anonymous satire or bitter caricature would become a personal duty, in order to avoid the injurious gnawing of a "depressing emotion." If there be no access to literature and art, to secure a confidant to whom backbiting speeches can be safely made, without danger of their being retailed, would not seem so much an ignoble indulgence as a medical precaution. Where is this doctrine, that the complete restraint of the "depressing emotions" is injurious to the nervous system, to lead us to, in the absence of any code of right and wrong that assumes the freedom of the will, and the power of obeying or infringing a divine moral law? It would suggest a perfectly new law of conduct, according to which we should shape our inward life, not with relation to any spiritual ideal within us, but in relation to the expediency of letting off dangerous physiological steam, by expressing whatever it might be injurious to repress. Quilp's device of keeping a wooden effigy, on which to let loose his evil passions, might become a serious suggestion in this physiological school of ethics; and what it might lead to in the direction of physical passion it is not even tolerable to contemplate.

Certainly there is one tenet of the Physiological school of ethics which is more and more frequently recommended to the world for its acceptance, not only by the apostles of these doctrines, but by the partisans of culture. Goethe was the first famous teacher who not only taught, but systematically acted upon, the teaching that men should deliberately turn away from all sources of disturbing emotion, and keep their minds fixed on tranquillizing objects of contemplation. That was the physiological ethics arrived at from a different side—from that side of the mind which yearns after unshaken intellectual dignity, after calm self-possession. In other words, penitence for sin of any thorough kind should be carefully eschewed, for it involves strong emotion; and the inexhaustible craving after a perfection that cannot be attained should also be kept down, for that implies an inward gnawing of the heart which is dangerous to intellectual calm. Thus, what the physiologist reaches through the doctrine of "tissue," the apostle of culture reaches through the idolatry of intellectual calm. Does it need to be said that any genuine ethical doctrine, while it will listen to and not despise the lesson of physiology and the *cultus* of serenity, will regard both the one and the other as utterly subordinate considerations in relation to the moral ideal? As it may be right to lay down the life for others, so it may be right to endanger health, to draw too heavily on the supplies of nervous tissue, to face the possibility of a sacrifice of intellectual calm, in a word to run counter to the admonitions both of physiology and of culture. We should say, for instance, that to look any pain that naturally befalls us—intellectual, moral, or only of the heart—steadily in the face, and realize fully what it is and means, is one of the most imperative of inward duties, and that one is sensible of a certain unmanly cowardice in all the expedients for escaping from it by taking refuge in lower though perfectly innocent excitements, for hiding it away from one's self without learning all it means. And yet to grasp the full meaning of any real pain, whether due to one's own unexpected intellectual or moral shortcomings—whether it arises from shrinking of will, or failure of faculty, or the sin which brings remorse, or simply from the unfaithfulness of others, or from death—is one of the most "depressing" of the duties of the inward life, and one from which the natural man usually turns away without the need of warning from the physiologist. And if the comparative clearness of physiological science should ever lead to the substitution of a physiological for a truly moral code of conduct, we are quite sure that the very first result would be to render men less sincere with themselves, not only less able to govern themselves, but less willing even to face that which is painful or evil in their own natures. Nervous health is one thing, and moral health is another. We suspect that what is good for the one is often bad for the other, and that the doctrine which discourages the simple suppression of feelings that are beneath us, and the steady encounter with forms of inward pain from which Nature tempts us to escape, as a shying horse starts away from an object it dreads, is a doctrine which would sacrifice the highest part of man—that for which life is given—to the conservation of the tissues of the brain, and the cultivation of that coolness of temperament which is the best security for a somewhat ignoble longevity. —*London Spectator*.

BRAIN-WORK AND THE EMOTIONS.

AMONG the legitimate solaces of the toils of the modern biologist, there should certainly be reckoned the grim delight which he were less than human if he did not feel in terrifying Mrs. Grundy. Merely to hear a Huxley or a Spencer shout "Boh!" to a flock of the terrified orthodox is amusing, but to the man himself who makes it the fun must be even perilously fascinating. Doubtless, there is some danger of carrying the joke too far. One has heard of a philosopher, who, when courteously asked by a company of the most intelligent of the London clergy to explain some of the principal points of conflict between scientific data and conventional religious theory, began his speech by bluntly telling his audience that he was going to relate important facts, but that his hearers were such unimportant people that he did not care a button whether they believed the facts or not. Such rudeness gives even more pain to the truly scientific mind than it inflicts upon the immediate sufferers.

However, there really is legitimate amusement to be had, and even much good to be done, by the biologist, in shocking the theoretical prejudices of the metaphysicians. The irony of Von Hutten, and the delicate wit of Erasmus, when exposing the intellectual contemptibility of the opponents of the Reformation, were not more truly helpful to the progress of humanity, than are the assaults of those physiologists and physicists who are even now smashing the crockeryware of the metaphysicians and kicking the fragments about with a fury that one can easily see is partly fun. As for that large section of the clergy who persist in looking at the phenomena of mind only through the spectacles of Hamilton and Mansel, there really is no way of dealing with them at all except that of pelting them with incessant ridicule. It is inexpressibly comical, and yet provoking, to hear them keep chattering about the tendency of modern biology to degrade our ideas respecting mind; for one has only to look back some fifty or sixty years to remember the days when mind was considered exclusively the domain of theologians and metaphysicians, and mental diseases were treated according to "high priori" notions instead of medical science. One would think that the cruel and shameful failure of that old system, and the striking benefits that at once accrued to the mentally afflicted when physicians boldly declared that the mind could only be successfully treated by treating the brain—one would think that these and many other similar things would have taught the metaphysicians modesty; but such is not the case. It was but four years since that the Archbishop of York delivered himself of a most presumptuous and densely ignorant attack on modern biological speculation, and was promptly castigated by Dr. Maudsley. To this day, the typical clergyman—we do not speak of such exceptionally liberal men as one often meets in London—holds as firmly as ever to the belief that all discussions of moral perversion, which deal with it from the side of mere bodily organization and health, are an insult to religion—a lapse into the black gulf of what he calls "materialism."

It is not with such persons, however, that we are now concerned, but rather with a class of writers, truly liberal and full of culture, who, nevertheless, cannot get over what seems to them the hopeless divergence between recent physiological doctrines and any systematic teaching of the "higher ethics." To this estimable class belongs the writer of a thoughtful article in the *Spectator*, on "Nervous Health and Moral Health." His text is the recent discussion originated by a remarkable leader in the *Times*, which declared that brain-*work* does not kill, but that brain-*worry*—especially stifled emotion—is the really fatal agent in nearly all cases where overwork gets credited with a death. Let us repeat here that the experience of medical men undoubtedly shows that this is no fancy, but (with comparatively trifling exceptions) an important general fact. The *Spectator* does not venture to deny this statement altogether, but, accepting it provisionally as correct, argues that such teaching would lead to dangerous results, unless we acknowledged that what is good merely for nervous health *may* be bad for moral health, and *vice versa.* We certainly cannot admit this, and we believe that the fears of the *Spectator* as to modern physiology leading to bad ethics are quite groundless.

To the writer in the *Spectator* the danger seems to be that medical philosophers are proposing to extinguish human emotion, and reduce all men to a dead level of intelligent but selfish complacency, reaching the same point, for the sake of preserving health, as Goethe aimed at for the sake of preserving perfect artistic culture—or "sweetness and light," as Mr. Matthew Arnold would call it. We cannot, of course, stand sponsors for the original writer in the *Times;* but we cannot see that this was what he intended to say; and, at any rate, this is not the voice of modern physiology as we understand it. What the physiological psychologists do affirm is this: That, whereas serious and calm intellectual work is only very slowly destructive to the nervous health, emotion, *unless directed into proper channels*, is highly destructive to the stability of the nervous system. And they further say that the conventional ideas as to the propriety and utility of certain kinds of emotional excitement do visibly bear, in the experience of medical men, the very worst fruit possible. They do not say, as the *Spectator* hints, that the emotion of repentance for *real guilt* is a thing to be shunned; but they declare that the habit of self-torturing introspection, which the clergy and teachers are especially earnest in recommending as a means of spiritual purification, is so far from promoting the existence of a really high and pure standard of ethics, that it ruins both body and soul, in the majority of cases, wherever it is applied on the large scale. More especially they believe that the habit of inducing unnecessary emotional excitement, in young persons who are just entering the dangerous period of commencing sexual life, is so morally and physically injurious to a large number of individuals, that it may well be questioned whether those individuals might not have been more safely left in total neglect and ignorance. We suspect the writer in the *Spectator* little knows—for no one but a medical man can know—the terribly doubly-edged character of all those more powerful emotions which he believes are so exalting in their effects upon the spiritual nature. Here and there, it is true, we do find some one of such stern Roman nature that he can take a torturing emotion into the recesses of his heart, and discipline himself by the pain which its repression causes, and by that pain alone. But, for the common race of man, it seems to be the duty of the physiologist to insist—first, that the immature and tender system of the young should never be exposed to the influence of any avoidable emotion, unless it be such as can be freely and harmlessly expressed, and in particular that self-invented spiritual tortures should be absolutely interdicted; and secondly, that older persons, who must be exposed to disturbing emotions, should at least be encouraged by all means to balance painful with pleasing and refining feelings, and, above all, to have confidence in the really soothing and strengthening character of regular fairly strenuous intellectual work, and the favorable influence which is exerted, even upon moral character, by the substitution of productive labor for the fluctuations of sterile excitement.—*London Lancet.*

THE ROMANCE OF MEDICINE.

By FREDERICK ARNOLD.

IN once more gathering up the threads of this subject from other years, and endeavoring to address a lay audience from a laic point of view, one would naturally desire, according to the limited measure of one's ability, to grasp some medical subject for which we all have an affinity, and which may be of usefulness to some. But in these papers I enter into an implied bargain with my readers to tell them something picturesque and odd—something that may even be romantic and sensational: but I am also troubled with the uneasy idea that I might ventilate some matters that might be for the health and happiness of some of us. I am like some honest citizen who has only got some modest extent of garden-plot, which he feels bound to lay out with flowers, but at the same time he has some yearnings toward homely but esculent vegetables; or, to vary the simile, just as mathematicians have their pure and applied mathematics, so in discussing questions of medical life and science, one desires not only to look at the subject on its abstract and literary side, but to aim at some concrete good. I will propose, *lector benevole*, that we attempt a compromise; that while, in random, discursive talk, I am permitted, as heretofore, to cull some anecdotes, thoughts, and illustrations, such as outsiders may care to gather from a particular science, I may yet dwell on matters that may be of essential home interest to us, and hope there may be a somewhat serious design and meaning underlying our *olla podrida*.

In Medicine, the first object of interest and attention is the medical man himself. An author is to me something more interesting than any thing he does in authorship; a great classic's works are only the fossil remains of a vanished world of intelligence. When patients ponder on pills and potions, I the rather wonder why they do not examine into the nature and idiosyncrasy of their medical man. They may depend upon it that, if he is worth much, he will be examining into *their* nature and idiosyncrasy. The great question for the patient to solve is, whether his doctor has got the mystic gift. He may be chuckful of science; tap him anywhere, and there will be a clear-running stream of fact and comment; but the practical question is, whether he will prove a healer to me. High science may leave a man very stupid for practice. The knowledge of things is but an adjunct to the knowledge of ends. The physician, aware, in the first instance, of all the dangers his patient is liable to, should, then, from his own knowledge, select the best means of obviating them; but, though he had the whole *materia medica* by heart, he would not be nearer his mark if he knew nothing of disease; and this is essentially the full-gotten knowledge of good and evil impressed on him through a susceptibility of his mind altogether distinct from the acquisition of natural history and chemistry. To remember well the pains and the moments of relief of all the sufferers he has witnessed is the first requisite of a physician; to couple these with their attendant circumstances, and to store them up too, is a further extension of the practical intelligence. On this foundation he ought to build a store of Nature-knowledge, of book-knowledge, and of logical acumen. As a man, prudent for himself, should remember adequately all his own pains, so a man, skilfully prudent for the sick, should remember all their pains and weaknesses in the first instance; his head should be more full of misery than the box of Pandora, and his only solace should be the hope at the bottom. This is a wise set of sentences, which I have found stored up among my medical notes and reflections, and, I believe, goes pretty deep into the heart of things medical.

If a medical man shows at great advantage in your home or in his own, there is one place in which he is too often uncomfortable, and makes other people uncomfortable as well. This is the witness-box. There is hardly any great trial for murder, but doctors and counsel come into fierce collision; there is the conflict of medical testimony, and the common-sense of judge and jury is frequently insulted. It would be a golden rule for a medical man never to use a scientific term if a popular term would serve his use as well. The medical man not only states facts, but obtrudes his explanations and theories about them, and does so in highly technical language. The legal mind revolts against the assumption of the medical mind, and in this way much prejudice is done to science. The lawyers are pretty unanimous in holding that a medical man is the worst possible witness. He cannot plead privilege, like the lawyer or the confessor, and his best plan is to tell his story at once, in the most intelligible and straightforward way that he can. The eminent German physician, Caspar, who for many years was forensic physician to the Berlin justiciary courts, is very severe upon medical witnesses: "How often have I heard physicians talking to the judge and jury of 'excited sensibility,' 'reflex movements,' 'coma,' 'idiopathic,' etc., without for one minute considering that they were using words and expressions wholly unintelligible to unprofessional parties!" Caspar's work is a perfect *thesaurus* of odd incidents and cases; and, if read, it ought to be compared with Taylor's "Medical Jurisprudence," that we may compare the difference between the English and the Prussian systems. The Prussian plan of having an accredited medical officer attached to a court, who in some sort of way is a minister of justice, is certainly an improvement on a scene not infrequently witnessed in English courts, where a criminal trial is turned into an arena for the conflict of scientific testimony.

If you take the volumes of Caspar, and Prof. Taylor's book, and throw in a little more sparkling literature, like "Christison on Poisons"—Christison, like the Fat Boy, will make your flesh creep—you will have the materials—a veritable huge quarry—out of which you may hammer all kinds of sensational and romantic stories. You may read up the murderers, just as old Boffin read up the misers. There is the eccentric Miss Blandy, of Oxfordshire, who poisoned her father as a means for promoting her matrimonial projects; the highly luxurious and wealthy people who have tried to poison, not with vulgar lead and arsenic, but with silver and gold; the aberrant wife who poured poison down her husband's open mouth as he was sleeping. Then there are cases where a three-volume plot might easily be elaborated—where a man or woman had actually taken poison, and secreted poison about the effects of an innocent person, that suspicion and punishment might be directed toward the innocent person. These are cases out of Christison. That learned professor gives a word of caution against a practice that has received considerable laudation. Some preparation of antimony "is often foolishly used, in the way of amusement, to cause sickness and purging, and likewise to detect servants who are suspected of making free with their mistress's tea-box or whiskey-bottle; and in both of these ways alarming effects have sometimes been produced."

It is curious to see the race between sin and science: how the tests of the chemist even more than keep up with the craft of the murderer. Some of our most celebrated poisons are of comparatively recent date. Prussic acid was discovered, not so very many years ago, by Scheele—though poisoning by cherry-laurel was a well-known process; and the late Mr. Palmer, of Rugeley, first brought strychnine into such felonious popularity. The toxicologists can count up their martyrs to science. It is curious to observe how each advancing wave of time blots out the records of crime. The crime that was a national event becomes a tradition—is lost in a black abyss of forgetfulness. There, so far as we are concerned, let such traditions rest.

We come back, however, to the point of departure whence we digressed. The culture of the medical man is also combined with a very large experience of life in its broadest bearings and its intensest moments. The education, instead of being confined to a single school, has very commonly been carried on at several great medical centres. Travel is more than ever becoming one of the marks of a highly-trained medical man. There is a period of leisure for nearly every medical man, which, rightly used, may be one of unspeakable preciousness and importance for him. This is the time that lies between the call to a profession and the obtaining any large share of work. As a rule, all preparatory studies have not done more than to break up the ground, and prepare it for the fertilizing process. The real work is to be done when the mind is released from tutors and governors, and can concentrate itself on the thought and work of maturer years. Travel is the opportunity that best enables a man to combine study, thought, and observation. It is astonishing what a large and increasing space is occupied in medical life by travel. It is now not at all uncommon for English medical students to spend a great deal of time at the medical schools of Paris and Vienna. They generally prefer Paris to Vienna, and London to either. The best medical men more than ever seem to be familiarized with the scientific medical thought of Germany. The custom of going out as medical officer to vessels is very largely on the increase. Many young men go with the steamers that traverse the regular ocean thoroughfares. Men who have risen to, or descended from, eminence have been glad to take positions on the great lines of steamers. They are found a most agreeable addition to all the social arrangements—with the drawback, however, of being obliged to subsist in a chronic state of flirtation. Others take longer voyages, and, generally speaking, seek a more adventurous line of life. Thus there are, among men I have known, those who have gone to the Greenland seas, round Cape Horn, to Australia, to India, and the Pacific islands, and have gone, again and again, induced by the divine passion for knowledge and travel. There would be many competitors for the place of medical officer to travel with some of the expeditions that nowadays go round the world. What such travel might be can be seen, with admiring despair, in Darwin's "Voyage of the Beagle." Then many people, when they travel, are neither easy nor happy unless they can afford the luxury of a "medical attendant." Some of the best specimens of medical literature that we have are due to this interesting class of medical men. A Milor on his travels likes a parson, a doctor, and a traveller's major-domo; but the doctor is least easily dispensed with. In this way, by the medical education abroad, by travelling engagements, and by taking appointments on board ship, we have a travelled class of medical men who represent, perhaps, the most interesting, and certainly the most amusing, section of the profession. Wherever in this wide world the medical man goes, he can carry his work with him and his own letter of introduction. The wants which surgery and medicine relieve speak their own vehement, universal language, and stand in need of no interpreter. The lawyer can do no good with his law when once he is out of England. The clergyman must learn the language of the natives, and find his opportunity and his audience. But the medical man speaks the universal language, inasmuch as he answers a universal need. The philosopher and the parson can never be quite sure that they have done any good; the good is so remote and hidden, and it rarely happens that it is ascertained. But the surgeon goes to a man in a state of positive torture, and by a happy bit of carpentering puts him to rights, gives the intense happiness of a sudden cessation from intense pain, and at once earns a thrilling amount of very transitory gratitude. It would be only reciting truisms to speak of the immense generous good they achieve. The amount of self-denying generosity which a physician can practise, and does, is simply incalculable, and there are, indeed, few of us who could not easily furnish a collection of instances.

The curiosities of medical life and practice are endless. If we hear very often of medical men doing arduous work for very scanty remuneration, sometimes there is an agreeable obverse of receiving very splendid remuneration for very scanty services. We know of a medical man whose duty it is to take lunch every day at a great castle belonging to a noble lord. The household is immense; and there is just the chance that there may be some case of indisposition demanding attention. He gets some of the best company and best lunches in England, and duly charges a guinea for each attendance. There is a very wealthy man near a great city, who cannot bear to be left for the night. There is a physician of great ability who drives out of town nightly to sleep at his residence; he is consequently debarred evening society, and if he goes out to dinner he has to leave his friends before wine. He has to charge his patient a thousand a year; and, I think, he works hard for his money. Sometimes the services are such that money cannot repay them. A friend of mine, a young medicus, had a standing engagement of four hundred a year to look after the health of an old lady. She required to be inspected three times a day, and make an exhibition of tongue and pulse. What made matters so aggravating was, that she was as strong as a horse, while the doctor was a delicate man. She was so selfish and perverse, that he was obliged to tell her that he would have nothing to do with her case. Similarly, I have known the son of a rich man who proposed to pay a clergyman several hundred pounds a year for leave to spend his evenings with him. The parson, however, was obliged to tell his rich friend that he talked such intolerable twaddle, that he could not accept his company on any terms that could be named! But the oddest of these arrangements is the following: A medical man has been attending a patient several years, and yet he has never seen his patient. The gentleman firmly believes that he has an œsophagus of peculiar construction, and that he is accordingly liable at any moment to be choked. That help may be at hand whenever any sudden emergency may occur, he has a physician in the house night and day. The physician, being human, must needs take his walks abroad, and it becomes necessary to provide a substitute for him two hours a day. Accordingly a doctor attends daily from twelve to two, fills up his time by disposing of an admirable lunch, and finds the gold and silver coin, in their usual happy combination, neatly put by the side of his plate, in tissue-paper. Up to the present date he has never had the pleasure of exchanging words with his interesting patient.

It is in medical biography, or, rather, medical autobiography, that we must look for our most valuable and authentic instances. Medical literature is not rich in this way; some half-dozen volumes would nearly include the whole. It is to be regretted, indeed, that the best medical men write the least; those who have obtained the highest rank in their profession, and who would have most of science, most of incident to impart. There is all the difference in the world between books that are written to obtain practice, and books that are written out of the fulness of practice. . . . In medical autobiography we have such charming narratives as those written by Sir Benjamin Brodie and Sir Henry Holland. There is no doubt that even fictitious narratives, such as "Early Struggles," in the "Diary of a Late Physician," really give us facts substantially as true as any which we find in regular memoirs. I myself know physicians of singular learning and ability, who for half a dozen years have not taken half a dozen guineas a year. Other men, by the happy use of dress and address, though inferior, leave them far behind. One instance is on record which might well be worked up into some narrative like Mr. Warren's. An able man waited and waited hopelessly till ruin stared him in the face. One night, when brooding on his miseries, he heard a bell ringing violently at his surgery door. Opening it, he found that a man had been thrown out of his cab and nearly killed, and they wanted to bring him into the surgery. The medical man found that there were concussion of the brain and dislocation of the shoulder-joint. His card-case showed that he was a man of birth and a well-known politician. He stopped some time at the surgeon's house, who was thus enabled to lay the foundation of a large and lucrative connection.

Dr. Denman, the father of the great Lord Chief Justice, and the grandfather of our new judge, who has so worthily been promoted to the bench, which he will adorn, prefixed an autobiographical narrative to his "Introduction to the Practice of Midwifery." He was educated at the Free School at Bakewell, and, going up to London to study at St. George's Hospital, he boarded and lodged with a hair-dresser at half a guinea a week. In six months his money was gone, and he thought, as a desperate chance, he might get a surgeon's appointment on a king's ship. To his great astonishment, he passed, but he had to pawn his watch before he could join his ship. Once he tried to set up a practice, but he was obliged to betake himself to the royal navy again. However, he tried again. "I had taken a small house in Oxendon Street; but I furnished only one parlor, thinking to complete it gradually as I was able, and I hired a maid-servant, who cheated me very much. When I went into this house, excepting my furniture, I had but twenty-four shillings in the world, but I was out of debt." He got on gradually, made a very happy marriage, bought houses, bought land, kept his coach, and, what, as a Bakewell man, pleased him immensely, he was called in to attend the Duchess of Devonshire. "I was made happy," he writes, "by the birth of a son, which was an unexpected blessing, as I had given up all hopes of having any more children." This son was the celebrated Lord Chief Justice. In time, Dr. Denman became the head of his profession.

Many similar instances might be supplied. Even John Hunter had to make his way amid the greatest difficulties, having to satisfy his brother William of his genius before he could satisfy the outside world. Sir James Simpson is another instance of a man who might have taken *nitor in adversum* as his motto. He was one of the poorest of poor students who flock to a Scottish university. There is a pretty little village called Inverkip on the Frith of Clyde, near which is Sir Michael Shaw Stewart's great place. He applied for the office of village surgeon, but, not having any local influence, the appointment was refused him. Sir James used to say that he felt a deeper amount of chagrin and disappointment from this circumstance than from any other event in his life. Going before a famous pathologist for examination, the examiner was so pleased with him that he asked him to become his assistant. When Simpson became a candidate for the chair of Midwifery at Edinburgh, the great local interests were again enlisted against him. It was alleged that his election would be prejudicial to the interests of hotel-keepers and city tradesmen, for it was not likely that many strangers would be induced to visit Edinburgh for the purpose of getting professional advice. It was not for the first time that the highest intellectual interests had been imperilled at Edinburgh by such petty considerations. As a matter of fact, no physician ever attracted such a number of visitors; the invalids came in shoals. Simpson once told his pupils that many of his best papers were written by the bedsides of his patients. His great principle, when he met with any apparently hopeless case, was to interrogate what Nature did in the rare instances in which she effected cures. Simpson's great discoveries may be here enumerated; they form the most thrilling page of modern medical history. His first great achievement was that he procured chloroform undiluted, and discovered the effects of the vapor. This great discovery alone would suffice to associate his name with that of Harvey. That night of the 28th of November, 1847, is much to be remembered, when this great discovery was made. He then demonstrated the possibility of banishing pain and subjecting it to human control. There are now a great many manufactories of chloroform in Edinburgh alone—one that makes several million doses a year. His great surgical invention is acupressure—stopping blood from cut arteries by the use of metallic needles. His third great achievement was his contributions to that great work in which Dr. William Budd has preëminently labored. This is to endeavor to *stamp out* contagious diseases as completely as the poleaxe could exterminate the rinderpest. His last great work was in the direction of hospital reform. How was it, he asked, that, in the hospital, the mortality in cases of amputation was one in 30, and elsewhere one in 180? Hospitalism has its special evils, that are fatal in these palaces of human suffering. Sir James Simpson's final suggestion goes to the root of the matter—that all staircases, etc., should be outside the building, and that no one ward should ever have even the slightest chink of communication with another.

This last reform of Sir James Simpson's is especially important. It is not too much to say that all the great triumphs of surgery, such as those in lithotrity and ovariotomy, have been practically neutralized by foul hospital air, to which is due one-half of the deaths in our great metropolitan hospitals. In surgical wards there is a condensation of foul air, and, in addition, the specific poisonous effluvia given off by foul air. Mr. Spencer Wells is famous for that wonderful operation by which the lingering agony of years is prevented by the knife being used under anæsthetics. He generally uses the new anæsthetic methylene, which, in many cases, is preferable to chloroform. He found that there was a large mortality in hospitals, which was reduced to one-eighth in private practice. St. George's Hospital has now a small institution for ovariotomy at Wimbledon, an example which may be extensively followed. It is to be hoped that in the magnificent sea-side institutions that are so much increasing among us there will be a conspicuous adherence to the principle of the cottage hospital. The National Hospital at Ventnor is constructed on the cottage principle, and we have before had occasion in these pages to testify to its wonderful efficiency.

A case, which, some time ago, was tried in the Court of Queen's Bench, illustrates, in a striking manner, some of the dangers that belong to the annual national migration to the sea-side, and also suggests some very large and important considerations affecting the national health. Without going fully into the details of a peculiarly painful case, it will be sufficient to mention the salient facts. Sea-air having been ordered for a child by a medical man after an attack of scarlatina, a lady took her nurse, governess, and children, to the coast, and hired apartments without telling the lodging-house keeper of the nature of the illness in her family. After a time this most infectious of all infectious diseases broke out afresh, apparently from the neglect of the proper disinfecting processes, and the poor lady lost two of her children, and the unhappy landlady of the lodging-house also lost two little ones. The anguish of parental grief cannot be measured by a pecuniary standard, but actual medical and funeral expenses, and the injury done to the course of business, are susceptible of being assessed, and the jury gave the lodging-house keeper substantial damages. It is impossible not to feel commiseration for the sea-side visitors who experienced this blow in addition to their own calamities, but the verdict was not unwarranted by the facts, nor, to use regretfully a harsh word, undeserved. Those who are acquainted with the history of special classes among the poor are aware how much deadly illness there has been at times in the families of laundresses and pawnbrokers, who have had under their charge the raiment of fever-patients, to which no purifying process had been applied. (Still greater mischief has been done by milk which has been adulterated with water taken from some impure source.) We know, also, of cases where lodgings or furnished houses have been let, in the holiday season of the year, after the occurrence of contagious illness, and yet no disinfectants have been used, and no honest warning has been given. It must increasingly be felt how necessary are some caution and judgment in making holiday arrangements. It is comparatively easy for a lodging-house keeper to recover damages from a well-to-do family in a case where fever has been propagated through a want of care and candor; but, if the converse case had occurred—and it happens in at least an equal degree—it is hardly likely that substantial damages could be obtained from the landlord, even if bereaved fathers, in their grief, should be inclined to seek them. Scarlet fever slays in this country annually some twenty thousand people, and disables, more or less, for a longer or shorter time, a hundred thousand more. Yet, humanly speaking, the larger amount of this mortality might be averted by the processes of disinfection, separation, and, we may add, a religious adherence to truth.

It is not pleasant to think of the successive steps in the history of the sad case to which we have alluded, yet they illustrate the dangers of the travelling public, and might explain the apparently mysterious origin of many a similar attack. The mischief arose with a convalescent patient going to the sea-side. We easily picture him going to the terminus in a London cab, travelling in a public railway-carriage, then travelling in another public conveyance, and finally deposited in a public lodging-house. Early convalescence is often a most dangerous period in the disorder, when minute particles from the skin—invisible, impalpable—take wings, and become elements of danger, multiplying seeds of disease and death. It is safer to travel in a carriage with parcels of nitro-glycerine than with such a patient. If our national sanitary arrangements were in a satisfactory state, such a case would be certified from the London to the local physician, and, both on road and rail, special carriages would be provided, or the ordinary carriages be at once disinfected. Or if, as is usual in this country, such things must be left in private hands, there is a proper treatment which would entirely, or almost entirely, annihilate the danger of contagion. Many of our readers will recollect the piteous case set forth some time back by Dr. Bradley, the present head of University College, when he was head master of Marlborough College. He wanted to know, in the columns of the *Times*, and various afflicted parents made the same inquiry, when it would be safe for a boy recovering from scarlet fever to return to his home. Scarlatina is almost the one terrible rock ahead which public and private schools have to fear. Many of us know very sad stories of the premature deaths of the young, and the losses and even ruin of school-masters through this terrible visitation. It is not every school which has the vitality of Marlborough College to withstand such trials. In answer to these appeals, the whole theory and practice of disinfection were clearly set forth by competent medical authority. Such obvious methods were suggested as the isolating the patient, the anointing him from head to foot with camphorated olive-oil, the destruction or most thorough cleansing of all things infected, the use of entirely untainted clothes; and then we are assured that patients might be restored to society after a very limited quarantine. The natural apprehension would be that these simple means might not prove sufficient; but the real fact is, that it is extremely difficult to make people resort even to such simple means as these. Not one hundredth part is found of the energy in preventing disease that is employed in attempting to work its cure. What is wanted is a wider teaching of the elementary principles of such matters, and a greater degree of courage and conscience in applying them.

The fact is, that the prevention of diseases should be more regarded than it is, as a true end and scope of medical science. It is to the credit of medical men that they are more and more devoting their best energies in this direction. The skill of medical diagnosis has been carried to the utmost, but not with the result of any corresponding subjugation of disease. Indeed, it is a humiliating fact that, in those chest-cases where medical science has made the most marvellous discoveries, the actual amount of disease is probably greater than ever it was. The doctors are even quarrelling among themselves, whether certain illnesses are contagious or non-contagious. There is no doubt that scarlatina is contagious; but, at the time of the illness of the Prince of Wales, it was sharply debated whether typhoid fever was infectious or not. Even the fact of such a discussion is hardly creditable, for it might have been thought that scientific men, by a scientific induction of facts, could have set such a question at rest by this time. But we feel quite certain, especially in days when people travel and sojourn away from home, that no case of illness should be found to exist which any opinion entitled to respect should consider infectious, but it should be surrounded with safeguards, and so be saved from becoming the source of those terrible domestic tragedies with which we are all so unhappily familiar.

We have now brought our readers to a point to which we have been working up in the course of this paper, a point of extreme practical importance and urgency, on which the opinions of the public and their suffrages should be collected. We wish to draw more particular attention to a subject which we have just lightly touched on, one which we believe cannot be too much ventilated and discussed among general readers, and on which they are qualified to form an opinion, and to take action upon it. The theory involved is extremely simple and interesting, albeit strictly scientific; but the practical importance of it is enormous. Somewhere in the dim perspective many of us can discern the promise of a golden age, when all curable accidents will be cured, and all preventible diseases will be prevented. There can be no doubt but a simple contagious disease is susceptible of being stamped out. We stamped out the cattle-plague, and, if the plagues of men touched the same obvious and immediate pecuniary interests as the plagues of cattle, we might stamp out similar calamities among human beings. To a certain extent the history of the small-pox shows how much can be done this way. In the remarks we are about to make we most especially acknowledge our obligations to Dr. William Budd's writings and teachings on the subject, who has developed his views, full of import to the happiness and well-being of humanity, with immense ability and experience, and much literary skill. The theory is, that any contagious disease can be eradicated; or, at all events, limited within a very slender area; and that various diseases are in reality contagious, such as typhoid fever and consumption, where the ordinary medical and general mind does not admit the fact of the contagiousness. If we resort to the primitive processes of counting noses, or listening for the largest amount of shouting, we shall decide against the theory; but at present legitimate argument and logical deduction appear to be in its favor.

Mr. Disraeli's policy was lately denounced as a policy of sewage. What has been called by some a policy of sewage, has been more properly called by others a question of life and death. We do not mind Mr. Disraeli and his friends having a policy of sewage, but it is essential that the policy should be accurate and enlightened. The advocates of the contagion theory have no weakness for sewage, especially in an olfactory point of view. They say, also, that it places disease under the most favorable conditions for the consummation of its evil mission. But they assert, in opposition to former theories of the Board of Health—that has an unlimited command of print and pay—that sewage, in itself, does not breed fever and infection, unless it is charged with specific ingredients of contamination. Infectious diseases are only communicated by the virus of specific poison. Many of us, in the course of the holiday season of the year, accumulate a collection of instances on the subject. In the famous cities of the Continent, and in exquisite Swiss villages, we have the most noisome stinks and sights, yet we hear nothing of fever. In fact, it almost seems a rule that, where Heaven throws the greatest beauty and magnificence, man should exhibit the greatest abominations. Natural beauty goes, like King Cophetua's beggar-maid, in rags. Clovelly, in Devonshire, is the most romantic spot we know in the western land, and, till recently, it was the most undisguisedly dirty. But all through the west of England, and, indeed, we are afraid, all over the three kingdoms, we shall find lovely villages that, despite their loveliness, will give the utmost offence to sight and smell. Yet, for whole decades of years, no infectious illness is heard of in these villages; and then, suddenly, fever or small-pox breaks out, and, to say the least of it, simply decimates the humble inhabitants. The contagionists will assert that the evil state of things was comparatively harmless until charged with a specific virus. One fact bearing on the subject will be fresh in the recollection of all readers. Many years ago, the Thames began to stink horribly in the hot months. The law courts broke up, the Houses of Parliament were saturated with chloride of lime, the river steamers lost their traffic, and business-men went miles out of their way, in order to avoid crossing a city bridge. "India is in revolt, and the Thames stinks," were the two national humiliations bracketed by our severe friend "the intelligent foreigner." It so happened, also, that a Thames waterman died of the cholera; and that unfortunate waterman created the utmost consternation in the country. A frightful outbreak of cholera and fever was expected. But nothing of the kind happened. The health of the metropolis was remarkably good; the death-rate below the average, especially in the diseases supposed to result from poisonous emanations. There was certainly a failure in the supposed connection between epidemics and a bad sanitary state of things; and the suggestion arises that we were mercifully saved the introduction of some element that might have wrought all the misery we dreaded.

When the Prince of Wales was ill, we all of us, unhappily, acquired some kind of notion on the subject of typhoid fever. Each morning paper became a kind of daily *Lancet.* It is not much to the credit of the medical profession that there has been a great deal of confusion between typhus and typhoid. The latter, from which our prince suffered, is totally distinct from typhus, and has its own distinctive marks, as much as small-pox itself. An eminent physician suggests that it should be called the *pythogenetic* fever, which is, however, begging the question at issue, which is the great medical problem of our time, whether this disease is the result of malaria or of contagion. Dr. Budd argues that as it is in typhoid fever, so it is in small-pox; as it is in small-pox, so it is in measles; as it is in measles, so it is in scarlatina; as it is in scarlatina, so it is in malignant cholera: amid all varying phenomena, *one thing constant, a specific morbid cause,* "a cause which is neither a permanent product of the soil, nor of the air, nor of particular seasons, but which is susceptible of transmission from place to place; which breeds as it goes, and then again dies out, or becomes dormant, without leaving any sign to mark its track."

The slaughter of the Franco-Germanic War is repeated year by year in England by preventible diseases. This enormous mass of disease furnishes ample material for infection on every side. A most infinitesimal germ, invisible, impalpable, would suffice to infect a single human body, and that body might suffice to infect very many others. It may be said that the link of connection is not always sufficiently clear between the infector and the *infectee.* In a vast proportion of cases this is clear enough, and it is no argument where it is not. People have been taken ill of small-pox even in prison, under solitary confinement; yet how could we doubt of real though remote infection? Let each individual do his part in the holy crusade against ignorance and disease. Let it be asked, amid contemplated legislation, whether the state cannot give effectual hope. We may then hope to transmit to our children their heritage of earth and time less stained by scalding tears and passions of regret than it has been to us and to our fathers.—*London Society.*

THE EXPRESSION OF THE EMOTIONS.

WHATEVER may be the ultimate verdict as to the truth of those views which are associated with the name of Darwin, it certainly cannot be denied that Mr. Darwin himself has a profound belief in them. The work which he has just published, under the title "On the Expression of the Emotions in Man and Animals," is a new test to which he subjects his own doctrines. He considers the subject from the point of view of evolution, and, though many may consider that he is far from having established his case, it will be admitted by every reader that he has thrown much new light upon it, and made a most fascinating and instructive book. Mr. Darwin distinguishes between physiognomy and expression. The former is statical, the latter dynamical. Physiognomy aims at the recognition of character through the study of the permanent form of the features. Expression, on the other nand, deals with actions, or the play of features and gesture in man and animals, as constituting the natural language of the feelings. Much has been written upon the subject of Expression by men of various countries, but Mr. Darwin recognizes that Sir Charles Bell, in his "Anatomy and Philosophy of Expression," published in 1806, not only laid the foundations of the subject as a branch of science, but built it up into a noble structure. Mr. Darwin is of opinion that the subject has hitherto been pursued by a false method, or has been vitiated in its treatment by erroneous assumptions. Bell, Gratiolet, Duchenne, and the other leading writers upon the question, have dealt with it on the old hypothesis, that the different animal species came into existence just as they are now, wholly distinct from each other; but Mr. Darwin maintains that, so long as man and all other animals are viewed in this way as independent creations, the true philosophy of the subject cannot be reached. The simple before the complex; the lower forms of life as interpreting the higher, and the whole as a connected scheme of development, is now the method of biology, and for this investigation it is, therefore, necessary to study the manifestations of character in their simplest forms.

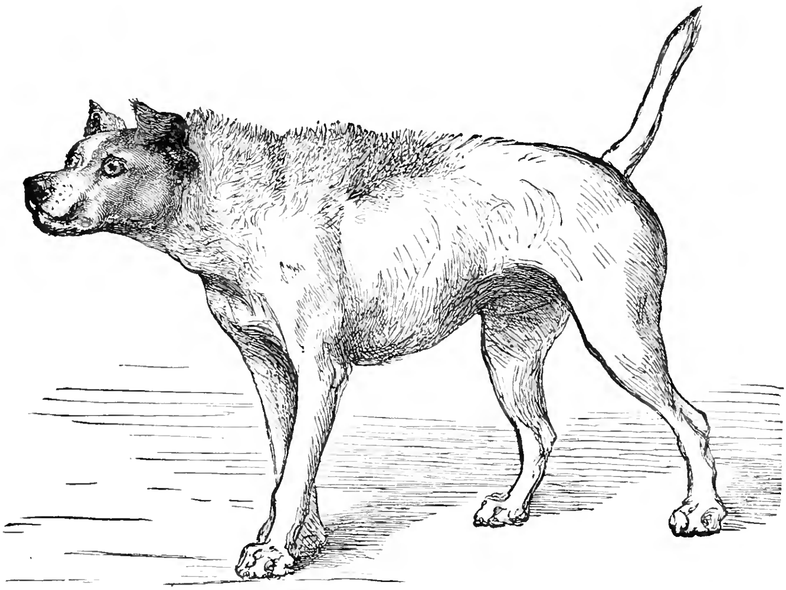
An able writer in the *Saturday Review* summarizes Mr. Darwin's views as follows: "The tendency to draw as broadly as possible the distinction between man and brutes led Sir Charles Bell to deny to the lower animals any expression beyond what might be referred more or less plainly to acts of volition or necessary instincts, their faces seeming to him to be chiefly capable of expressing merely rage or fear. The facial muscles in man he thought to be a special provision for the sole object of expression, and so far distinctive of humanity. But the simple fact that the anthropoid apes possess the same facial muscles that we do, renders it most improbable, apart from any reference to teleology in general, that we were endowed with these muscles for any such purpose, still more that monkeys had special muscles given to them solely for the purpose of exhibiting their hideous grimaces. Since distinct uses can, with much probability, be assigned to almost all the facial muscles, we may look upon expression as but an incidental result of muscular or organic function. Mr. Darwin's early inclination toward the doctrine of evolution, or the origin of man from lower forms, led him five-and-twenty years ago to regard the habit of expressing our feelings by certain movements, innate as it has now become, as having been in some manner gradually acquired at the first. Seeking back for the origin of movements of this kind, he, in the first place, was led to observe infants, as exhibiting emotions with extraordinary force, as well as with a simplicity and an absence of convention which cease with more mature years. Secondly, the insane had to be studied, being liable to the strongest passions, and giving them uncontrolled vent. Dr. Duchenne's ingenious application of photography, representing the effects of galvanism upon the facial muscles of an old man, gave some assistance toward distinguishing varieties of expression. Less aid than was expected was found to be derived from the study of the great masters in painting and sculpture; beauty in works of art excluding the display of strong facial muscles, and the story of the composition being generally told by accessories skilfully introduced. More important it was to ascertain how far the same expressions and gestures prevail among all races of mankind, especially among those who have associated but little with Europeans. With this view a list of 16 questions was circulated by Mr. Darwin within the last five years, to which 36 answers have been received from missionaries, travellers, and other observers of aboriginal tribes, whose names are appended to Mr. Darwin's introductory remarks. The evidence thus accumulated has been supplemented by the close and keen observation of the author himself through a wide range of animal life. It seemed to him of paramount importance to bestow all the attention possible upon the expression of the several passions in various animals, not, of course, as deciding how far in man certain expressions are characteristic of certain states of mind; but as affording the safest basis for generalization on the causes or the origin of the various movements of expression. In observing animals we are not so likely to be biassed by our imagination, and we may feel sure that their expressions are not conventional.

"As the result of his observations, Mr. Darwin has arrived at three principles, which appear to him to account for most of the expressions used by man and the lower animals under the influence of various emotions and sensations. The first of these is the principle of serviceable associated habits. Movements which are of service in gratifying some desire, or in relieving some sensation, become by repetition so habitual that they are performed, whether they are of any service or not, whenever the same desire or sensation is felt, even in a very weak degree. Actions, which were at first performed consciously, become, through habit and association, reflex or automatic—the sensory nerve-cells exciting the motor nerve-cells, without first communicating with those cells on which our consciousness and volition depend. Starting at the approach of danger, and blinking with the eyelids so as to protect the eyes, become perfectly spontaneous. Reflex actions, too, gained for one purpose, may be modified independently of the will or of habit, so as to serve for some other distinct purpose; or, they may be developed through natural selection. And they are thus often brought into play in connection with movements expressive of emotion. When movements associated through habit with certain mental states are partially repressed by the will, the strictly involuntary muscles retain their action, and may be highly expressive; and when, on the other hand, the will is relaxed, the voluntary muscles fail before them. Debility of the brain, Sir C. Bell remarked, is most shown in the case of those muscles which are in their natural condition most under the control of the will. A further mode of expression arises when the checking of one habitual movement calls up another.

"The second principle is that of antithesis. When certain movements or gestures have been acquired as aforesaid, and have come to be habitually performed in connection with a certain state of mind, there will then be a strange and involuntary tendency under the opposite state of mind to directly opposite movements, whether in any way serviceable or not. Hence alone, Mr. Darwin thinks, can be explained, not only the sudden and extreme changes of expression in the attitudes of animals, but many gestures used by savages, or by the deaf and dumb. This antithesis in attitude, from anger and defiance to affectionate crouching, is illustrated by him in the case of the dog and the cat, by means of photography. The Cistercian monks, among whom speaking was sinful, invented a gesture language, founded upon the principle of antithesis. It is clear that in this principle the will intervenes largely.

"Mr. Darwin is, however, less confident in referring expressive signs or gestures to the action of this principle, than to his third originating cause, *the direct agency of the nervous system.* When the sensorium is strongly excited, nerve-force is generated in great excess, and is transmitted in certain directions, determined by the connection of the nerve-cells, or, where the muscular system is concerned, by the nature of the movements of face or limb, which correspond to each nervous impulse. These are, at the first, at least, independent of the will, or even of habit, though in later stages habit may have considerable play, inasmuch as nerve-force tends to pass along accustomed channels. Mr. Darwin inclines to think that what seem the most strictly involuntary actions, such as the bristling of the hair in fear or anger, may have been effected by the mysterious power of the will. He is far, however, from laying down dogmatic views upon the operation of these various agencies in causing or varying expression, nor is he prepared to draw sharp lines between the action of his three elementary principles. Many phases or signs of expression may partake, he considers, of all three, and may be referable to no single or direct physiological cause. The visible apparatus of expression may of course be taken as muscular, and he begins with laying down diagrams of the various muscles of the face in man, those in particular which are connected with the eyes and mouth. . . . . Suppose we take as an illustration the oblique or upturned eyebrows of a man suffering from grief or anxiety. Every one must be familiar, both from Nature and works of art, with the way in which the inner angle of the eyebrow is drawn up under this emotion, the forehead being contracted or wrinkled at the same time. Mr. Darwin evolves the origin of this involuntary movement, through the same logical train of sequence by which we have seen him, in his earlier and more elaborate works, draw out the extraordinarily complex chain of laws, which runs through natural history. When infants scream loudly from hunger or pain, the circulation is affected, and the eyes tend to become gorged with blood. In consequence, the muscles surrounding the eyes are strongly contracted by an involuntary action as a protection. This action, in the course of many generations, has become firmly fixed and inherited. With advancing years and culture, the habit of screaming is partially repressed; but the muscles round the eyes still tend to contract when-

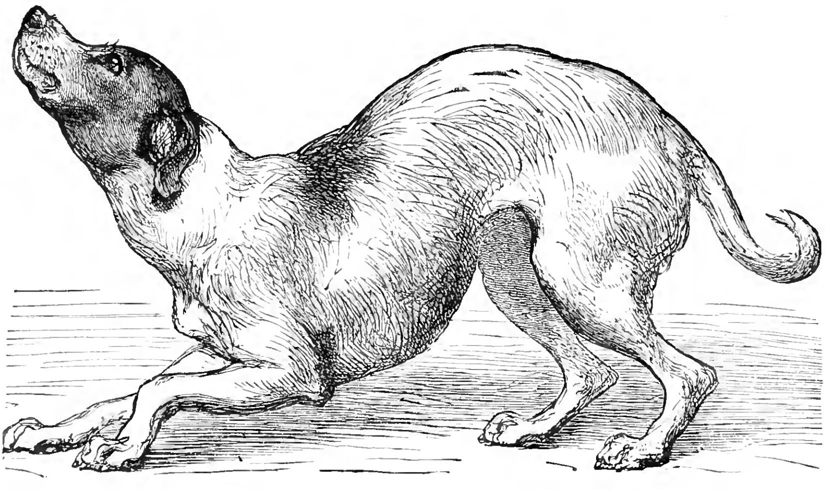
Fig. 1.



Dog approaching another Dog with Hostile Intentions.—(By M. Riviere.)

ever even slight distress is felt. Of these the pyramidal muscles of the nose are less under the control of the will than the others, and their contraction can be checked only by that of the central fasciæ of the frontal muscle. These latter fasciæ draw up the inner ends of the eyebrows, and wrinkle the forehead in the peculiar manner which we immediately recognize as the expression of grief or anxiety. Laughter and tears form media of expression, which have been often subjected to analysis, but never with the same physiological minuteness and precision as in Mr. Darwin's special chapters on the phenomena of the vaso-muscular and nervous systems. The excess of nervous energy produced by pleasure and enjoyment, passing on by an efflux through the motor nerves to various classes of the muscles, finds a vent in joyous merriment, dancing, clapping the hands, and, above all, in emissions of sound and motions of the zygomatic muscles, which draw the mouth backward and upward. From the manner in which the upper teeth are exposed in laughter and broad smiling, Mr. Darwin cannot doubt that some of the muscles running to the upper lip are likewise brought into moderate action. The upper and lower orbicular muscles of the eyes are at the same time more or less contracted, while the contractile force exerted upon the vessels or glands of the eye causes the same flow of tears in extreme laughter as in sorrow. Both laughing and weeping are seen in a minor degree in many of the lower animals. In children tears do not flow, Mr. Darwin assures us, at the first, but are induced by the effect of prolonged screaming, in gorging the vessels of the eye. This suffusion, leading at first consciously, and at last habitually, to the contraction of the muscles round the eyes, in order to protect or relieve them, the lachrymal glands become affected through reflex action. Thus, although in the

FIG. 2.



THE SAME IN A HUMBLE AND AFFECTIONATE FRAME OF MIND.—(By M. Riviere.)

first instance a merely incidental result, as purposeless as the secretion of tears from a blow outside the eye, or as a sneeze from bright light affecting the retina, we may understand how the shedding of tears serves as a natural relief to suffering."

Mr. Darwin's work is profusely illustrated by woodcuts and photographs of the human face, and of the attitudes and expressions of various animals. We give some of his figures, with his accompanying descriptions, exemplifying the principle of antithesis in the dog and cat.

He says: "When a dog approaches a strange dog or man in a savage or hostile frame of mind, he walks upright and very stiffly; his head is slightly raised, or not much lowered; the tail is held erect and quite rigid; the hairs bristle, especially along the neck and back; the pricked ears are directed forward, and the eyes have a fixed stare. (*See* Figs. 1 and 3.) These actions, as will hereafter be explained, follow from the dog's intention to attack his enemy, and are thus to a large extent intelligible. As he prepares to spring with a savage growl on his enemy, the canine teeth are uncovered, and the ears are pressed close backward on the head; but with these latter actions we are not here concerned. Let us now suppose that the dog suddenly

Fig. 3.

Half-beed Shepherd Dog in the same State as in Fig. 1.—(By Mr. A. May.)

discovers that the man whom he is approaching is not a stranger, but his master; and let it be observed how completely and instantaneously his whole bearing is reversed. Instead of walking upright, the body sinks downward or even crouches, and is thrown into flexuous movements: his tail, instead of being held stiff and upright, is lowered and wagged from side to side; his hair instantly becomes smooth; his ears are depressed and drawn backward, but not closely to the head; and his lips hang loosely. From the drawing back of the ears, the eyelids become elongated, and the eyes no longer appear round and staring. It should be added that the animal is at such times in an excited condition from joy; and nerve-force will be generated in excess, which naturally leads to action of some kind. None of the above movements, so clearly expressive of affection, are of the least direct service to the animal. They are explicable, as far as I can see, solely from being in complete opposition or antithesis to the attitude and movements which, from intelligible causes, are assumed when a dog intends to fight, and which consequently are expressive of anger. I request

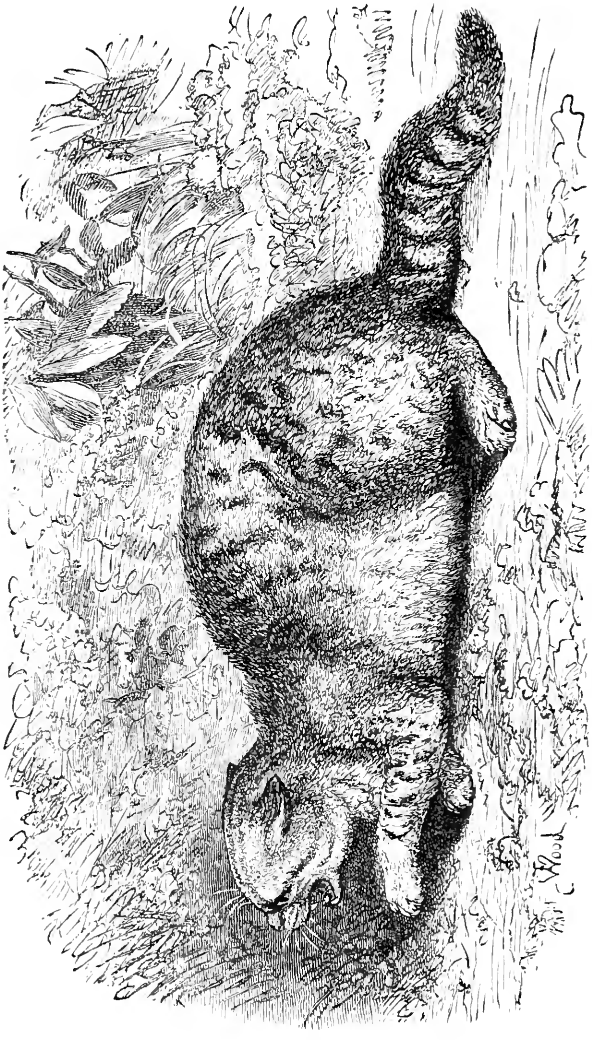
Fig. 4.

The same caressing his Master.—(By Mr. A. May.)

the reader to look at the four accompanying sketches, which have been given in order to recall vividly the appearance of a dog under these two states of mind. It is, however, not a little difficult to represent affection in a dog, while caressing his master and wagging his tail, as the essence of the expression lies in the continuous flexuous movements.

"We will now turn to the cat. When this animal is threatened by a dog, it arches its back in a surprising manner, erects its hair, opens its mouth and spits. But we are not here concerned with this well-known attitude, expressive of terror combined with anger; we are concerned only with that of rage or anger. This is not often seen, but may be observed when two cats are fighting together; and I have

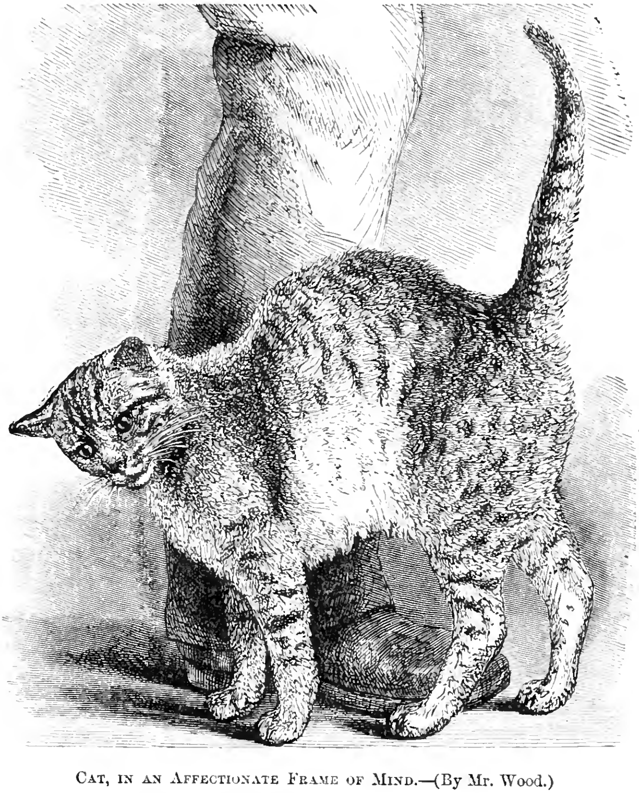
Fig. 5.



Cat, savage and prepared to fight.—(Drawn from Life by Mr. Wood.)

seen it well exhibited by a savage cat while plagued by a boy. The attitude is almost exactly the same as that of a tiger disturbed and growling over its food, which every one must have beheld in menageries. The animal assumes a crouching position, with the body extended; and the whole tail, or the tip alone, is lashed or curled from side to side. The hair is not in the least erect. Thus far, the attitude and movements are nearly the same as when the animal is prepared to spring on its prey, and when, no doubt, it feels savage. But, when preparing to fight, there is this difference, that the ears are closely pressed backward; the mouth is partially opened, showing the teeth; the fore-feet are occasionally struck out with protruded claws; and the animal occasionally utters a fierce growl. (*See* Figs. 5 and 6.) All, or almost all, these actions naturally follow (as hereafter to be explained) from the cat's manner and intention of attacking its enemy.

FIG. 6.

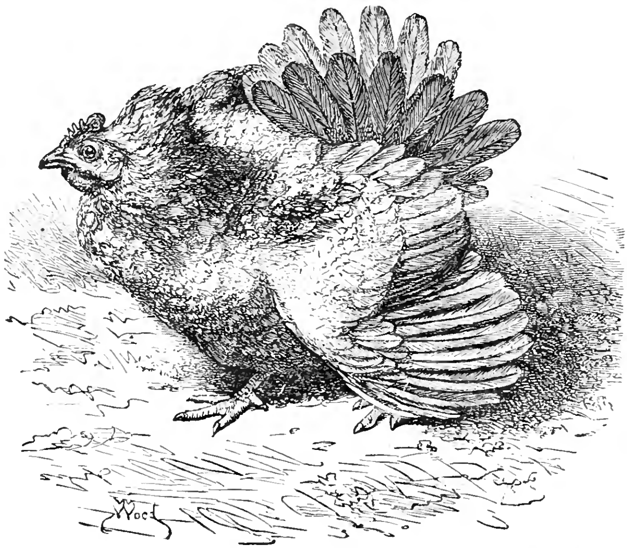


CAT, IN AN AFFECTIONATE FRAME OF MIND.—(By Mr. Wood.)

"Let us now look at a cat in a directly opposite frame of mind, while feeling affectionate and caressing her master; and mark how opposite is her attitude in every respect. She now stands upright, with her back slightly arched, which makes the hair appear rather rough, but it does not bristle; her tail, instead of being extended and lashed from side to side, is held quite stiff and perpendicularly upward; her ears are erect and pointed; her mouth is closed; and she rubs against her master with a purr instead of a growl. Let it further be observed how widely different is the whole bearing of an affectionate cat from that of a dog, when, with his body crouching and flexuous, his tail lowered and wagging, and ears depressed, he caresses his master. This contrast in the attitudes and movements of these two carnivorous animals, under the same pleased and affectionate frame of mind, can be explained, as it appears to me, solely by their movements standing in complete antithesis to those which are naturally assumed, when these animals feel savage and are prepared either to fight or to seize their prey.

"In these cases of the dog and cat, there is every reason to believe that the gestures both of hostility and affection are innate or inherited; for they are almost identically the same in the different races of the species, and in all the individuals of the same race, both young and old."

Fig. 7.

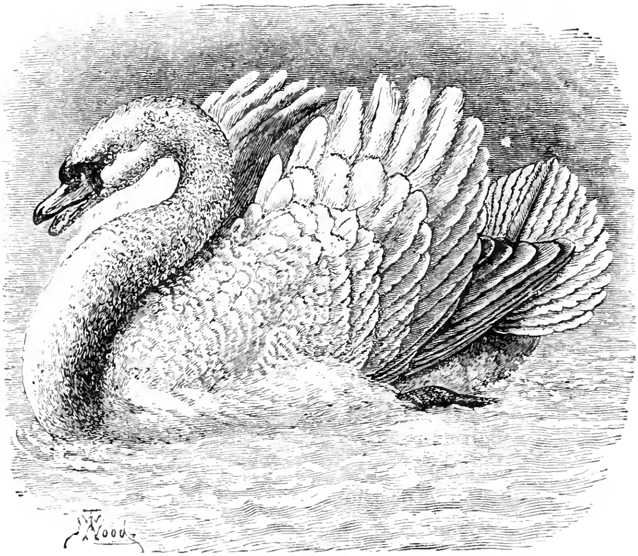


Hen driving away a Dog from her Chickens.—(Drawn from Life by Mr. Wood.)

Mr. Darwin has an interesting chapter on the erection of the dermal appendages as expressive of emotion. He observes: "Hardly any expressive movement is so general as the involuntary erection of the hairs, feathers, and other dermal appendages; for it is common throughout three of the great vertebrate classes. These appendages are erected under the excitement of anger or terror; more especially when these emotions are combined, or quickly succeed each other. The action serves to make the animal appear larger and more frightful to its enemies or rivals, and is generally accompanied by various voluntary movements adapted for the same purpose, and by the utterance of savage sounds. Mr. Bartlett, who has had such wide experience with animals of all kinds, does not doubt that this is the case; but it is a different question whether the power of erection was primarily acquired for this special purpose.

"With the carnivora the erection of the hair seems to be almost universal, often accompanied by threatening movements, the uncovering of the teeth, and the utterance of savage growls. The enraged lion erects his mane. The bristling of the hair along the neck and back of the dog, and over the whole body of the cat, especially on the tail, is familiar to every one. With the cat it apparently occurs only under fear; with the dog, under anger and fear; but not, as far as I have observed, under abject fear, as when a dog is going to be flogged by a severe game-keeper. If, however, the dog shows fight, as sometimes happens, up goes his hair. I have often noticed that the hair of a dog is particularly liable to rise, if he is half angry and half afraid, as on beholding some object only indistinctly seen in the dusk.

Fig. 8.



Swan driving away an Intruder.—(Drawn from Life by Mr. Wood.)

"I have been assured by a veterinary surgeon that he has often seen the hair erected on horses and cattle, on which he had operated and was going again to operate.

"Birds belonging to all the chief orders ruffle their feathers when angry or frightened. Every one must have seen two cocks, even quite young birds, preparing to fight with erected neck-hackles; nor can these feathers when erected serve as a means of defence, for cock-fighters have found by experience that it is advantageous to trim them. The male ruff (*Machetes pugnax*) likewise erects its collar of feathers when fighting. When a dog approaches a common hen with her chickens, she spreads out her wings, raises her tail, ruffles all her feathers, and, looking as ferocious as possible, dashes at the intruder. The tail is not always held in exactly the same position; it is sometimes so much erected, that the central feathers, as in the accompanying drawing, almost touch the back. Swans, when angered, likewise raise their wings and tail, and erect their feathers. They open their beaks, and make by paddling little rapid starts forward, against any one who approaches the water's edge too closely. Tropic birds [1] when disturbed on their nests are said not to fly away, but 'merely to stick out their feathers and scream.' The barn-owl, when approached, 'instantly swells out its plumage, extends its wings and tail, hisses and clacks its mandibles with force and rapidity.' [2] So do other kinds of owls. Hawks, as I am informed by Mr. Jenner Weir, likewise ruffle their feathers, and spread out their wings and tail under similar circumstances. Some kinds of parrots erect their feathers; and I have seen this action in the cassowary, when angered at the sight of an ant-eater. Young cuckoos in the nest raise their feathers, open their mouths widely, and make themselves as frightful as possible.

"Small birds, also, as I hear from Mr. Weir, such as various finches, buntings, and warblers, when angry, ruffle all their feathers, or only those round the neck; or they spread out their wings and tail-feathers. With their plumage in this state, they rush at each other with open beaks and threatening gestures. Mr. Weir concludes from his large experience that the erection of the feathers is caused much more by anger than by fear. He gives as an instance a hybrid goldfinch of a most irascible disposition, which, when approached too closely by a servant, instantly assumes the appearance of a ball of ruffled feathers. He believes that birds when frightened, as a general rule, closely adpress all their feathers, and their consequently diminished size is often astonishing. As soon as they recover from their fear or surprise, the first thing which they do is to shake out their feathers. The best instances of this adpression of the feathers and apparent shrinking of the body from fear, which Mr. Weir has noticed, have been in the quail and grass-parrakeet. The habit is intelligible in these birds from their being accustomed, when in danger, either to squat on the ground or to sit motionless on a branch, so as to escape detection. Though, with birds, anger may be the chief and commonest cause of the erection of the feathers, it is probable that young cuckoos when looked at in the

[1] *Phaeton rubricauda:* "Ibis," vol. iii., 1861, p. 180.

[2] On the *Strix flammea*, Audubon, "Ornithological Biography," 1864, vol. ii., p. 407 I have observed other cases in the Zoological Gardens.

nest, and a hen with her chickens when approached by a dog, feel at least some terror. Mr. Tegetmeier informs me that, with game-cocks, the erection of the feathers on the head has long been recognized in the cockpit as a sign of cowardice."

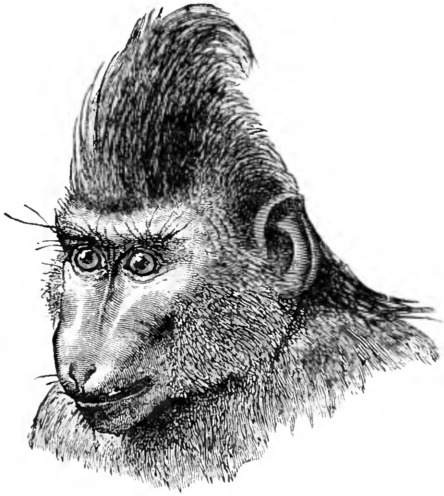
In his chapter on the special expressions of animals, Mr. Darwin thus speaks of the monkeys: "With monkeys the expression of slight pain, or of any painful emotion, such as grief, vexation, jealousy, etc., is not easily distinguished from that of moderate anger; and these states of mind readily and quickly pass into each other. Grief, however, with some species is certainly exhibited by weeping. A woman, who sold a monkey to the Zoological Society, believed to have come from Borneo, said that it often cried; and Mr. Bartlett, as well as the keeper, Mr. Sutton, has repeatedly seen it, when grieved, or even when much pitied, weeping so copiously that the tears rolled down its cheeks. There is, however, something strange about this case, for two specimens subsequently kept in the Gardens, and believed to be the same species, have never been seen to weep, though they were carefully observed by the keeper and myself when much distressed and loudly screaming. Rengger states that the eyes of the *Cebus azaræ* fill with tears, but not sufficiently to overflow, when it is prevented getting some much-desired object, or is much frightened. Humboldt also asserts that the eyes of the *Callithrix sciureus* 'instantly fill with tears when it is seized with fear;' but when this pretty little monkey in the Zoological Gardens was teased, so as to cry out loudly, this did not occur. I do not, however, wish to throw the least doubt on the accuracy of Humboldt's statement.

"The appearance of dejection in young orangs and chimpanzees, when out of health, is as plain and almost as pathetic as in the case of our children. This state of mind and body is shown by their listless movements, fallen countenances, dull eyes, and changed complexion.

"Baboons often show their passion and threaten their enemies in a very odd manner, namely, by opening their mouths widely, as in the act of yawning. Mr. Bartlett has often seen two baboons, when first placed in the same compartment, sitting opposite to each other and thus alternately opening their mouths; and this action seems frequently to end in a real yawn. Mr. Bartlett believes that each animal wishes to show to the other that he is provided with a formidable set of teeth, as is undoubtedly the case. As I could hardly credit the reality of this yawning gesture, Mr. Bartlett insulted an old baboon and put him into a violent passion; and he almost immediately thus acted. Some species of Macacus and of Cercopithecus behave in the same manner. Baboons likewise show their anger, as was observed by Brehm with those which he kept alive in Abyssinia, in another manner, namely, by striking the ground with one hand, 'like an angry man striking the table with his fist.' I have seen this movement with the baboons in the Zoological Gardens; but sometimes the action seems rather to represent the searching for a stone or other object in their beds of straw.

"A young orang, made jealous by her keeper attending to another monkey, slightly uncovered her teeth, and, uttering a peevish noise

Fig. 9.



Cynopithecus niger, in a Placid Condition.—(Drawn from Life by Mr. Wolf.)

like *tish-shist*, turned her back on him. Both orangs and chimpanzees, when a little more angered, protrude their lips greatly, and make a

Fig. 10.

The same, when pleased by being caressed.

harsh barking noise. A young female chimpanzee, in a violent passion, presented a curious resemblance to a child in the same state.

She screamed loudly with widely-open mouth, the lips being retracted so that the teeth were fully exposed. She threw her arms wildly about, sometimes clasping them over her head. She rolled on the ground, sometimes on her back, sometimes on her belly, and bit every thing within reach. A young gibbon (*Hylobates syndactylus*) in a passion has been described[1] as behaving in almost exactly the same manner.

"The lips of young orangs and chimpanzees are protruded, sometimes to a wonderful degree, under various circumstances. They act thus, not only when slightly angered, sulky, or disappointed, but when alarmed at any thing—in one instance, at the sight of a turtle[2]—and

FIG. 11.

CHIMPANZEE DISAPPOINTED AND SULKY.—(Drawn from Life by Mr. Wood.)

likewise when pleased. But neither the degree of protrusion nor the shape of the mouth is exactly the same, as I believe, in all cases; and the sounds which are then uttered are different. The accompanying drawing represents a chimpanzee made sulky by an orange having been offered him, and then taken away. A similar protrusion or pouting of the lips, though to a much slighter degree, may be seen in sulky children."

[1] G. Bennett, "Wanderings in New South Wales," etc., vol. ii., 1834, p. 153.
[2] W. C. Martin, "Natural History of Mammiferous Animals," 1841, p. 405.

THE STUDY OF SOCIOLOGY.

By HERBERT SPENCER.

VII.—*Subjective Difficulties—Emotional.*

THAT passion perverts judgment, is an observation sufficiently trite; but the more general observation of which it should form part, that emotion of every kind and degree disturbs the intellectual balance, is not trite, and, even where recognized, is not duly taken into account. Stated in full, the truth is that no propositions, save those which are absolutely indifferent to us, immediately and remotely, can be contemplated without likings and repugnances affecting the opinions we form about them. There are two modes in which our conclusions are thus falsified. Excited feelings make us wrongly estimate probability, and also make us wrongly estimate importance. Some cases will show this.

All, who are old enough, remember the murder committed by Müller on the North London Railway some years ago; for, even after reaching that stage at which accounts of crime lose their interest, and police-reports become unreadable, it is impossible to avoid gathering from gossip some knowledge of startling tragedies. Most persons, too, will remember that for some time afterward there was universally displayed a dislike to travelling by railway in company with a single other passenger—supposing him to be unknown. Though, up to the date of the murder in question, almost innumerable journeys had been made by two strangers together in the same compartment without evil being suffered by either—though, after the death of Mr. Briggs, the probabilities were immense against the occurrence of a similar fate to another person similarly placed—yet there was habitually roused a fear that would have been appropriate only had the danger been considerable. The amount of feeling excited was quite incommensurate with the risk. Though the chance was a million to one against evil, the anticipation of evil was as strong as though the chance had been a thousand to one or a hundred to one. The emotion of dread destroyed the balance of judgment, and a true estimate of likelihood became impossible; or, rather, any rational estimate of likelihood that might be formed was wholly inoperative on conduct.

Another instance was thrust on my attention during the small-pox epidemic, which a while since so unaccountably spread, after twenty years of compulsory vaccination. A lady living in London, sharing in the general trepidation, was expressing her fears to me. I asked her whether, if she lived in a town of 20,000 inhabitants, and heard of one person dying of small-pox in the course of a week, she would be much alarmed. Naturally she answered, "No;" and her fears were somewhat calmed when I pointed out that, taking the whole population of London, and the number of deaths per week from small-pox, this was about the rate of mortality at that time caused by it. Yet in other minds, as in her mind, panic had produced an entire incapacity for forming a rational estimate of the danger. Nay, indeed, so perturbing was the emotion that an unusual amount of danger to life was imagined at a time when the danger to life was smaller than usual. For the returns showed that the mortality from all causes was rather below the average than above it. While the evidence proved that the risk of death was unusually small, this wave of feeling which spread through society produced an irresistible conviction that it was unusually great.

These examples show in a clear way, what is less clearly shown in countless other examples, that the associated ideas constituting a judgment are much affected in their relations to one another by the coexisting emotion. Two ideas will cohere feebly or strongly according as the correlative nervous states involve a feeble or a strong discharge along the lines of nervous connection; and hence a large wave of feeling, implying as it does a voluminous discharge in all directions, renders such two ideas more coherent. This is so even when the feeling is irrelevant, as is shown by the vivid recollection of trivialities observed on occasions of great excitement; and it is still more so when the feeling is relevant—that is, when the proposition formed by these ideas is itself the cause of excitement. Much of the emotion tends in such case to discharge itself through the channels connecting the elements of the proposition; and predicate follows subject with a vividness and persistence out of all proportion to that which is justified by experience.

We see this with emotions of all orders. How greatly maternal affection falsifies a mother's estimate of her child, every one observes. How those in love fancy superiorities where none are visible to unconcerned spectators, and remain blind to defects that are conspicuous to every one else, is matter of common remark. Note, too, how in the holder of a lottery-ticket hope generates a belief utterly at variance with probability as numerically estimated, and how an excited inventor has a confidence in success which calm judges see to be impossible. That "the wish is father to the thought," here so obviously true, is true more or less in nearly all cases where there is a wish. And in other cases, again, as where horror is aroused by the fancy of something supernatural, we see that, in the absence of wish to believe, there may yet arise belief if violent emotion goes along with the ideas that are joined together.

Though there is some recognition of the fact that men's judgments on social questions are distorted by their emotions, the recognition is extremely inadequate. Political passion, class-hatred, and feelings of great intensity, are alone habitually admitted to be large factors in determining opinions. But, as above implied, we have to take account of emotions of many kinds and of all degrees, down to slight likes and dislikes. For, if we look closely into our own beliefs on public affairs, as well as into the beliefs of those around us, we find them to be caused much more by aggregates of feelings than by examinations of evidence. No one, even if he tries, succeeds in preventing the slow growth of sympathies with, or antipathies to, certain institutions, customs, ideas, etc.; and, if he watches himself, he will perceive that unavoidably each new question coming before him is considered in relation to the mass of convictions which have been gradually moulded into agreement with his sympathies and antipathies.

When the reader has admitted, as he must if he is candid with himself, that his opinion on any political act or proposal is commonly formed in advance of direct evidence, and that he rarely takes the trouble to inquire whether direct evidence justifies it, he will see how great are those difficulties in the way of sociological science, which arise from the various emotions excited by the matters it deals with. Let us note, first, the effects of some emotions of a general kind, which we are apt to overlook.

The state of mind we call impatience is one of these. If a man swears at some inanimate thing which he cannot adjust as he wishes, or if, in wintry weather, slipping down and hurting himself, he vents his anger by damning gravitation, his folly is manifest enough to spectators, and to himself also when his irritation has died away. But in the political sphere it is otherwise. A man may here, in fact if not in word, damn a law of Nature, without being himself aware, and without making others aware, of his absurdity.

The state of feeling often betrayed toward Political Economy exemplifies this. An impatience, accompanying the vague consciousness that certain cherished convictions or pet schemes are at variance with politico-economical truths, shows itself in contemptuous words applied to these truths. Knowing that his theory of government and plans for social reformation are discountenanced by it, Mr. Carlyle manifests his annoyance by calling Political Economy "the dismal science." And, among others than his adherents, there are many belonging to all parties, retrograde and progressive, who display repugnance to this body of doctrine with which their favorite theories do not agree. Yet a little thought might show them that their feeling is much of the same kind as would be scorn vented by a perpetual-motion schemer against the principles of mechanics.

To see that these generalizations which they think of as cold and hard, and acceptable only by the unsympathetic, are nothing but statements of certain modes of action arising out of human nature, that are no less beneficent than necessary, they need only suppose a moment that human nature had opposite tendencies. Imagine that, instead of preferring to buy things at low prices, men habitually preferred to give high prices for them; and imagine that, conversely, sellers rejoiced in getting low prices instead of high ones. Is it not obvious that production and distribution and exchange, supposing them possible under such conditions, would go on in ways utterly different from their present ways? If men went for each commodity to a place where it was difficult of production, instead of to a place where it could be produced easily, and if, instead of transferring articles of consumption from one part of a kingdom to another along the shortest routes, they habitually chose roundabout routes, so that the cost in labor and time might be the greatest, is it not clear that, could industrial and commercial arrangements of any kinds exist, they would be of natures so unlike the present ones as to be inconceivable by us? And, if this is undeniable, is it not equally undeniable that the processes of production, distribution, and exchange, as they now go on, are processes determined by certain fundamental traits in human nature, and that Political Economy is nothing more than a statement of the laws of these processes, as inevitably resulting from such traits?

That the generalizations of political economists are not all true, and that some, which are true in the main, need qualification, is very likely. But, to admit this, is not in the least to admit that there are no true generalizations of this order to be made. Those who see, or fancy they see, flaws in politico-economical conclusions, and thereupon sneer at Political Economy, remind one of the theologians who lately rejoiced so much over the discovery of an error in the estimation of the sun's distance, and thought the occasion so admirable a one for ridiculing men of science. It is characteristic of theologians to find cause for extreme satisfaction in whatever shows human imperfection; and in this case they were much elated because astronomers discovered that, while their delineation of the Solar System remains exactly right in all its proportions, the absolute dimensions assigned were too great by about one-thirtieth. In one respect, however, the comparison fails: for, though the theologians taunted the astronomers, they did not venture to include astronomy within the scope of their contempt—did not do as those to whom they are here compared, who show contempt, not for political economists only, but for Political Economy itself.

Were they calm, these opponents of the political economists would see that as, out of certain physical properties of things there inevitably arise certain modes of action, which, as generalized, constitute physical science; so out of the properties of men, intellectual and emotional, there inevitably arise certain laws of social processes, including, among others, those through which mutual aid in satisfying wants is made possible. They would see that, but for these processes, the laws of which Political Economy seeks to generalize, men would have continued in the lowest stage of barbarism to the present hour; they would see that, instead of jeering at the science and those who pursue it, their course should be to show in what respects the generalizations thus far made are untrue, and how they may be so expressed as to correspond to the truth more nearly.

I need not further exemplify the perturbing influence of impatience in sociological inquiry. Along with the irrational hope so conspicuously shown by every party having a new project for the furtherance of human welfare, there habitually goes this irrational irritation in presence of stern truths which negative sanguine anticipations. Be it some way of remedying the evils of competition, some scheme for rendering the pressure of population less severe, some method of organizing a government so as to secure complete equity, some plan for reforming men by teaching, by restriction, by punishment; any thing like calm consideration of probabilities, as estimated from experience, is excluded by this eagerness for an immediate result; and, instead of submission to the necessities of things, there comes vexation, felt if not expressed, against them, or against those who point them out, or against both.

That feelings of love and hate make rational judgments impossible in public affairs, as in private affairs, we can clearly enough see in others, though not so clearly in ourselves. Especially can we see it when these others belong to an alien society. France, during and since the late war, has furnished us almost daily with illustrations. The fact that, while the struggle was going on, any foreigner in Paris was liable to be seized as a Prussian, and that, if charged with being a Prussian, he was forthwith treated as one, sufficiently proves that hate makes rational estimation of evidence impossible. The marvellous distortions which this passion produces were abundantly exemplified during the reign of the Commune; and yet again after the Commune was subdued. The "preternatural suspicion," as Mr. Carlyle called it, which characterized conduct during the first revolution, characterized conduct during the late catastrophe. And it is displayed still. The sayings and doings of French political parties, alike in the Assembly, in the press, and in private societies, show that mutual hate causes mutual misinterpretations, fosters false conclusions, and utterly vitiates sociological generalizations.

While, however, it is manifest to us that, among our neighbors, strong sympathies and antipathies stand in the way of reasonable views and well-balanced policy, we do not perceive that among ourselves sympathies and antipathies distort judgments in degrees, not perhaps so extreme, but still in very great degrees. Instead of French opinion on French affairs, let us take English opinion on French affairs—not affairs of recent date, but affairs of the past; and, instead of a case showing the false estimation of evidence which sympathies and antipathies produce, let us take a case showing how perverted may be the estimates of the relative gravities of evils, and the relative degrees of blameworthiness of actions.

Feudalism had decayed: its benefits had died out, and only its evils had survived. While the dominant classes no longer performed their functions, they continued their exactions and maintained their privileges. Seignorial power was exercised solely for private benefit, and at every step met the unprivileged with vexatious claims and restrictions. The peasant was called from his heavily-burdened bit of land to work gratis for a neighboring noble, who gave him no protection in return. He had to bear uncomplainingly the devouring of his crops by this man's game; to hand him a toll before he could cross the river; to buy from him the liberty to sell at market—nay, such portion of grain as he reserved for his own use he could eat only after paying for the grinding of it at his seigneur's mill, and for having it baked at his bakehouse. And then, added to the seignorial exactions, came the exactions of the Church, still more mercilessly enforced. Along with all these local abuses and exasperating obstacles to living, there had gone on at the governing centre maladministration, corruption, extravagance: treasures were spent in building vast palaces, and enormous armies were sacrificed in inexcusable wars. Profuse expenditure, demanding more than could be got from crippled industry, had caused a chronic deficit. New taxes on the poor workers brought in no money, but only clamor and discontent; and to tax the rich idlers proved to be impracticable: the proposal, that the clergy and *noblesse* should no longer be exempt from burdens such as were borne by the people, brought from these classes "a shriek of indignation and astonishment." And then, to make more conspicuous the worthlessness of the governing agencies of all orders, there was the corrupt life led by the court, from the king downward —France lying "with a harlot's foot on its neck." Passing over the various phases of the break-up which ended this intolerable state—phases throughout which the dominant classes, good for nothing and unrepentant, strove to recover their power, and, enlisting foreign rulers, brought upon France invading armies—we come presently to a time when, in a storm of anger and fear, the people revenged themselves on such of their past tormentors as remained among them. Leagued, as many of these were, with those of their order who were levying war against liberated France—leagued, as many others were supposed to be, with these enemies to the Republic at home and abroad—incorrigible as they proved themselves by their plottings and treacheries; there at length came down upon them the September massacres and the Reign of Terror, during which nearly 10,000 of those implicated, or supposed to be implicated, were killed or formally executed. The Nemesis was sufficiently fearful. Lamentable sufferings and death fell on innocent as well as guilty. Hate and despair combined to arouse an undistinguishing cruelty, and, in some of the leading actors, a cold-blooded ferocity. Nevertheless, recognizing all this—recognizing also the truth that those who wreaked this vengeance were intrinsically no better than those on whom it was wreaked—we must admit that the bloodshed had its excuse. The panic of a people threatened with reimposition of dreadful shackles was not to be wondered at. That the expected return of a time like that, in which gaunt figures and haggard faces about the towns and the country indicated the social disorganization, should excite men to a blind fury, was not unnatural. If they became frantic at the thought that there was coming back a state under which there might again be a slaying of hundreds of thousands of men in battles fought to gratify the spite of a king's concubine, we need not be greatly astonished. And some of the horror expressed at the fate of the ten thousand victims might fitly be reserved for the abominations which caused it.

From this partially-excusable bloodshed, over which men shudder excessively, let us turn now to the immeasurably greater bloodshed, having no excuse, over which they do not shudder at all. Out of the sanguinary chaos of the Revolution, there presently rose a soldier whose immense ability, joined with his absolute unscrupulousness, made him now general, now consul, now autocrat. He was untruthful in an extreme degree, lying in his dispatches day by day, never writing a page without bad faith,[1] nay, even giving to others lessons in telling falsehoods.[2] He professed friendship while plotting to betray, and quite early in his career made the wolf-and-lamb fable his guide. He got antagonists into his power by promises of clemency, and then executed them. To strike terror, he descended to barbarities like those of the blood-thirsty conquerors of old, of whom his career reminds us: as in Egypt, when, to avenge fifty of his soldiers, he beheaded 2,000 fellahs, throwing their headless corpses into the Nile; or as at Jaffa, when 2,500 of the garrison, who finally surrendered, were at his order deliberately massacred. Even his own officers, not over-scrupulous, as we may suppose, were shocked by his brutality—sometimes refusing to execute his sanguinary decrees. Indeed, the instincts of the savage were scarcely at all qualified in him by what we call moral sentiments; as we see in his proposal to burn "two or three of the larger communes" in La Vendée; as we see in his wish to introduce bull-fights into France, and to revive the combats of the Roman arena; as we see in the cold-blooded sacrifice of his own soldiers, when he ordered a useless outpost attack merely that his mistress might witness an engagement! That such a man should have prompted the individual killing of leading antagonists, and set prices on their heads, as in the cases of Mourad-Bey and Count Frotté, and that to remove the Duc d'Enghien he should have committed a crime

[1] Translation of Lanfrey, vol. ii., p. 25.
[2] Ibid., vol. ii., p. 442.

like in its character to that of one who hires a bravo, but unlike by entailing no danger, was quite natural. It was natural, too, that, in addition to countless treacheries and breaches of faith in his dealings with foreign powers, such a man should play the traitor to his own nation, by stamping out its newly-gained free institutions, and substituting his own military despotism. Such being the nature of the man, and such being a few illustrations of his cruelty and unscrupulousness, contemplate now his greater crimes and their motives. Year after year he went on sacrificing by tens of thousands and hundreds of thousands the French people and the people of Europe at large, to gratify his lust of power and his hatred of opponents. To feed his insatiable ambition, and to crush those who resisted his efforts after universal dominion, he went on seizing the young men of France, forming army after army that were destroyed in destroying like armies raised by neighboring nations. In the Russian campaign alone, out of 552,000 French left dead or prisoners, but a small portion returned to France; while the Russian force of more than 200,000 was reduced to 30,000 or 40,000: implying a total sacrifice of considerably more than half a million lives. And when the mortality on both sides by death in battle, by wounds and by disease, throughout all the Napoleonic campaigns is summed up, it exceeds, at the lowest computation, two millions.[1] And all this slaughter, all this suffering, all this devastation, was gone through because one man had a restless desire to be despot over all men.

And now what has been thought and felt in England about the two sets of events above contrasted, and about the actors in them? For the bloodshed of the Revolution there has been utter detestation, and for those who wrought it unqualified hate. For the immeasurably greater bloodshed which these wars of the Consulate and the Empire entailed, little or no horror is expressed; while the feeling toward the

[1] M. Lanfrey sets down the loss of the French alone, from 1802 onward, at nearly two millions. This may be an over-estimate; though, judging from the immense armies raised in France, such a total seems quite possible. The above computation of the losses to European nations in general has been made for me by adding the numbers of killed and wounded in the successive battles, as furnished by such statements as are accessible. The total is 1,500,000. This number has to be greatly increased by including losses not specified—the number of killed and wounded on one side only, being given in some cases. It has to be further increased by including losses in numerous minor engagements, the particulars of which are unknown. And it has to be further increased by allowance for understatement of his losses, which was habitual with Napoleon. Though the total, raised by these various additions probably to something over two millions, includes killed and wounded, from which last class a large deduction has to be made for the number who recovered, yet it takes no account of the loss by disease. This may be set down as greater in amount than that which battles caused. (Thus, according to Kolb, the British lost in Spain three times as many by diseases as by the enemy; and in the expedition to Walcheren seventeen times as many.) So that the loss by killed and wounded and by disease, for all the European nations during the Napoleonic campaigns, is probably much understated at two millions.

modern Attila who was guilty of this bloodshed is shown by decorating rooms with portraits and busts of him. See the beliefs which these respective feelings imply:

Over ten thousand deaths we may fitly shudder and lament.	Two million deaths may be contemplated without much shuddering and lamentation.
As the ten thousand were slain because of the tyrannies, and cruelties, and treacheries, committed by them or by their class, their deaths are especially pitiable.	As the two millions, innocent of offence, were taken against their wills from classes already oppressed and impoverished, the slaughter of them need not excite our pity.
The sufferings of the ten thousand and of their relatives, who expiated their own misdeeds and the misdeeds of their class, may fitly form subjects for heart-rending stories and pathetic pictures.	There is nothing heart-rending in the sufferings of the two millions who died for no crimes of their own or their class; nor need we see pathos in the fates of the poor families throughout France and all neighboring countries from which the two million victims were taken.
That despair and the indignation of a betrayed people brought about this slaughter of ten thousand, makes the atrocity without palliation.	That one man's lust of power was gratified through the deaths of the two millions, greatly palliates the sacrifice of them.

These are the antithetical propositions tacitly implied in the opinions that have been current in England about the French Revolution and the Napoleonic wars. Only by acceptance of such propositions can these opinions be defended. Such have been the emotions of men that, until quite recently, it has been the habit to speak with detestation of the one set of events, and to speak of the other set of events in words betraying admiration. Nay, even now these feelings are but partially qualified. While the names of the leading actors in the Reign of Terror are names of execration, we speak of Napoleon as "the Great," and Englishmen worship him by visiting his tomb and taking off their hats!

How, then, with such perverting emotions, is it possible to take rational views of sociological facts? Forming, as men do, such astoundingly false conceptions of the relative amounts of evils and the relative characters of motives, how can they judge truly among institutions and actions, past or present? Clearly, minds thus swayed by disproportionate hates and admirations cannot frame those balanced conclusions, respecting social phenomena, which alone constitute Social Science.

The sentiment which thus shudders with horror at bad deeds for which there was much excuse, while to deeds immeasurably more dreadful and without excuse it gives applause very slightly qualified with blame, is a sentiment which, among other effects, marvellously perverts men's political conceptions. This awe of power, by the help of which social subordination has been, and still is, chiefly maintained—this feeling which delights to contemplate the imposing, be it in military successes, or be it in the grand pageantries, the sounding titles, and the sumptuous modes of living that imply supreme authority—this feeling which is offended by outbreaks of insubordination, and acts or words of a disloyal kind; is a feeling that inevitably generates delusions respecting governments, their capacities, their achievements. It transfigures them and all their belongings, as does every strong emotion the objects toward which it is drawn out. Just as maternal love, idealizing offspring, sees perfections but not defects, and believes in the future good behavior of a worthless son, notwithstanding countless broken promises of amendment; so this power-worship idealizes the State, as embodied either in a despot, or in king, lords, and commons, or in a republican assembly, and continually hopes in spite of continual disappointments.

How awe of power sways men's political beliefs will be perceived, on observing how it sways their religious beliefs. We shall best see this by taking an instance supplied by people whose religious ideas are extremely crude. Here is an abstract of a description given by Captain Burton:

"A pot of oil with a lighted wick was placed every night, by the half-bred Portuguese Indians, before the painted doll, the patron saint of the boat in which we sailed from Goa. One evening, as the weather appeared likely to be squally, we observed that the usual compliment was not offered to the patron, and had the curiosity to inquire why. 'Why?' vociferated the tindal (captain), indignantly, 'if that chap can't keep the sky clear, he shall have neither oil nor wick from me, d—n him!' 'But I should have supposed that in the hour of danger you would have paid him more than usual attention?' 'The fact is, Sahib, I have found out that the fellow is not worth his salt: the last time we had an infernal squall with him on board, and if he does not keep this one off, I'll just throw him overboard, and take to Santa Caterina; hang me, if I don't—the brother-in-law!'" (brother-in-law, a common term of insult).[1]

To us it seems scarcely imaginable that men should thus behave to their gods and demi-gods—should pray to them, should insult and sometimes castigate them for not answering their prayers, and then should presently pray to them again. Let us pause a moment before we laugh. Though in the sphere of religion our conduct does not pre-

[1] Burton's "Goa," etc., p. 167.

sent such a contradiction, yet a contradiction essentially similar is betrayed by our conduct in the political sphere. Perpetual disappointment does not here cure us of perpetual expectation. Conceiving the state-agency as though it were something more than a cluster of men (a few clever, many ordinary, and some decidedly stupid), we ascribe to it marvellous powers of doing multitudinous things which men otherwise clustered are unable to do. We petition it to procure for us, in some way which we do not doubt it can find, benefits of all orders; and pray it with unfaltering faith to secure us from every fresh evil. Time after time our hopes are balked. The good is not obtained, or something bad comes along with it; the evil is not cured, or some other evil as great or greater is produced. Our journals, daily and weekly, general and local, perpetually find failures to dilate upon; now blaming, and now ridiculing, first this department and then that. And yet, though the rectification of blunders, administrative and legislative, is a main part of public business—though the time of the Legislature is chiefly occupied in amending and again amending, until, after the many mischiefs implied by these needs for amendments, there often comes at last repeal; yet from day to day increasing numbers of wishes are expressed for legal repressions and state-management. This emotion which is excited by the forms of governmental power, and makes governmental power possible, is the root of a faith that springs up afresh however often cut down. To see how little the perennial confidence it generates is diminished by perennial disappointment, it needs but to remind ourselves of a few state-performances in the chief state departments.

On the second page of the first chapter, by way of illustrating Admiralty mismanagement, brief reference was made to three avoidable catastrophes which had happened to vessels-of-war within the twelvemonth. Their frequency is further shown by the fact that, before the next chapter was published, two others had occurred: the Lord Clyde ran aground in the Mediterranean, and the Royal Alfred was seven hours on the Bahama reef. And then, more recently, we have had the sinking of a vessel at Woolwich by letting a 35-ton gun fall through her bottom. That the authorities of the navy commit errors which the merchant service avoids, has been repeatedly shown of late, as in times past. It was shown by the disclosure respecting the corrosion of the Glatton's plates, which proved that the Admiralty had not adopted the efficient protective methods long used by private shipowners. It was shown when the loss of the Ariadne's sailors brought out the facts that a 26-gun frigate had not as many boats for saving life as are prescribed for a passenger-ship of less than 400 tons; and that for lowering her boats there was on board neither Kynaston's apparatus nor the much better apparatus of Clifford, which experience in the merchant service has thoroughly tested. It was shown by the non-adoption of Silver's governor for marine steam-engines; long used in private steamships to save machinery from breakage, but not used in the navy until much machinery had been broken. On going back a little, this relative inefficiency of administration is still more strikingly shown: instance the fact that, during the Chinese Expedition of 1841, a mortality, at the rate of three or four per day in a crew of 300, arose from drinking muddy water from the paddy-fields, though, either by boiling it or by filtering it through charcoal, much of this mortality might have been prevented; instance the fact that, within the memory of living officers (I have it from the mouth of one who had the experience), vessels-of-war, leaving Deptford, filled their casks with Thames-water taken at ebb-tide, which water during its subsequent period of putrefaction had to be filtered through handkerchiefs before drinking and then swallowed while holding the nose; or instance the accumulation of abominable abuses and malversations and tyrannies which produced the mutiny at Spithead. But, perhaps, of all such illustrations, the most striking is that which the treatment of scurvy shows us. It was in 1593 that sour juices were first recommended by Albertus; and in the same year Sir R. Hawkins cured his crew of scurvy by lemon-juice. In 1600 Commodore Lancaster, who took out the first squadron of the East India Company's ships, kept the crew of his own ship in perfect health by lemon-juice, while the crews of the three accompanying ships were so disabled that he had to send his men on board to set their sails. In 1636 this remedy was again recommended in medical works on scurvy. Admiral Wagner, commanding our fleet in the Baltic in 1726, again proved it to be a specific. In 1757, Dr. Lind, the physician to the naval hospital at Haslar, collected and published, in an elaborate work, these and many other proofs of its efficacy. Nevertheless, scurvy continued to carry off thousands of our sailors. In 1780, 2,400 in the Channel Fleet were affected by it; and in 1795 the safety of the Channel Fleet was endangered by it. At length, in that year, the Admiralty ordered a regular supply of lemon-juice to the navy. Thus two centuries after the remedy was known, and forty years after a chief medical officer of the Government had given conclusive evidence of its worth, the Admiralty, forced thereto by an exacerbation of the evil, first moved in the matter. And what had been the effect of this almost incredible perversity of officialism? The mortality from scurvy during this long period had exceeded the mortality by battles, wrecks, and all casualties of sea-life put together![1]

How, through military administration, there has all along run, and still runs, a kindred stupidity and obstructiveness, pages of examples might be accumulated to show. The debates pending the abolition of the purchase-system furnish many; the accounts of life at Aldershot and of autumn manœuvres furnish many; and many might be added in the shape of protests like those made against martinet

[1] *See* Tweedie's "System of Practical Medicine," vol. v., pp. 62–69.

riding-regulations, which entail ruptures on the soldiers, and against "our ridiculous drill-book," as independent officers are now agreeing to call it. Even limiting ourselves to sanitary administration in the army, the files of our journals and the reports of our commissions would yield multitudinous instances of scarcely credible bungling—as in bad barrack arrangements, of which we heard so much a few years ago; as in an absurd style of dress, such as that which led to the wholesale cutting-down of the Twelfth Cameronians when they arrived in China in 1841; as in the carelessness which lately caused the immense mortality by cholera among the Eighteenth Hussars at Secunderabad. Or, not further to multiply instances, take the long-continued ignoring of ipecacuanha as a specific for dysentery, which causes so much mortality in our Indian service:

"It is a singular fact that the introducers of the ipecacuanha into European practice, the Brazilian traveller Marcgrav, and the physician Piso (in 1648), explicitly stated that the powder is a specific cure for dysentery, in doses of a drachm and upward; but that this information appears never to have been acted upon till 1813, when Surgeon G. Playfair, of the East Indian Company's service, wrote testifying to its use in these doses. Again, in 1831, a number of reports of medical officers were published by the Madras Medical Board, showing its great effects in hourly doses of five grains, till frequently 100 grains were given in a short period; testimony which, notwithstanding its weight, was doomed to be similarly overlooked, till quite recently, when it has been again brought directly under the notice of the Indian Government, which is making very vigorous efforts to introduce the culture of the plant into suitable districts of India."[1]

So that, notwithstanding the gravity of the evil, and the pressing need for this remedy from time to time thrust on the attention of the Indian authorities, nearly sixty years passed before the requisite steps were taken.[2]

That the State, which fails to secure the health of men, even in its own employ, should fail to secure the health of beasts, might perhaps be taken as self-evident; though possibly some, comparing the money laid out on stables with the money laid out on cottages, might doubt the corollary. Be this as it may, however, the recent history of cattle-diseases and of legislation to prevent cattle-diseases yields the same

[1] "Report on the Progress and Condition of the Royal Gardens at Kew, 1870," p. 5.

[2] My attention was drawn to this case by one who has had experience in various government services; and he ascribed this obstructiveness in the medical service to the putting of young surgeons under old. The remark is significant, and has far-reaching implications. Putting young officials under old is a rule of all services—civil, military, naval, or other; and, in all services, necessarily has the effect of placing the advanced ideas and wider knowledge of a new generation under control by the ignorance and bigotry of a generation to which change has become repugnant. This, which is a seemingly ineradicable vice of public organizations, is a vice to which private organizations are far less liable; since, in the life-and-death struggle of competition, merit, even if young, takes the place of demerit, even if old.

lessons as are yielded above. Since 1848 there have been seven Acts of Parliament bearing the general titles of Contagious Diseases (Animals) Acts. Measures to "stamp out," as the phrase goes, this or that disease, have been called for as imperative. Measures have been passed, and then, expectation not having been fulfilled, amended measures have been passed, and then reamended measures; so that of late no session has gone by without a bill to cure evils which previous bills tried to cure, but did not. Notwithstanding the keen interest felt by the ruling classes in the success of these measures, they have succeeded so ill, that the "foot-and-mouth disease" has not been "stamped out," has not even been kept in check, but during the past year has spread alarmingly in various parts of the kingdom. Continually the *Times* has had blaming letters and reports of local meetings called to condemn the existing laws, and to insist on better. From all quarters there have come accounts of ineffective regulations and incapable officials—of policemen who do the work of veterinary surgeons—of machinery described by Mr. Fleming, veterinary surgeon of the Royal Engineers, as "clumsy, disjointed, and inefficient."[1]

Is it alleged that the goodness of State-agency cannot be judged by measures so recent, the administration of which is at present imperfect. If so, let us look at that form of State-agency which is of most ancient date, and has had the longest time for perfecting its adjustments—let us take the law in general, and its administration in general. Needs there do more than name these to remind the reader of the amazing inefficiency, confusion, doubtfulness, delay, which, proverbial from early times, continue still? Of penal statutes alone, which are assumed to be known by every citizen, 14,408 had been enacted from the time of Edward III. down to 1844. As was said by

[1] Let me here add what seems to be a not impossible cause, or at any rate part-cause, of the failure. The clew is given by a letter in the *Times*, signed "Land-owner," dating Tollesbury, Essex, August 2, 1872. He bought "ten fine young steers, perfectly free from any symptom of disease," and "passed sound by the inspector of foreign stock." They were attacked by foot-and-mouth disease after five days passed in fresh paddocks with the best food. On inquiry he found that foreign stock, however healthy, "'mostly all go down with it' after the passage." And then, in proposing a remedy, he gives us a fact of which he does not seem to recognize the meaning. He suggests, "that, instead of the present quarantine at Harwich, which consists in driving the stock from the steamer into pens for a limited number of hours," etc., etc. If this description of the quarantine is correct, the spread of the disease is accounted for. Every new drove of cattle is kept for hours in an infected pen. Unless the successive droves have been all healthy (which the very institution of the quarantine implies that they have not been), some of them have left in the pen diseased matter from their mouths and feet. Even if disinfectants are used after each occupation, the risk is great—the disinfection is almost certain to be inadequate. Nay, even if the pen is adequately disinfected every time, yet if there is not also a complete disinfection of the landing appliances, the landing-stage, and the track to the pen, the disease will be communicated. No wonder healthy cattle "'mostly go down with it' after the passage." The quarantine regulations, if they are such as here implied, might with perfect truth be called "regulations for the better diffusion of cattle-diseases."

Lord Cranworth in the House of Peers, 16th February, 1853, the judges were supposed to be acquainted with all these laws, but, in fact, no human mind could master them, and ignorance had ceased to be a disgrace.[1] To this has to be added the accumulation of civil laws, similarly multitudinous, involved, unclassified, and to this, again, the enormous mass of "case law," filling over 1,200 volumes, and rapidly increasing, before there can be formed an idea of the chaos. And then consider how there has come this chaos, out of which not even the highest legal functionaries, much less the lower functionaries, much less the ordinary citizens, can educe definite conclusions. Session after session the confusion has been worse confounded by the passing of separate Acts, and successive amendments of Acts, which are left unconnected with the multitudinous kindred Acts and amendments that lie scattered through the accumulated records of centuries. Suppose a trader should make, day by day, separate memoranda of his transactions with A, B, C, and the rest of his debtors and creditors. Suppose he should stick these on a file one after the other as they were made, never even putting them in order, much less entering them in his ledger. Suppose he should thus go on throughout his life, and that, to learn the state of his account with A, B, or C, his clerks had to search through this enormous confused file of memoranda, being helped only by their memories and by certain private note-books which preceding clerks had made for their own guidance, and left behind them. What would be the state of the business? What chance would A, B, and C, have of being rightly dealt with? Yet this, which, as a method of conducting private business, is almost too ludicrous for fiction, is in public business nothing more than grave fact. And the result of the method is exactly the one to be anticipated. At the present time we have two ex-Chancellors giving conflicting judgments in assurance-arbitrations. The conflict may be taken as typical of the system from top to bottom. Every day's law-reports remind us that each decision given is so uncertain that the probability of appeal depends chiefly on the courage or pecuniary ability of the beaten litigant—not on the nature of the verdict; and, if the appeal is made, a reversal of the verdict is looked for as by no means unlikely. And then, on contemplating the ultimate result, we find it to be—the multiplication of aggressions. Were the law clear, were the verdicts certain to be in conformity with it, and did asking for its protection entail no chance of great loss or of ruin, very many of the causes that come before our courts would never be heard of, for the reason that the wrongs they disclose would not be committed; and there would not be committed those yet more numerous wrongs to which the bad are prompted by the belief that the persons wronged will not dare to seek redress. Here, where State-agency has had centuries upon centuries in which to develop its appliances and show its efficiency, it is so

[1] Fischel's "English Constitution," translated by Shee, p. 487.

inefficient that citizens dread employing it, lest, instead of getting succor in their distress, they should bring on themselves new sufferings. And then—startling comment on the system, if we could but see it—there spring up private voluntary combinations for doing the business which the State should do, but fails to do. Here in London there is now proposed a Tribunal of Commerce, for administering justice among traders, on the pattern of that which in Paris settles many thousands of cases a year.

Even after finding the State perform so ill this vital function, one might have expected that it would perform well such a simple function as the keeping of documents. Yet, in the custody of the national records, there has been a carelessness such as "no merchant of ordinary prudence" would show in respect to his account-books. One portion of these records was for a long time kept in the White Tower, close to some tons of gunpowder, and another portion was kept close to a steam-engine in daily use. Some records were deposited in a temporary shed at the end of Westminster Hall, and thence, in 1830, they were removed to other sheds in the King's Mews, Charing Cross, where, in 1836, their state is thus described by the Report of a Select Committee:

"In these sheds 4,136 cubic feet of national records were deposited in the most neglected condition. Besides the accumulated dust of centuries, all, when these operations commenced" (the investigation into the state of the Records), "were found to be very damp. Some were in a state of inseparable adhesion to the stone walls. There were numerous fragments which had only just escaped entire consumption by vermin, and many were in the last stage of putrefaction. Decay and damp had rendered a large quantity so fragile as hardly to admit of being touched; others, particularly those in the form of rolls, were so coagulated together that they could not be uncoiled. Six or seven perfect skeletons of rats were found embedded, and bones of these vermin were generally distributed throughout the mass."

Thus, if we array in order the facts daily brought to light, but which, unhappily, drop out of men's memories as fast as others are added, we find a like history throughout. Now the complaint is of the crumbling walls of the Houses of Parliament, which, built of stone chosen by a commission, nevertheless begin to decay in parts first built before other parts are completed. Now the disclosure is about a new fort at Seaford, based on the shingle so close to the sea that a storm washes a great part of it away. And now there comes the account of a million and a half spent in building the Alderney harbor, which, being found worse than useless, threatens to entail further cost for its destruction. Scarcely a journal can be taken up that has not some blunder referred to in a debate, or brought to light by a Report, or pointed out in a letter, or commented on in a leader. Do I need an illustration? I take up the *Times* of this morning (November 13th), and read that the new bankruptcy law, substituted for the bankruptcy laws which failed so miserably, is administered in rooms so crowded and noisy that due care and thought on the part of officials are scarcely possible; and, further, that, as one part of the court sits in the City and another part in Lincoln's Inn, solicitors have often to be in both places at the same time. Do I need more illustrations? They come in abundance between the day on which the foregoing sentence was written and the day (November 20th) on which I revise it. Within this short time mismanagement has been shown in a treatment of the police that has created a mutiny among them; in a treatment of government copying-clerks that causes them publicly to complain of broken promises; in a treatment of postmen that calls from them disrespectful behavior toward their superiors: all at the same time that there is going on the controversy about Park-rules, which have been so issued as to evade constitutional principles, and so administered as to bring the law into contempt. Yet, as fast as there come proofs of mal-administration, there come demands that administration shall be extended. Just as, in societies made restive by despotism, we see that, for the evils and dangers brought about, the remedy is more despotism; just as we see that, along with the failing power of a decaying Papacy, there goes, as the only fit cure, a reassertion of Papal infallibility with emphatic *obligato* from a Council; so, to set right the misdoings of State-agency, the proposal is always more State-agency. When, after long continuance of coal-mine inspection, coal-mine explosions keep recurring, the cry is for more coal-mine inspection. When railway accidents multiply, notwithstanding the oversight of officials appointed by law to see that railways are safe, the unhesitating demand is for more such officials. Though, as Lord Salisbury lately remarked of governing bodies deputed by the State, "they begin by being enthusiastic and extravagant, and they are very apt to end in being wooden" —though, through the press and by private conversation, men are perpetually reminded that, when it has ceased to wield the new broom, each deputy governing power tends to become either a king-stork that does mischief, or a king-log that does nothing—yet more deputy governing powers are asked for with unwavering faith. While the unwisdom of officialism is daily illustrated, the argument for each proposed new department sets out with the postulate that officials will act wisely. After endless comments on the confusion and apathy and delay of Government offices, other Government offices are advocated. After ceaseless ridicule of red-tape, the petition is for more red-tape. Daily we castigate the political idol with a hundred pens, and daily pray to it with a thousand tongues.

The emotion which thus destroys the balance of judgment lies deep in the natures of men as they have been and still are. This root, out of which there grow hopes that are no sooner blighted than kindred hopes grow up in their places, is a root reaching down to the earliest stages of civilization. The conquering chief, feared, marvelled at, for his strength or sagacity, distinguished from others by a quality thought of as supernatural (when the antithesis of this with natural becomes thinkable), ever excites a disproportionate faith and expectation. Having done or seen things beyond the power or insight of inferiors, there is no knowing what other such things he may not do or see. After death, his deeds become magnified by tradition; and his successor, inheriting his authority, executing his commands, and keeping up secret communication with him, acquires either thus, or by his own superiority, or by both, a like credit for powers that transcend the ordinary human powers. So there accumulates an awe of the ruler, with its correlative faith. As we trace the genealogy of the governing power, thus beginning as god, and descendant of the gods, and having titles and a worship in common with the gods, we see there clings to it, through all its successive metamorphoses, more or less of this same ascribed character, exciting this same sentiment. "Divinely descended" becomes presently "divinely appointed," "the Lord's anointed," "ruler by divine right," "king by the grace of God," etc. And then as fast as declining monarchical power brings with it decreasing belief in the supernaturalness of the monarch (which, however, long lingers in faint forms, as instance the supposed cure of king's evil), the growing powers of the bodies that assume his functions bring to them a share of the still-surviving sentiment. The "divinity that doth hedge a king" becomes, in considerable measure, the divinity that doth hedge a Parliament. The superstitious reverence once felt toward the one is transferred, in a modified form, to the other, taking with it a tacit belief in an ability to achieve any end that may be wished, and a tacit belief in an authority to which no limits may be set.

This sentiment, inherited and cultivated in men from childhood upward, sways their convictions in spite of them. It generates an irrational confidence in all the paraphernalia and appliances and forms of State-action. In the very aspect of a law-deed, written in an archaic hand on dingy parchment, there is something which raises a conception of validity not raised by ordinary writing on paper. Around a Government-stamp there is a certain glamour which makes us feel as though the piece of paper bearing it was more than a mere mass of dry pulp with some indented marks. To any legal form of words there seems to attach an authority far greater than that which would be felt were the language free from legal involutions and legal technicalities. And so is it with all the symbols of authority, from royal pageants downward. That the judge's wig gives to his decisions a weight and sacredness they would not have were he bareheaded, is a fact familiar to every one. And, when we descend to the lowest agents of the executive organization, we find the same thing. A man in blue coat and white-metal buttons, which carry with them the thought of State-authority, is habitually regarded by citizens as having a trustworthiness beyond that of a man who wears no such uniform; and this confidence survives all disproofs. Obviously, then, if men's judgments are thus ridiculously swayed, in spite of better knowledge, by the mere symbols of State-power, still more must they be so swayed by State-power itself, as exercised in ways that leave greater scope for the imagination. If awe and faith are irresistibly called out toward things which perception and reason tell us positively should not call them out, still more will awe and faith be called out toward those State-actions and influences on which perception and reason can less easily be brought to bear. If the beliefs prompted by this feeling of reverence survive even where they are flatly contradicted by common-sense, still more will they survive where common-sense cannot so flatly contradict them.

How deeply rooted is this sentiment excited in men by embodied power will be seen, on noting how it sways in common all orders of politicians, from the old-world Tory to the Red Republican. Contrasted as the extreme parties are in the types of Government they approve, and the theories they hold respecting the source of Government authority, they are alike in their unquestioning belief in governmental authority, and in showing almost unlimited faith in the ability of a Government to achieve any desired end. Though the form of the agency toward which the sentiment of loyalty is directed is much changed, yet there is little change in sentiment itself, or in the general conceptions it creates. The notion of the divine right of a person has given place to the notion of the divine right of a representative assembly. While it is held to be a self-evident falsity that the single will of a despot can justly override the wills of a people, it is held to be a self-evident truth that the wills of one-half of a people, *plus* some small fraction, may with perfect justice override the wills of the other half, *minus* this small fraction—may override them in respect of any matter whatever. Unlimited authority of a majority has been substituted for unlimited authority of an individual. So unquestioning is the belief in this unlimited authority of a majority, that even the tacit suggestion of a doubt produces astonishment. True, if, of one who holds that power deputed by the people is subject to no restrictions, you ask whether, if the majority decided that no person should be allowed to live beyond sixty, the decision might be legitimately executed, he would possibly hesitate. Or, if you asked him whether the majority, being Catholic, might rightly require of the Protestant minority that they should either embrace Catholicism or leave the country, he would, influenced by the ideas of religious liberty in which he has been brought up, probably say no. But, though his answers to sundry such questions disclose the fact that State-authority, when an embodiment of the national will, is not believed by him to be absolutely supreme, his latent conviction, that there are limits to it, lies so remote in the obscure background of his consciousness as to be practically non-existent. In all he says about what a legislature should do, or forbid, or require, he tacitly assumes that any regulation may be enacted, and when enacted must be obeyed. And then, along with this authority not to be gainsaid, he believes in a capacity not to be doubted. Whatever the governing body decides to do can be done, is the postulate which lies hidden in the schemes of the most revolutionary reformers. Analyze the programmes of the Communalists, observe what is hoped for by the adherents of the Social and Democratic Republic, or study the ideas of legislative action which our own Trades-Unionists entertain, and you find the implied belief to be that a Government, organized after an approved pattern, will be able to remedy all the evils complained of, and to secure each proposed benefit.

Thus, the emotion excited by embodied power is one which sways, and indeed mainly determines, the beliefs, not only of those classed as the most subordinate, but even those classed as the most insubordinate. It has a deeper origin than any political creed, and more or less distorts the conceptions of all parties respecting governmental action.

This sentiment of loyalty, making it almost impossible to study the natures and actions of governing agencies with perfect calmness, greatly hinders sociological science, and must long continue to hinder it. For the sentiment is all-essential. Throughout the past, societies have been mainly held together by it. It is still an indispensable aid to social cohesion and the maintenance of order. And it will be long before social discipline has so far modified human character that reverence for law, as rooted in the moral order of things, will serve in place of reverence for the power which enforces law.

Accounts of existing uncivilized races, as well as histories of the civilized races, show us *a posteriori* what we might infer with certainty *a priori*, that, in proportion as the members of a society are aggressive in their natures, they can be held together only by a proportionately strong feeling of unreasoning reverence for a leader or a ruler. Some of the lowest types of men, who show but little of this feeling, show scarcely any social cohesion, and make no progress—instance the Australians. Where appreciable social development has taken place, we find subordination to chiefs; and, as the society enlarges, to a king. If we need an illustration that, where there is great savageness, social union can be maintained only by great loyalty, we have it among those ferocious cannibals the Fijians. Here, where the barbarism is so extreme that a late king registered by a row of many hundred stones the number of human victims he had devoured, the loyalty is so extreme that a man stands unbound to be knocked on the head if the king wills it: himself saying that the king's will must be done. And if, with this case in mind, we glance back over the past, and note the fealty that went along with brutality in feudal ages; or if, at the present time, we observe how the least advanced European nations show a superstitious awe of the ruler, which, in the more advanced, has become conventional respect; we shall perceive that decrease of the feeling goes on, and can normally go on, only as fast as the fitness of men for social coöperation increases. Manifestly, throughout all past time, assemblages of men in whom the aggressive selfishness of the predatory nature existed without this feeling, which induces obedience to a controlling power, dissolved and disappeared, leaving the world to be peopled by those who had the required emotional balance. And it is manifest that, even in civilized society, if the sentiment of subordination becomes enfeebled without self-control gaining in strength proportionately, there arises a danger of social dissolution—a truth of which France supplies an illustration.

Hence, as above said, the conceptions of sociological phenomena, or, at least, of those all-important ones relating to governmental structures and actions, must now, and for a long time to come, be rendered more or less untrue by this perturbing emotion. Here, in the concrete, may be recognized the truth before stated in the abstract, that the individual citizen, embedded, as it were, in the social organism as one of its units, mainly moulded by its influences, and aiding reciprocally to remould it, furthering its life while enabled by it to live, cannot so emancipate himself as to see things around him in their real relations. Unless the mass of citizens have sentiments and beliefs in something like harmony with the social organization in which they are incorporated, this organization cannot continue. These sentiments proper to each type of society will inevitably sway the sociological conclusions of its units. And, among other sentiments, this awe of embodied power will take a large share in doing this.

How large a share it takes, we shall see on contemplating the astonishingly perverted estimates of rulers it has produced, and the resulting perversions of history. Recall the titles of adoration given to emperors and kings; the ascription to them of capacities, beauties, powers, virtues, transcending those of mankind in general; the fulsome flatteries used when commending them to God in prayers professing to utter the truth. Now, side by side with these, put records of their deeds throughout all past times in all nations; notice how thickly these records are sprinkled with crimes of all orders; and then dwell a while on the contrast. Is it not manifest that the conceptions of State-actions that went along with these profoundly untrue conceptions of rulers must also have been profoundly untrue? Take, as a single example, King James, who, as described by Mr. Bisset in agreement with other historians, was "in every relation of life in which he is viewed . . . . equally an object of aversion or contempt;" but to whom, nevertheless, the English translation of the Bible is dedicated in sentences beginning, "Great and manifold were the blessings, most dread sovereign, which Almighty God, the Father of all mercies, bestowed upon us the people of England, when first He sent Your Majesty's Royal Person to rule and reign over us," etc., etc. Think of such a dedication of such a book to such a man; and then ask if, along with a sentiment thus expressing itself, there could go any thing like balanced judgments of political transactions.

Does there need an illustration of the extent to which balanced judgments of political transactions are made impossible by this sentiment during times when it is strong? We have one in the warped conceptions formed respecting Charles I. and Cromwell; and respecting the changes with which their names are identified. Now that many generations have gone by, and it begins to be seen that the one was not worthy to be prayed for as a martyr, while the other deserved treatment quite unlike that of exhuming his body and insulting it, it begins to be seen, also, how utterly wrong have been the interpretations of the events they took part in, and how entirely men's sentiments of loyalty have incapacitated them for understanding those events under their sociological aspects.

Naming this as an instance of a more special perverting effect of this sentiment, we have here chiefly to note its more general perverting effect. From the beginning it has tended ever to keep in the foreground of consciousness the governing agent as causing social phenomena; and so has kept in the background of consciousness all other causes of social phenomena—or, rather, the one has so completely occupied consciousness as to exclude the other. If we remember that history has been full of the doings of kings, but that only in quite recent times have the phenomena of industrial organization, conspicuous as they are, attracted any attention—if we remember that, while all eyes and all thoughts have been turned to the actions of rulers, no eyes and no thoughts have, until modern days, been turned to those vital processes of spontaneous coöperation by which natural life, and growth, and progress, have been carried on—we shall not fail to see how profound have been the resulting errors in men's conclusions about social affairs. And, seeing this, we shall infer that the emotion excited in men by embodied political power must now, and for a long time to come, be a great obstacle to the formation of rational sociological conceptions—tending, as it must ever do, to exaggerate the importance of the political factor in comparison with other factors.

Under the title of "Subjective Difficulties—Emotional," I have here entered upon an extensive field, the greater part of which remains to be explored. The effects of impatience, the effects of that all-glorifying admiration felt for military success, the effects of that sentiment which makes men submit to authority by keeping up a superstitious awe of the agent exercising it, are but a few among the effects which the emotions produce on sociological beliefs. Various other effects have now to be described and illustrated. We will deal with them in chapters on "the Educational Bias," "the Bias of Patriotism," "the Class-Bias," "the Political Bias," and "the Theological Bias."

THE WARMING OF HOUSES.

By JOHN P. SEDDON, Esq.

THE usual appliances for warming houses, setting aside comprehensive systems, resolve themselves into open grates, close stoves, and, under special conditions, gas apparatus, and pipes for hot air or water for warming halls and passages.

For the whole of these certain general rules may be laid down:

1. More cannot be got out of any one of them than is put into it. This is an axiom which, truism as it appears, is necessary should be impressed upon the public mind, which is apt to assume that engineering skill can multiply the heating power of fuel indefinitely. Thus, materials like fire-clay, which are absorbent of heat and useful to prevent its escape, and retain it till needed, must abstract it first from the fuel before it can dispense it.

2. There are but 100 degrees of percentage. This simple fact should be kept in mind in considering methods of saving fuel, the inventors of which would otherwise persuade one that reference to coal-merchants is a work almost of supererogation.

3. Some proportion of the heat generated must be expended in maintaining a draught in the flue, which is to carry off the products of combustion. This is by no means unprofitably lost, since it promotes ventilation as well.

4. To minimize this proportion of escaping heat to as nearly as possible what is just necessary, and to take toll from it during its passage, as by warming the air which is to replace that abstracted by the flue, are the principal directions which efforts to economize fuel should take.

5. The products of combustion, being noxious, must be wholly removed, unless they can be chemically transformed. It is as barbarous to allow the fumes from gas to invade rooms, as it is to let the door be the sole outlet for peat-smoke in an Irish cabin, or as it was to provide only louvers in the roofs of the halls of our forefathers for the smoke of their wood-fires. The evil may be disguised, but the poison is the more insidious from being comparatively unfelt. The lungs of the living animals, as the leather of dead ones on the book-shelves, become corroded alike by its pernicious influence.

6. Warming and ventilation are so intimately connected that, although the latter is not my special subject upon this occasion, it is

necessary that it should be kept in mind throughout while treating of the former. In fact, infusing heated air is a more economical and pleasanter mode of warming houses than direct radiation, and it is only by their capability of combining the two methods that open fires can maintain ascendency over stoves, and it is only by uniting proper ventilation with stoves that they ought to be tolerated.

Lastly, all appliances should be simple and as self-acting as possible. This is essential for those intended for the use of the poor, whose treatment of them is of the roughest, and who neither need nor understand any thing complicated. If there be a damper to be drawn, or a handle to be turned by them, neither will be drawn nor turned except occasionally the wrong way, and if there be any cover or part that is loose, it is safe to be lost. At the risk, therefore, of some waste, their scanty fuel must be consumed in the most primitive manner possible. With somewhat less force the same caution may be given to those who design apparatus for the upper classes. Every thing even for them should be as self-acting as possible, for, though individuals may for a time take a fancy to an ingenious arrangement that requires personal adjustment, they tire of it in time; servants in their succession are not to be drilled into its use, and the thing is soon left to itself, and failure is the inevitable result.

To proceed to the several appliances themselves:

In the race to attain *economy*, it must be acknowledged, at the outset, that close stoves completely distance open grates, and that they in their turn are as far ahead of all gas-apparatus as at present invented; and yet all have some advantages as well as disadvantages peculiar to themselves, to which it is worth giving some consideration.

In stoves, the heat from fuel can be almost wholly extracted and utilized, and even the little that escapes with the gaseous products of combustion is heavily taxed when its ultimate exit is by the few insignificant pipes, or diminutive chimney-stalks, which alone are suffered to peep above the roofs of houses on the Continent. English ideas of comfort will not, however, permit of the general introduction of the stove system into this country, and it is hardly to be desired that it should, unless great improvement be grafted upon that in vogue abroad, in which stuffiness is ever an accompaniment of warmth.

Our British privilege, however, of being able to poke the fire, although purchased dearly by its concomitant dust and the labor it entails upon servants, is not likely soon to be relinquished, and the luxury of an open fire is a fact which no theory can demolish.

Still, the grates in common use savor of barbarism, and much can and should be done to gain further refinement, economy, and immunity from nuisance. There is no need, for instance, that our roofs should be disfigured by the ugly and even comical flue terminals which Dickens satirized in one of his latest Christmas publications. We ought not to be subject to vexatious down-draughts in windy weather, nor to chimneys that smoke unless a door or window be open. Our drawing-rooms should not be invaded by sooty chimney-sweepers, and all ought not to have to scramble for a place near the fire in a room to be warm, nor when there to have to rotate like a smoke-jack to prevent being frozen on one side while we are scorched on the other.

Such evils are to be obviated by simple means, and yet ninety-nine out of every hundred Englishmen submit to them supinely if not patiently. Whole streets, occupied by men of means, have their sky-line fringed with demon-like excrescences which tell a sure tale of internal discomfort. Such was the case with that in which my own residence is situated. When I took my house upon lease, though it had been well built by an eminent architect for his own use, yet, in common with all its neighbors, it displayed a grim array of tall-boys and tortuous contrivances as chimney terminals. All these I swept away at once, without inquiry, feeling that, whatever might be needed, they certainly could not be. I then introduced an air-pipe to each fireplace through the floors, and, as I expected, found no smoky chimneys to complain of, though my neighbors still grumble at theirs, as I do of their futile and unsightly expedients to remedy them.

So much depends upon the proper construction of fireplaces and their flues, without which no appliance in the shape of a grate can have fair play, that I shall in the first place describe the points to be attended to in the erection of these portions of a building, and in palliating evils in those which already exist.

The first essential to insure a good draught is that the flue should be sufficiently rarefied. For this purpose it is desirable that it should not be in an outer wall; but, if it be necessarily so, the enclosing wall should be thick (at least 9 in. between the flue and the outer air) or else it should be protected by a double casing, with intermediate hollow space. Materials which absorb damp should be avoided for the construction, as they tend to the evaporation and loss of the heat generated; and the interior of the flue should be well pargetted, to further prevent the suction of external cold by the up-draught within. Another important point is that the flue be not too large, or currents of cold air descending will interfere with the ascending heated air. In old buildings flues are found of large size—as 18 in. by 12 in.—with wide throats, funnel-shaped, diminishing upward. But the fuel used in them was wood, and abundant, and men were more hardy, and minded not the roaring of wind in the chimney, or cowered over the embers within the vast embrasure of the fireplace, which formed an inner room of itself. There are those who would revive these large flues, on the ground that no cowls decorate their terminals. If, however, we are to recur to the practice of our ancestors, we might as well revert to that of a still earlier age, when the stately hall of Penshurst had its fire upon a hearth in the centre, and the graceful wreaths of smoke thence found exit by the lantern in the roof. We must needs then have the same goodly logs as fuel, and a supply which will enable us to afford the blaze that alone would suffice to rarefy a cavern. The ordinary coal-fires of our apartments do not need a larger flue than a pipe of 9 in. in diameter. Mr. Richardson, in his work, states that the houses built by Cubitt in Belgravia have flues 9 in. by 9 in. only, while others erected later have them 14 in. by 9 in., and that these are distinguishable outside by the absence or presence of objectionable cowls respectively. Kitchen-flues must be larger, in proportion to their fires, or better, perhaps, doubled—a practice for which old precedents may be found, and which seems calculated to avoid down-draughts.

For the avoidance of that particular nuisance, however, special provision should be made in every flue. This may be done by an enlarged space, wherein the force of gusts of wind may expend itself upon, as it were, a cushion of air. If the first pipe above the chimney-mantel be a 9-inch pipe, let the next be a 15-inch one, and the flue above continued with 9-inch ones. A somewhat similar arrangement has been proposed by Mr. Boyd for brick flues. He discontinues the vertical flue a few feet above the mantel with an enlarged space or pocket, and carries an inclined one from the fireplace into this on one side, and the down-draught, thus meeting resistance at the bottom, eddies round the space, without being able to check the upward draught from below. Mr. Cubitt's continuation of the flue to the basement also obviously affords a resisting column of air to accomplish the same purpose. It may be impossible to make such cavities large enough to overcome the effect of every down-draught, but these provisions against them will generally secure this desired end if combined with ample provision of air to the fireplace.

The use of pipes for the lining of flues has the advantage of compelling a good and non-porous finish, which would otherwise be neglected by careless workmen, who often will not take the trouble to properly parget and core the flues in stone and brick walls. The interior of the pipes, however, should be rough, and by no means glazed, or their inability to give any means of adherence to soot will be found a nuisance, in consequence of its continual dropping. The old funnel-shaped throat left a large space above the grate filled with cold air, which checked the draughts. This depends much upon the grate itself; but, generally speaking, the flue should be contracted to its smallest size as soon as possible above the mantel. Iron frames for this purpose, serving as mantel-bars as well, such as Gibbs's registered fireplace-lintel, are useful appliances. A concrete block may be made of the shape required at perhaps the least cost. . . .

The construction of the fireplace itself is of the most importance. The contraction of the flue immediately over it is the first point to be looked to, and next the provision of a proper supply of air for the combustion of the fuel. To illustrate this in the simplest manner, I may refer to a small room with a large fireplace in it, belonging to a friend, which was complained of as simply uninhabitable by reason of the draughts that invaded it from all sides. A piece of iron pipe, with the lower end protruded through the outer wall, the middle brought through the fire, and the upper end open to the room, stopped all cause for complaint. The reason for this is so obvious that it seems hardly credible that a vast majority of dwellers in houses are enduring continual torture for want of this pipe or some equivalent simple appliance. One looks in vain along the walls of our streets for any signs of air-bricks or other inlets of air, and, with closed doors and plate-glass windows, one wonders where the air comes from to feed the fires within. There are but few available sources, which are these: 1. The joints of the window-frames and chinks round doors, through which cold blasts whistle as they are sucked in, so that these are pasted up, and as far as possible this means of supply intercepted. 2. Unused flues of other rooms down which air pours mixed with smoke; and 3. The soil and waste pipes, the water in the taps of which cannot hinder the precious element from coming even by such undesirable channels, in obedience to the powerful suction of the several fires in the house. These failing, there are positively no other sources. Then, fortunately, the fires begin to smoke, and doors and windows are perforce opened to abate that by far the smallest and least dangerous nuisance of the whole.

The remedy for this is to provide a sufficiently ample supply of pure, fresh air in such a manner that it may come in moderately warm, and from such quarter that it be felt as a draught. There are several means of doing this, each hotly maintained by its partisans to be the only fit and proper one. The bottom, the centre, and the top of the room, are each pointed out as being specially adapted for the purpose by those much-enduring laws of Nature, and the course of the currents of air, demonstrated by flights of the most obedient and flexible arrows. This certainly may be taken for granted: if openings be made in any or all of the positions indicated, the laws of Nature will make a beneficial use of them, but it will be capriciously, one moment as an inlet and one as outlet, as the occasion may need. The fire being the motive power of the currents, the direction that the air will take if it can will be in a straight line to the fireplace, and, therefore, to obviate disagreeable draughts, the air-inlets must not be placed so that currents thence must necessarily impinge upon the inmates of the room, as in the case of the undesigned ones of the chinks round the doors and windows. Again, they should not be so near and below the grate as to rush direct to feed the fire, and thus, not only not aid to ventilate the room, but absolutely take from the fire that valuable office. By far the best mode, in my opinion, is to introduce the air below the hearth, and carry it thence through warming-chambers at the back or sides of the grate, and allow it to issue into the room above the fireplace, or from the outer sides from the chimney-piece, so that it must ascend and mix with the air in the room before it finds its ultimate exit by the fireplace or outlet-flue. In fact, the fireplace itself should be the fountain of warmed fresh air to an apartment, since no draught thence can be annoying to any of the inmates of the room. The air may be brought, according to its position upon different floors, from below, by air-bricks inserted in the walls between the joists, or from above the roof by a flue constructed for the purpose; and if this flue be carried in close connection with the chimney-flue, whether in separate pipes, as by Mr. Jennings's method, by the use of Boyd's metal withes, or ordinary brick ones, the air drawn down by the suction of the fire will have the temperature considerably raised above that of the outer atmosphere, the coldness of which, entering by windows, is unendurable.—*Builder.*

IS ELECTRICITY LIFE?

By HENRY LAKE.

WE have had many specimens of electricity this summer—more, perhaps, than for fifty years previously. Those, particularly, who lived in the north and west of England, have had a greater demonstration of the powers of this extraordinary agent than in any ten years, rolled into one, of the last quarter of a century. The thunder season began with five days' successive storms in Liverpool and its neighborhood. The first arrived on Monday, soon after the fire which broke out at the Northwestern Hotel had frightened the people half out of their senses. The storms culminated on Thursday, when the fire literally "ran along upon the ground," and the thunder bellowed in the ears of the merchants, so that business was suspended and "high 'Change" was a desert at mid-day. Fortunately, the only serious result was the firing of a house at Birkenhead, stunning the lady inmates, knocking down the chimneys, fusing the bell-wires, and melting the gas-pipes. After a few discharges here and there, with more or less injury to life and property (notably in Manchester), the atmosphere became wonderfully settled, and Monday, the 17th of June, was one of the finest days, and one of the calmest and brightest evenings amid the usual long twilight of the North. Those particularly who were travelling at that time will not soon forget that extraordinary evening, when, by the most peculiar clearness of the atmosphere, every object was brought out with a sharpness which rendered the whole landscape a new sensation. It was the quiet rest of Nature before the battle of the elements which was to follow.

The 18th of June will long be remembered by all the people of the north of England. An Egyptian darkness came down upon the land at mid-day. While the sun was shining, the lightning fired the electric gun at Newcastle three minutes before its time, casting a slur on the chronometer of the best ship lying in the river; and then, like a pall, the clouds descended and literally walked through the town. There was no looking *up* at the lightning; it was on a level with the eye. The streets were a deluge, and old people and children and furniture were hurled along in the torrent. At the height of the storm, twenty-one flashes were counted in a minute, and the thunder rolled without intermission, only enlivened by a loud discharge as from a sixty-four pounder. Wherever there was a window open, the lightning ran in and out in mad revel. Houses were struck in every direction, and windows of whole streets were smashed, though no one knew whether by the hail or the thunder. Families assembled for prayer, believing they had arrived at the final consummation; and all who witnessed this storm—whether the population, scared out of their wits for many a day, or the fifteen people who were struck by the lightning, or the five who were killed by it (if they could have returned to give their testimony)—would have decided the question at the head of this paper, and said, "Electricity is *death*."

And yet "electricity *is* life." It is the very soul of the universe. It permeates all space, surrounds the earth, and is found in every part of it. Its pristine character is by no means what we have above described. It is naturally the most peaceful agent in creation. It is eminently social, and nestles round the form it inhabits. Unlike many human specimens, it never desires to keep all its good to itself, but is ever ready to diffuse its beneficence. It is only in abnormal conditions, and in unexpected *rencontres*, that it displays itself in that brilliant flash and that deafening roar with which its majestic force yields up its great spirit.

The ocean, for instance, is compounded of water and salt; one is an electric, the other not. The friction of these causes the phosphorescent appearance so often observed at sea. But, when clouds arise from the ocean and come inland, they are mostly highly charged with electricity, and, being naturally anxious to give up the good things they possess, when they meet clouds not so much electrified, they hand over their surplus commodity, and the deliverance makes the earth and all created things in the neighborhood tremble. Or, if clouds arise from fresh waters, or from land not having much electric fire, the sun himself warms them up in a friendly manner; and, as they become charged with the vital fluid, and, in a drunken sort of way, stumble against the sides of mountains or against other clouds, the same benignant tendency to part with what they have too much of induces them to give up their vital force, and the fire flashes across the sky, and all creation bows before the artillery of the heavens. And then they weep together over the kindly exchange, though their tears do sometimes swell the rivers and produce a number of catastrophes not originally in the programme, as at Manchester and throughout Yorkshire this season; and their friendly distribution of fire sometimes fails to reach the intended cloud, and strikes down towers, churches, trees, and houses, and occasionally destroys a human body not possessed of its proper quantity of electricity. For that is, most probably, the reason why we so often find one person struck by lightning in a place where several others are assembled and escape.

A singular instance of the friendly interchange of civilities among clouds was observable at Bridlington Quay this summer. Those who know the place will remember the long stretch of table-land lying north and south, and facing the ocean. A large cloud over the sea lowered and approached the south point of the table-land. Immediately a flash ascended from the earth to the cloud, and this again occurred more than twenty times as the cloud sailed majestically over the fringe of the table-land from south to north. And now overhead might be seen a succession of minor clouds, arriving from all directions, but all evidently having their eye upon the big cloud that was approaching them, until they hovered round it like a parcel of school-boys round a newly-arrived cake. At length the cake was cut. A flash came out from the big cloud, then another and another; then the nearest clouds flashed out again to those which were farther removed. Down came a deluge of rain, the thunder rolled incessantly, till, the distribution of good things having been completed, the clouds sailed away, and the sun shone again merrily.

That all created living bodies are electric there can be no question; and as little that some persons, animals, and plants, are more electric than others. Two forms of the latter are familiar. Few school-boys are guiltless of experiments on poor puss, from whose much-enduring back electric sparks may be drawn, especially in dry, frosty weather; and most young ladies have admired the elegant sensitive-plant, whose leaves seem to move and feel,

"And with quick horror fly the neighboring hand"

that draws from it the electricity which it contains more than other plants; and its leaves at once fall flaccidly, until a new supply of electric force renders them once more turgid.

But bodies have not only electricity within them, but an electric atmosphere, of the form of the body which it surrounds, and which is attracted by it. Without this, we could not shake hands with a friend, or kiss a lip, without the danger of the excess of electricity flying off and destroying us, or the he or she that we would greet or kiss. Perhaps it is the commingling of these electric atmospheres that makes kissing so nice.

Two conditions of the human body are also illustrative of its varied electrical action. A person who has the small-pox cannot be electrified, while sparks of electricity may be drawn from the body of a patient dying of cholera. In the first instance, it appears that the body is fully charged with its own electricity, since it is impossible to electrify a body beyond a certain degree; in the latter, there seems to be a tendency to part with the electrical force which is essential to the support of life, and which may account for the distressing and rapid weakness of cholera patients.

We have hitherto spoken only of electricity of very high tension, which produces the lightning-spark; and which boys and girls know as the product of the frictional electrical machine, the shock of which their elbow-joints constantly remember. We wish now to refer to something infinitely more quiet and peaceful, and to which we are indebted for many of our greatest luxuries.

Galvani's boy-pupil, amusing himself in his master's laboratory, accidentally bringing the legs of a recently-killed frog into an electric current, the great philosopher perceived at once the manifestation of a new power. It remained only for Volta to invent his pile, consisting of a continued series of zinc and copper plates, with pieces of cloth between, and the foundation and general principles of electro-galvanism and voltaic electricity were laid down.

Frictional electricity has been compared to the high-pressure steam of a locomotive, and voltaic electricity to the steam rising quietly from an open boiler. The chemical action of frictional electricity is very feeble; it has great intensity but little quantity; while the voltaic pile will yield an enormous *quantity* of electricity but with feeble *intensity*. Faraday calculated that it would require a Leyden battery to be charged by 800,000 turns of a powerful plate machine to decompose a single grain of water, which by one of Pulvermacher's bands may be done in a few seconds.

It is to this latter agent, voltaic electricity, that we are indebted for electro-plate, which has not only rendered our tables more decent, but has supplied real works of art, and statues and ornaments innumerable. That is also the power by which we are enabled to convey our thoughts thousands and thousands of miles, over mountains and through vast oceans, and to converse from our dining-room with our friends in almost every part of the world; while by its agency rocks are blasted, cannons and torpedoes are fired, and even the bells of some of our houses are rung.

Undoubtedly, however, the greatest marvels of this beneficent agent are to be found in its influence on the human frame, and in the cure of disease. But, like every thing that is destined eventually to be accepted by the public as a matter of course, it has had to pass through the usual three stages of contempt, controversy, and adoption. More than a hundred years ago John Wesley said: "How much sickness and pain may be prevented or removed, and how many lives saved, by this unparalleled remedy! And yet with what vehemence has it been opposed! Sometimes by treating it with contempt, as if it were of little or no use; sometimes by arguments, such as they were; and sometimes by such cautions against its ill-effects as made thousands afraid to meddle with it." And he thus sums up his opinion of the medical profession, and their opposition to the use of electricity in disease: "There cannot be in Nature any such thing as an absolute *panacea*, a medicine that will cure every disease incident to the human body. If there could, electricity would bid fairer for it than any thing in the world. Mr. Lovett is of opinion that the electrical method of treating disorders cannot be expected to arrive at any considerable degree of perfection till administered and applied by the gentlemen of the faculty. Nay, then, *quantâ de spe decidi!* all my hopes are at an end. For when will it be administered and applied by them? Truly *ad Græcas calendas.* Not till the gentlemen of the faculty have more regard to the interest of their neighbors than their own. Therefore, without waiting for what probably never will be, and what indeed we have no reason to expect, let men of sense do the best they can for themselves, as well as for their poor sick helpless neighbors. I doubt not but more nervous disorders would be cured in one year by this single remedy, than the whole English *materia medica* will cure by the end of the century."

This is hard upon the doctors, yet it only fairly expresses their conduct at that period. They alone, however, are not to be held responsible for the delay in adopting the curative powers of electricity. Every thing worth having has to force its way to acceptance. A popular writer has well said: "If London could be lit, like the city in the fairy tale, with a single diamond, which rendered it brighter at midnight than at mid-day, it would take ten years to smoothe away prejudices and conciliate self-interests, so as to admit of the illuminating gem being displayed." All the astonishing cures in the early period of electricity were effected by clumsy and unportable machinery, with "shocks" of high-tension current, which are peculiarly disagreeable to some persons. They are indeed like the actual cautery—the hot iron to the wound—when compared with the modern appliances of chain batteries and bands, whose action is so tender that a baby would not wince at it, and which are so portable that the whole apparatus may be carried in the pocket. It has fallen to the man of science, and not to the medical practitioner, to enforce a belief in the curative powers of electricity upon the public.

About the centre of the fashionable side of Regent Street may be seen the establishment of Mr. Pulvermacher. How many suffering from disease which has baffled the skill of physicians, how many whose nervous feelings render life a burden to them, how many afflicted with tic-douloureux or neuralgia, limping with gout or rheumatism, shivering with palsy, or bent with paralysis, pass that establishment, ignorant that therein most probably lies the mitigation of their suffering, if not their absolute cure!

There can be no question of the curative powers of electricity, since there is now extant a scientific literature, by the most eminent physiologists and thaumaturgists, affirming these powers; but, as we have said, electricity has been clumsy in its apparatus, and unpleasant in its action. These difficulties Mr. Pulvermacher has effectually overcome, to the satisfaction not only of most of the scientific men on the Continent, but also of such men as Sir C. Locock, Sir H. Holland, Sir William Ferguson, Sir J. R. Martin, Dr. Sieveking, Dr. Quain, Dr. Andrew Clarke, Dr. Golding Bird, Dr. Thompson, and a host of other English celebrities.

The great advantage of electrical action is, that it brings relief in a large number of diseases confessedly beyond the reach of the ordinary remedies of the physician. How powerless, for instance, is ordinary medical skill in tic-douloureux! Tic, tic, tic; it is a recurring gentle monosyllable, suggestive of something peculiarly quiet and peaceful; but, madam, that tic shoots through your head like a shot from a nine-pounder, the only difference being that after the "tic" you have your head ready for another, while after the shot you would have no head worth mentioning. Or, see the tears rolling down the cheeks of that pretty girl, whose ideas of love and romance and sentiment are scared away by the wearing pain of neuralgia; or, racking with the pain of gout and rheumatism, the man of middle age passes his restless nights, gaining temporary respite from pain by colchicum, or a fitful repose from morphine, and buying present ease at the cost of an unhappy and painful old age. Why, madam, do you endure this tic? Why, dear young lady, do you pine under neuralgia? Why, old man, do you writhe in gouty or rheumatic agony, when help is so near? It is the *vis inertiæ*, the unbelief in the face of facts, the idiotic negligence of remedies which appear simple. If they had been bid to do some great thing, would they not have done it? But these little chains, that can be worn like a piece of ribbon, what are they in the face of tic, and neuralgia, and rheumatism? These chain-batteries, that look like pieces of jewelry, what can they do to strengthen the trembling hand, or revive the withering limb?

We will tell you what they are, and what we have seen them do. We have seen this little band, which you seem to think so little of—you, the sufferer from acute pain—we have seen it with only four or five elements—that is, about a foot long—dry and unexcited, placed for one second to the upper plate of an electroscope, and it has produced the phenomena of attraction and repulsion on the gold-leaf. We have seen a band half an inch wide prove the power of the electric current, by passing through two persons and decomposing water in a test-tube. We have seen the little glittering chain-battery, which could be carried in the waistcoat-pocket, produce a continuous current that diffused a perfect glow of warmth through the system; and with a little instrument, called a "contact-breaker," appended to the same chain, we have had the intermittent current, which can be regulated, from a gentle vibratory motion to shocks as powerful as could be gained from a huge or cumbrous battery, and far more powerful than we cared to endure.

But, if these chains and bands are small, they are not only powerful but valuable; and, as money is the great test of value in this eminently commercial country, it may be right to state that £10,000 was the penalty inflicted by the Imperial Court of Appeals in Paris, for the infringement of the patent.

Here, then, we have an electric source divested of all machinery and complication, which could be carried in a cigar-case, and which can be made to furnish both the interrupted and the continuous current in large quantities. It can be set in action by the simplest means —merely a little vinegar and a little water; and it can be applied not only, as in the old mode, to the extremities, but so as to surround the body of the patient.

Although we are not continually made sensible of it, men and women are electrical machines. The researches of Matteucci, Dubois-Reymond, Rutter, and Faraday, prove that there exists, both in the muscles and nerves of human beings and all animals, a natural electricity, independent of mechanical, physical, or chemical actions, exterior or interior; that this electricity is manifested under the form of closed currents circulating along the muscles or nerves; that the presence of this free electricity is subordinate to the state of the life of the animal, and disappears with the vital force; that all parts of the body furnish signs of free positive electricity, especially when the circulation is excited, which signs disappear under the action of cold and in rheumatic fever; that quantity currents of low tension are constantly acting throughout the vascular system, while currents of high tension, but of inferior quantity, are to be found in the cerebral, spinal, and nervous systems, flowing, in a state of rest of the individual, in directions defined by Nature, from the centre to the circumference.

The direction of this current is modified by voluntary muscular contractions, but its flow may be obstructed by hostile, poisonous influences. A deficiency of the powers of the body for this electro-generation, or a deficiency in the conducting powers of the vascular and nervous systems, is to be remedied by an artificial supply of electricity, precisely as we go to the fire to warm ourselves. But, precisely as we do not put ourselves on the fire, but take its heat steadily and lastingly, so we do not now take a dose of electricity sufficient to shake us to pieces, but, by these chains and bands, keep up and sustain a genial warmth of the parts affected, or of the whole system. Nor is there the slightest inconvenience in wearing the bands, which are made to fit any part of the body, or to surround it altogether, as is advised in cases of general weakness. Having once been wetted with vinegar-and-water, the action commences, and the moisture of the body is sufficient to sustain the excitation of the chain or band for an indefinite time. That the current does exist, even in its dry state, we have already shown by the test of the electroscope.

An interesting experiment, showing the electricity of the human frame, and bearing strongly on the importance of these inventions for restoring the lost or suspended electric powers, was made by Mr. Rutter, of Black Rock, Brighton. Having brought the two ends of the conducting wires of a galvanometer into two basins of water, a lady, acknowledged to be in consumption, placed a hand in each basin, and grasped two pieces of wood—with the left hand lightly to complete the contact, while her right pressed the wood firmly with muscular contraction. The needle of the galvanometer at once deflected from twelve to fifteen degrees, but in a few moments came back to zero; and no muscular effort on her part could deflect it. A stalwart blacksmith was then brought in and the same experiment tried, but with all his muscular contraction the needle was only deflected about 5 degrees. He was then made to give 25 strokes on an anvil with his sledge-hammer, and when he afterward repeated the experiment the needle deflected at once 12 degrees.

By this experiment two things are shown—that, in a state of disease, the body readily parts with, or rather has not the power to retain, its electricity; and that, in a state of health, muscular exertion of considerable severity is requisite to cause it to pass out of the system. There is just room, however, in this experiment, for the captious spirit to object that some chemical action took place by the use of the water. Mr. Pulvermacher has improved on the experiment, by using simply two metallic handles of the same kind of metal, when precisely the same effect is produced upon the galvanometer.

It was suggested, in 1850, by the writer of this article, that the proximate cause of cholera might be found in the rapid passage of electricity from the human frame; the peculiarity of the atmosphere, known to exist during cholera, favoring the passage of that which is the life itself to the human system.

Since that time, wonderful cures of cholera have been recorded by Dr. Godwin, of Elbœuf, Dr. Defontaine, of Mons, Dr. Atkinson, and others. The latter, on one of his cases, remarks: "It was indeed singular to notice the visible quantity of electric fluid which continually discharged itself on the approach of any conducting body to the surface of the skin of a patient laboring under the collapse stage." M. Andraud states that at the height of the epidemic in Paris, in 1849, it was impossible to obtain from the electrical machine any thing but slight cracklings without sparks, and on the 7th of June it was quite dumb. He continued his observations, and on the 9th the machine at the least touch rendered with facility most lively sparks. It is remarkable that, in the six days following the 8th of June, the mortality in Paris fell regularly from 667 to 355.

It is now only about 150 years since electricity was discovered, not more than 120 since the discovery of the Leyden jar enabled electricians to concentrate the vital fluid. What has it not done for us in that time! And while it was so decried at first, and has met with impediment after impediment, we now accept what it gives us, so quietly and so much as a matter of course, that a few days ago the announcement that electric communication was completed with the antipodes called forth nothing more than a short paragraph in the newspapers. May we not hope, then, the time has come when not only the scientific medical man, but every practitioner, will look for himself into the curative powers of electricity?

Every thing that is good, however, in the present day is sure to have a host of empirical imitators, and the inventions of which we have spoken are no exception to this rule. These chains and bands are really formed on scientific principles, giving the patient the benefit of the curative powers of electricity in a convenient form. There are many spurious appliances under the name of magnetic, electro-magnetic, and other high-sounding titles, that get confounded with the continuous current of electricity, which alone, in the opinion of the highest medical authorities, can have any effect on the diseases we have enumerated. The mischief done by these spurious imitations is incalculable, and they lead, not only to disappointment, but have a discouraging effect upon the public mind.

Judging by the extraordinary cases of cure by the use of these chains and bands, now well authenticated by the highest professional authorities, John Wesley was indeed prophetic when he wrote in 1759: "It is highly probable a timely use of this means might prevent, before they were thoroughly formed, and frequently even then remove, some of the most painful and dangerous distempers—cancers and scrofulous humors in particular—though they will yield to no other medicine yet discovered. It is certain nothing is so likely, by accelerating the contained fluids, to dilate and open the passages, as well as divide the coagulated particles of blood, that so the circulation may be again performed. And it is a doubt whether it would not be of more use, even in mortification, than either the bark or any other medicine in the world."—*Belgravia.*

DO BIRDS IMPROVE IN NEST-BUILDING?

TRANSLATED FROM THE REVUE DES DEUX MONDES,

By J. FITZGERALD, A. M.

"A MAN'S house," says a learned hygienist, "is but an extension of his clothing: the tent is next-door neighbor to the mantle, and the roof is simply a big head-gear." A house, just like the clothes we wear, is, first of all, a shelter to protect us against the medium around us, and to shield us against the inclemency of the seasons. The animal, in this happier than man, has no need of dress—Nature supplying it with plumage or with fur—but yet is required to build for itself the dwelling-place where it is to find shelter. May we suppose that here, too, Nature provides for every thing, and that blind instinct guides the bee in the construction of her cell, and the bird in the building of its nest? Such, indeed, is the opinion of most naturalists, and their chief argument is drawn from the fact that birds always follow the same plan in building their nests, while man is ever modifying and improving bit by bit his methods of construction. But, now, is this argument based on unquestionable facts, or is the conclusion legitimate? An English naturalist, Mr. Alfred Russel Wallace, undertakes to prove the contrary, in his work on Natural Selection. According to him, the bird does not build its nest by instinct; and the mental faculties it exhibits in this operation are of an identical order with those exhibited by man when he builds a house. In short, it is claimed that these faculties are simply imitativeness, and a sort of rudimentary ratiocination, which can take account of external surroundings, whatsoever they may be. Hence it is that birds do change and improve their processes of construction, under the influence of such causes as determine progress in man; and, in turn, man is at a stand-still when he receives no impetus from without.

What is instinct? It is "the faculty of performing complex acts, absolutely without instruction or previously-acquired knowledge." Instinct, then, would enable animals to perform spontaneously acts which, in the case of man, presuppose ratiocination, a logical train of thought. But, when we test the observed facts which are usually put forward to prove the power of instinct, it is found that they are seldom conclusive. It was on such grounds that the song of birds was taken to be innate, albeit a very ready experiment would have shown that it comes from the education they receive. During the last century Barrington brought up some linnets, taken from the nest, in company with larks of sundry varieties, and found that every one of his linnets adopted completely the song of the master set over him, so that now these linnets—larks by naturalization—formed a company apart when placed among birds of their own species. Even the nightingale, whose native song is so sweet, exhibits, under domestication, a considerable readiness to imitate other singing-birds. The song of the bird is, therefore, determined by its education, and the same thing must be true as to nest-building. A bird brought up in a cage does not construct the nest peculiar to its species. In vain will you supply all the necessary materials: the bird will employ them without skill, and will oftentimes even renounce all purpose of building any thing like a nest. Does not this well-known fact prove that, instead of being guided by instinct, the bird *learns* how to construct its nest, just as man learns how to build a house? This observation might be made complete, if we were to shut up in an enclosure, with a wire screen overhead, a pair of birds brought up in isolation from their kind, with a view to find out what manner of nest their inexperienced efforts would produce. But, even though we have not such evidence, there are plenty of other proofs which confirm Mr. Wallace's theory.

The form and structure of birds'-nests are more dependent than is usually supposed upon external conditions, and consequently they vary in proportion as these conditions are changed. Each separate species employs the materials it has at hand, chooses sites most agreeable to its habits; and the shape given to the nests often betrays very definite purposes, which are not to be detected without some degree of discernment. The wren, which dwells in hedge-rows and thickets, commonly builds its nest of the moss in which it is accustomed to search for insects; but at times it departs from this custom, and employs feathers and hay, when they are to be had. The raven, which feeds on carrion, frequenting pasture-grounds and warrens, builds its nest of wool and fur; the lark builds in a furrow, employing dry twigs, interwoven with fine blades of grass, which it collects when looking for worms; the kingfisher uses the bones of fishes he has eaten. The long-legged and big-beaked flamingo, which stalks about in wet flats, builds a conical hillock of mud, and in this deposits her eggs, so as to sit easily upon them, and to keep them out of the water.

In what respect are these animals, which avail themselves of the circumstances around them for a perfectly determinate object, inferior to the Patagonian, who builds for himself a rude shelter of foliage; or to the African negro, who scoops out a hole in the ground? It will be said that man progresses: but that is not universally the case. What progress is shown in the palm-leaf huts of American savages, the tent of the Arab, the Irish mud-cabin, the stone hovel of the Scottish peasant, which appear to belong to primitive times? The art of house-building remains stationary, if it is in conformity with tastes and habits which are unalterable, because the physical conditions which determine them are ever the same. Sometimes even a habit once engendered persists, though the exterior conditions be changed. The Malays from time immemorial built their houses on piles, after the manner of the lacustrine dwellings of ancient Europe; and this mode of building has sunk so deep into the manners of tribes which have penetrated into the interior of the islands and settled on arid plains, or on rocky mountains, that they still go on prudently raising their houses above the surface of the ground. And yet, no one imagines that in these inveterate habits we have a case of instinct; and certainly no one would suppose that an Arab infant brought up in France would feel the need of dwelling in a tent of skins, or that a young Malay, if brought to Europe, would bring with him his habit of building on piles. The unvarying processes of barbarous tribes are explained on the theory of a secular tradition, untroubled by any external influences.

But why not apply the same reasoning to the facts presented to us by the animal kingdom? The processes of nidification are determined by the physical circumstances, as well as by the conformation of the nest, and by the tools supplied by Nature, and they are modified in accordance with external conditions. An alteration of climate, any sensible change in the vegetation of a country, the introduction of new enemies, bring about architectural variations more or less marked. Several birds prefer the ends of threads which they pick up on the streets to the vegetable fibres used by them before, and of their own accord take up their quarters in boxes or hollow gourds arranged for their use, thus saving a part of their labor. The common sparrow readily adapts himself to circumstances: he takes far less pains with his work when he can avail himself of a nook in a wall, than when he is obliged to build in the open air, on the branch of a tree, for then his nest must be solidly built and well covered. The orchard oriole or bobolink, of the United States, builds his nest almost flat when he can fasten it on a stout, stiff branch, but far deeper when he has to hang it on the slender branches of the weeping-willow, where it may be swayed by the wind, and the chicks thrown out. Finally, M. J. A. Pouchet published, in 1870, some very curious observations on the progressive improvement of martins' nests. He kept for 40 years in the Rouen Museum some of these nests, which he had himself detached from the walls of old buildings in that city. Having one day got some new nests, he was amazed, on comparing them with the old, to perceive considerable differences. The new-style nests all came from a new quarter of the town, and were all built on the one plan; but on examining churches and other ancient buildings, as also certain rocks inhabited by martins, he found several nests of the old pattern, together with others constructed according to the more recent model. The figures and descriptions given by old naturalists portray only the primitive type, which is a quarter-hemisphere, having a very small circular orifice. The modern nest, on the contrary, has a width greater than its depth, and forms a segment of an oblate spheroid, the orifice being very wide. Here we see an evident progress, the new type being larger, more *comfortable*. The wider bed gives the chicks greater liberty of movement than they had in the deep and contracted nest of former times; the wider opening allows them to look out and take the air; in short, it is a sort of balcony, where two chicks find room without being in the way of the old birds. Nor is this all. Being situated nearer to the top of the nest, the opening is less exposed to rain and wind. One well-proved case of this kind is enough to show that the architecture of birds is susceptible of progress; and this would seem to overturn the hypothesis of blind instinct. Then, too, the evident imperfections observed in the nests of some species, and the awkwardness, not to say stupidity, of some birds, cannot be reconciled with the theory of infallible instinct.

To conclude, then, the nidification of birds exhibits phenomena which, if compared with the constructive processes of primitive man, show no essential difference in the nature of the faculties employed. We have here no innate ideas, or blind and irresistible tendencies. The bird learns how to build its nest, and each species has its own tradition, which can be modified according to external circumstances. As regards the origin of these constructive processes, it can be readily understood without supposing a special instinct, if we show that, at bottom, these processes are simpler than at first sight would appear. For we must not exaggerate the grade of intelligence needed by a bird in order to build a nest which to us appears simply marvellous, because it is so small. But this nest was first roughed out—twig on twig, fibre on fibre; next, the little architect stopped up the gaps with material easily brought in with its supple claws and its slender beak. We are charmed at the sight of this; but the rude mud wall of a peasant's hovel would, in the eyes of a giant, also appear to be fine handiwork. It all depends on perspective. Levaillant has observed the habits of an African bird which goes to work in a still more summary way. This bird gets together a heap of moss and cotton, converts it, by stamping, into a sort of felt, then hollows it out in the middle, and trims off the edge. Thus the inside of the nest becomes as smooth and compact as a piece of cloth. Why not admit that this process is the work of an inventor, whose invention benefits his posterity, they in turn improving it, and handing it down to succeeding generations, just as we say in the case of human discoveries, of which we are so vain? In studying the rise of architecture, we meet with many a type which attracts the eye, but which answers but imperfectly the needs for which it was produced, and which shows less rational foresight than do the nests constructed by sundry birds.

THE ANTIPODES AND PERIŒCI.

By HEZEKIAH BUTTERWORTH, Esq.

ABOUT few geographical positions are there more mistakes made by intelligent people than the situation of the antipodes and the periœci. It has been commonly taught in the schools, at least in New England, that the antipodes of the Eastern States, or of dwellers near parallel 40, are in China, and that the antipodes of Boston are in Peking. Of course, this error is not made by the best instructors, but it is often made, and that without correction, in the presence of the "honorable committee." Editors, too, are often as much at fault as teachers, in speaking of antipodal places. Thus, after the earthquake at Lone Pine, California, and that which destroyed a part of the ancient city of Antioch, the New York *World* published an article on these phenomena, from the pen of a correspondent, entitled "The Antipodes shaking." The editor of the *World* corrects its correspondent, who supposes that Lone Pine and Antioch are antipodal, and says: "A point immediately under Antioch is in the Pacific Ocean, about half-way between San Francisco and the Sandwich Islands." These errors were copied by other papers.

The word antipodes is of Greek origin, from ἀντί, *against*, and πούς, *a foot*, and means literally, *with feet opposite.* Hence the Latin word *antipodes*, which is plural, and as a pure Latin plural should be pronounced as in the original, or in four syllables, *an-tip-o-des.* But, as the English word *antipode is* used, the plural of this may be formed regularly in three syllables. This pronunciation is sanctioned by Dr. Webster, and may ultimately prevail. At present, however, the best scholars give the division and the accent of the pure Latin plural.

The word literally signifies, those who have their feet against each other, or, those whose feet point toward each other; that is, those whose feet are *diametrically* opposite. As applied to geography, it means, the dwellers at the opposite extremities of the diameter of the earth.

The periœci, or perieciaus, are often mistaken for the antipodes. The periœci are the inhabitants on the opposite side of the globe, on the same parallel of latitude. Hence, when people say that the antipodes of the Eastern States are in China, they mean the periœci.

Two antipodal parts of the earth have the same number of degrees of latitude, one north and the other south, unless one of these points is on the equator

Two antipodal points must be on one and the same meridional circle, separated from each other by half the circumference.

Being on one and the same meridional circle, they may differ in longitude 180°, with the exception of the poles themselves, which have no longitude.

And being separated from each other by half the circumference, they must be equidistant from the equator in opposite directions.

The longitude of two antipodal points, if east and west longitude is used, must together make up 180°, or 12 hours, one east, and the other west. The antipodes of a point in 40° north latitude and 60° east longitude are in 40° south latitude and 120° west longitude. The antipodes of a place in the eastern part of the United States, situated on parallel 40° north latitude, and on the meridian marked 7°, must be on the same parallel south latitude, and on that meridian which, added to 7°, will make up 180°, or 173°, which would be in the South Indian Ocean, a point between St. Paul's Island and Van Diemen's Land This point would be antipodal to Boston or New York.

The following principal cities and places in the world are antipodal

London	Antipodes Island, southeast of New Zealand.
New York	South Indian Ocean.
Lima	Siam.
Nanking	Buenos Ayres.
Quito	Sumatra.
Bermudas	Swan River.
Azores	Botany Bay.

Antipodal places have the same climate, with all of the seasons, days, and nights, completely reversed. When it is noon in London, it is midnight at Antipodes Island; and the noon of the longest day at the Bermudas is midnight of the shortest day at Swan River. When the sun is rising at New York, it is setting on the South Indian Ocean.

Antipodes Island, a small strip of land in the South Pacific Ocean, southeast of New Zealand, is so called because it is the nearest inhabitable point to the antipodes of Greenwich, latitude 49° 32′ south, longitude 178° 42′ east.

We said that the seasons at the antipodes were reversed. Take, for example, New Zealand, which is nearly antipodal to England. New Zealand has one of the finest climates in the world. The summer is a little longer and warmer than in England, the atmosphere more moist, and fogs are frequent. Spring begins in September, summer in December, autumn in April, and winter in June. January and February are the warmest months of the year, while July is the coldest. The flowers bloom in January, and the snow falls in June.

So, in a figurative sense, antipodes means opposite. As Shakespeare says, or makes one of his characters to say, in the play:

"Thou art as *opposite* to every good,
As the *antipodes* are unto us."

USEFUL THINGS.[1]

By EDMOND ABOUT.

UTILITY does not require to be defined. Nevertheless, an explanation of it may be profitable.

Many years have elapsed since man appeared on the earth. Geologists affirm that, before our appearance, this little globe moved round the sun for thousands and thousands of ages. During that period the soil, the sea, and the air, were of no benefit to anybody, because no one existed here below. A multitude of plants and animals was

[1] From advance-sheets of the "Hand-book of Social Economy." By Edmond About. D. Appleton & Co.

created before the germs of the first men were formed: these plants and animals, whatever properties and powers they might have had, were entirely useless, because utility, as we understand it, means the service which a thing might render to man; therefore, there was nothing useful prior to man's advent in the world.

Man is born, and all beings at once take rank in relation to him. The wild beast, rushing to devour him, enters into the first category of noxious things; the poisonous plant reveals to him its baneful properties; the thorns which prick his limbs, the insects which prey on his body, are noxious to him in degrees varying according to the amount of pain which he suffers or dreads.

The timid animals that flee before him, the plant which neither injures nor nourishes him, the hidden mineral lying in unseen veins under his feet, are all either unimportant or useless.

The useful is that which makes man's life more easy or more agreeable. But we have agreed, in the hypothesis of the shipwrecked sailor, that Nature by herself supplies us with very few useful things. Excepting the soil which sustains us, the air we breathe, the water we drink, there is nothing which, to my mind, is due to her.

Our first resources, or, more properly speaking, all the gifts of humanity, are the conquests of labor.

Man can neither create nor destroy an atom of matter, yet he can assimilate and identify himself with whatever suits him; he can turn aside whatever menaces him; above all, he can adapt for his use and employ for his profit, that which was originally valueless or even dangerous. By means of labor he impresses the stamp of utility upon all he touches, and thus little by little annexes, as it were, the entire earth.

Utility proceeds from and returns to man. If we do not create things themselves, we create their usefulness. But that costs something. Nothing is got for nothing. We are not Nature's spoiled children. After man was created, he appears to have been told: "I leave you to yourself. Whatever you produce is your own."

Do you wish to see by some examples how man does his part and becomes the producer of utility?

If, on leaving home an hour hence, you meet a lion at the bottom of the stair, should you hesitate for an instant in regarding it as a noxious animal? Is not this true?

However, thanks to the strenuous exertions of several generations, lions, driven from Europe, have now no abode save Africa. The distance which separates you from them enables you to think of them with indifference.

When an agile, a brave, and skilful man succeeds at the risk of his life in accomplishing the trifling task of lodging a ball between a lion's eyes, the animal is no longer noxious, nor even indifferent and useless. Its skin is worth 100 francs; it will make a rug.

Suppose that, instead of shooting the brute, a prudent hunter, by means of greater strategy, should entrap and imprison it in an iron cage and bring it to Marseilles! The lion disembarked at the dock would fetch many thousand francs.

If, by means of still more skilful and longer-continued labor, a lion-tamer, like Batty, subdues the dread monster, the lion would fetch thirty thousand francs at least. Nature creates a devouring animal: human skill converts it into a bread-winner.

The whole race of domesticated animals in man's service, yielding him eggs, milk, wool, and even flesh, was wild at first, that is to say, was so far separated from, as to be of no use to him. By his skill he not only tamed these animals, but, as it were, he has modified and remodelled them after a pattern supplied by himself.

Man fashions at will draught-horses and racers, oxen for the plough and oxen for the table, sheep which furnish wool and sheep which furnish tallow, fowls which lay eggs and fowls which are fitted for the spit, fat pigs and lean pigs: from one breed of dogs, man has produced the greyhound and the bull-dog, the setter and the harrier, the pointer and the lapdog. When you go to an exhibition of any sort of live animals, remember that art has as great and Nature as little a share in it as in an exhibition of pictures.

Apply the same method of reasoning to all agricultural, arboricultural, and horticultural exhibitions. Neither our gardens, our fields, nor our woods, are masterpieces of Nature, as is ignorantly said; they are masterpieces of human industry.

All double flowers, without exception, are man's work. Pluck a wild rose from a hedge-row, and then go and see a collection of Verdier's roses: you will learn how much Nature has bestowed, and what man has made of it.

All the pulpy and juicy edible fruits are man's work. Man went as far as Asia, and even farther, in quest of the coarse products which resemble our peaches, our cherries, our pears, as much as the wild-rose resembles the "Palace of Crystal" or the "Remembrance of Malmaison" rose.

Each of our vegetables represents not only distant voyages, but also centuries of skilled labor and assiduous elaboration.

It was not Nature that gave the potato to the poor of our land. Human industry went in quest of it to America, and has cultivated, modified, ameliorated, varied, and brought it step by step to its present state, accomplishing the result in less than a century. Yet to this century of culture must be added the prior labor bestowed on the plant by the natives of America. When the products of a distant country are brought to us, we are prone to believe that Nature alone has done every thing. But, when the Spaniards discovered America, it had been cultivated from time immemorial. Hence man had turned Nature to his advantage there, as well as in Europe and elsewhere.

Wheat, such as we see it, is not a gift of Nature. It grows spontaneously in Upper Egypt, yet there it yields but a poor and miserable seed, unfitted for making bread. Many ages and a prodigious expenditure of labor were required in order to develop, swell, and perfect the seeds of this useful food for man. Have you ever been told that wheat is distinguished from other cereals by its containing a notable proportion, sometimes a quarter, of nitrogenous substances? This valuable gluten represents the blood and flesh of thousands of generations that perished in the culture of wheat.

While labor supplied the most precious of its useful properties to this grain, of which each of us consumes three hectolitres yearly, pharmacy altered the use of fifty vegetable poisons, and converted them to the profit of our species. Not merely does man add a portion of utility to that which possesses none naturally, but he turns bad into good.

During how many ages did the electric fluid hold a place among the number of curses! We knew it only by the dreaded effects of lightning.

Franklin discovered the lightning-conductor, and conferred on everybody the means of neutralizing this great curse. A force, eminently mischievous, becomes indifferent to the man who is prudent and wise. Security during a storm is henceforth the price of easy and inexpensive labor.

But does man halt in so fine a path? No. Hardly has he conquered this hostile power, than he undertakes to domesticate it. Lightning, snatched from old Jupiter's hands by Franklin, becomes an instrument of progress. We employ it to transmit our thoughts, to reproduce our works of art, to gild our utensils, and we shall soon make it perform a thousand other services. Before the lapse of half a century we shall see electricity rendered more and more docile, furnishing us with movement, light, and heat, at pleasure.

Will you now study with me how human labor, incessantly multiplied, infinitely increases the usefulness of all our things?

An invisible, disregarded iron-mine renders no service to the men who tread upon it.

On the day the geologist, by the travail of his mind, divines this source of useful things beneath our feet, the soil which conceals it gains to some extent an increased value.

When laborious boring has proved the existence of the mineral, expectation is converted into certainty, and the value of the land is farther increased.

The result of employing labor to work the mine is to bring to the surface some tons of reddish stones containing iron. This matter is not really more useful than the pebbles in the neighboring stream; yet it is more valuable, because it is known that things more profitable to man can be extracted from it by labor. The mineral is treated, and the crude metal, which is of greater value, is obtained. The crude metal is refined, and iron is got, which is better. The iron is treated, and, by cementation, it is converted into steel. The steel is wrought, and a thousand things directly useful to man are produced.

The utility of these last products increases in a direct ratio to the amount of labor which men have expended. An anvil weighing a thousand pounds is less useful than a thousand wrought files; it costs less labor. A thousand pounds' weight of files costs less labor than a thousand pounds' weight of watch-springs; they contain in themselves a smaller sum of utility. You can easily understand that if the anvil made in a day contained as much utility and was of as great value as a ton of watch-springs, which it took several months to make, everybody would prefer to forge anvils, and no one would weary himself in flattening watch-springs.

Neither a decree, nor a decision, nor a political law, has arranged matters in this wise; Nature herself has done it.

It is necessary, indispensable, inevitable, that labor should constantly augment the utility of things, and that men should buy them at the price of greater efforts on learning that they are more useful. Not only is the existence of utility merely relative to man, but it continually varies with our natural or artificial wants.

A stove is useless at Senegal; an ice-making machine is useless at Spitzbergen. In a locksmith's eyes, pincers are objects of first necessity; a duchess has no use for them. On the other hand, a little bonnet, which does not cover her head, is more useful to her than sixty pairs of pincers, for she requires it to drive in her carriage in the park, and she pays for it accordingly. The agreeable and the useful are perpetually confounded in an advanced state of civilization: I have explained why, in showing that our wants increase with our resources.

Time and distance augment or diminish the utility of our goods. A thing in your hand is of more use to you than if it were ten leagues off. At the distance of ten leagues it is more useful than if it were in America. The greater the distance, the greater is the labor required to enjoy it; you must either pay the cost of carriage or go for it yourself. This fatigue and this outlay are equivalent to the labor that must be expended, for instance, in order to convert iron into steel. A thousand francs in Paris are worth more to a Parisian than a thousand francs in Brussels; a thousand francs in Brussels are worth more than if they were in New York. In like manner a thousand francs which are given you to-day are evidently of greater use than a thousand francs which will be given to you ten years hence. A thousand francs obtainable in ten years are more useful and are worth more than a thousand francs of which the possession is postponed for fifty years. The return may indeed be safe and certainly guaranteed; the question is utility as regards yourself, and you are not sure of living long enough to enjoy a benefit so long deferred.

The utility clearest to all eyes is that residing in material things.

Man understands without any effort that a bird in the hand is worth two in the bush, and that it is still more useful when leaving the spit. It is needless to tell you that first the sportsman and then the cook has added a surplus value to the bird. If I put before you a ton of pig-iron, worth fifty francs, and then a ton of fine needles, worth ninety thousand, you will instantly see the enormous supplement of utility which the work of men has added to the metal.

But there are other benefits of which the utility is not as directly visible to our eyes, though it be at least as great. An impalpable, invisible, imponderable idea is often more useful than a mountain of benefits clear to the naked eye. Man is a thinking body; his hands have done much to render the earth habitable, but his brain has done a hundred times more.

Suppose that a great manufacturer had converted a thousand million pounds of iron into steel. Would he have performed as much usefulness in his life as the discoverer of cementation, as he who has put it within the reach of all men to convert iron into steel? He who should transport a mountain ten miles would produce less utility than the discoverer of the lever. For, by teaching us a simple law of mechanics we have been put in a position to transport a hundred mountains, if we please, with less outlay and effort. An economy is thus rendered possible which will profit all men who have been and may be born.

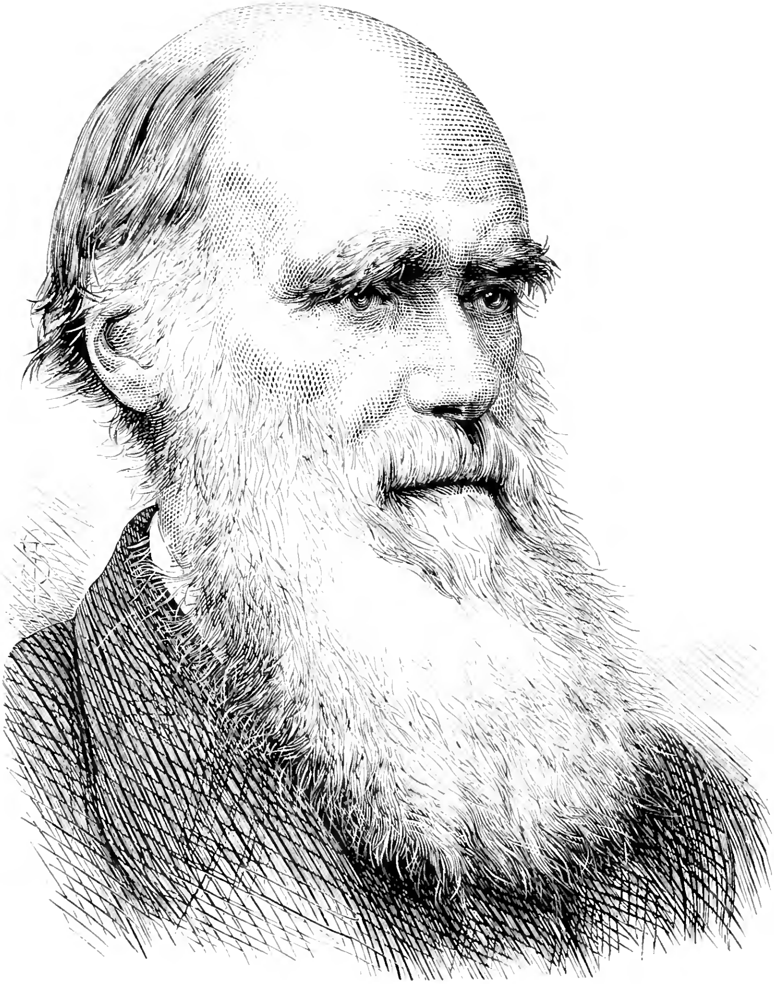
If Pascal had said to the men of his day, "I am rich, I possess a hundred miles of pasturage around Montevideo, and a thousand vessels on the Atlantic; I have caused half a million of horses to be transported hither, which I present to you, and which will work for you till their deaths," Pascal would have been less useful to the human race than on the day when, in his study, he invented the wheel-barrow.

Studious men, by a series of discoveries, superinduced the one upon the other, have given to us all the machines which abridge and facilitate labor. England alone possesses a hundred millions of horse-power which work for the profit of thirty millions of men.

The history of civilization may be summarized in nine words: the more one knows, the more one can perform.

In proportion as science and reasoning simplify production, the quantity of benefits produced tends to increase without augmentation of expense; work done helps the work to be done. The tools of the human race are nothing else than a collection of ideas. All levers are worn out in the long-run, and all wheel-barrows also; steam-engines are not everlasting, but the idea remains, and enables us indefinitely to replace the material which perishes. It follows from this that the first of useful things for man, is man himself.

You are of the greater use to yourself the more you are instructed, rendered better, and, so to speak, more perfect. The development of your personal faculties also enables you to be more useful to others, and to obtain from them greater services through reciprocity.



CHARLES DARWIN, M. A., F. R. S., Etc.

CHARLES ROBERT DARWIN.

MR. CHARLES R. DARWIN, the most eminent philosophic naturalist of the age, is now sixty-four years of age, having been born in Shrewsbury, England, in 1809. He is descended from distinguished ancestors on both sides. His father was Dr. Robert Waring Darwin, a Fellow of the Royal Society, and his paternal grandfather was Dr. Erasmus Darwin, author of the once-famous books, the "Botanic Garden" and the "Zoonomia." Mr. Darwin's grandfather on the maternal side was the celebrated Josiah Wedgwood, whose name is intimately associated with the progress of the art of pottery in England. Mr. Darwin attended the Shrewsbury School, spent two years in the University of Edinburgh, and took his degree of B. A. at Christ's College, Cambridge, in 1831.

Mr. Darwin inherited from the author of "Zoonomia" that love of natural history and the allied sciences which has been the labor and the pleasure of his life. In the autumn of 1831, Captain Fitz Roy, R. N., having offered to give up part of his own cabin to any naturalist who would accompany H. M. S. Beagle in her surveying voyage and circumnavigation, Mr. Darwin volunteered his services without salary. His scientific acquirements were already so well known that the offer was at once accepted, Mr. Darwin stipulating only that he should have the absolute disposal of all his collections. The Beagle sailed from England, December 27, 1831, and returned on the 27th October, 1836.

In 1839, Mr. Darwin published a volume as a part of Captain Fitz Roy's general work, descriptive of this voyage. The interest excited by this, one of the most graphic, and at the same time most philosophic book of travels that was ever published, led to its reproduction in a modified form, in 1845, under the title of "Journal of Researches into the Natural History and Geology of the Countries visited during the Voyage of H. M. S. Beagle round the World." This Journal shows Mr. Darwin to have been a singularly close observer of every phenomenon in natural history, and of every variety of condition, physical and mental, of the people whom they visited during this remarkable voyage, and exhibits the possession of perceptive powers of the highest order. No single phenomenon is described by Mr. Darwin until after it has been most cautiously examined, and the reader of the Journal is soon impressed with the persuasion that the facts narrated are placed beyond a doubt, and that his reasonings on those facts are ever guided by a system of most severe inductive philosophy. This is most especially exemplified in Mr. Darwin's reasonings on the origin of the coral-reefs of the Pacific.

In the beginning of 1839 Mr. Darwin married his cousin, Emma Wedgwood, and shortly after took up his residence at Down, near

Farnborough, in Kent. For twenty-six years, in the retirement of his home, Mr. Darwin has devoted himself to the care of a large family, and the quiet and close investigation of the works of Nature. His first labors, after this date, were editing the "Zoology of the Voyage of the Beagle," giving an account of the habits and ranges of the various animals therein described. In aid of the publication of this and other works bearing on the same subject, the Lords of the Treasury granted £1,000. In 1842, Mr. Darwin published his work on "The Structure and Distribution of Coral Reefs;" in 1845, "Geological Observations on Volcanic Islands;" and in 1846, "Geological Observations on South America."

Continuing, without rest, his researches, we find the results of his unwearying industry in two volumes published in 1851 and 1854, "On Pedunculated and Sessile Cirripedes," and, in two other volumes, on the fossil species of the same class.

Toward the close of 1859, Mr. Darwin published his "Origin of Species by means of Natural Selection." Of this work four English editions have appeared, and nine foreign editions, in French, German, Dutch, Italian, and Russian. Its popularity is shown by the fact that more than one hundred reviews, pamphlets, and separate books, have been published upon it, while the earnestness with which the question is still discussed shows that these will probably be doubled in a short time.

In 1834, Mr. Darwin was elected a Fellow of the Royal Society. In 1853, the Royal Society awarded to him the royal medal, and in 1859 the Wollaston medal was given to him by the Geological Society. In 1862, he published a book full of curious research, "On the Various Contrivances by which Orchids are fertilized." Of separate papers, published by this naturalist, we find the following among the more important: "On the Connection of Certain Volcanic Phenomena in South America;" "On the Distribution of Erratic Bowlders in South America;" "On the Formation of Mould by the Earthworm;" and "On the Geology of the Falkland Islands"—all published in the Transactions of the Geological Society. In the *Journal of the Linnean Society*, three papers have appeared from the pen of Mr. Darwin, "On the Dimorphous and Trimorphous States of Primula," and one paper "On the Movements and Habits of Climbing Plants." This last one has since been published as a separate work. In 1864, the Royal Society awarded to Mr. Darwin the Copley medal, and he has been elected a member of various foreign scientific bodies.

The latest works of this indefatigable naturalist are, "The Variation of Animals under Domestication," in two volumes; the "Descent of Man," in two volumes; and a book "On the Expression of the Emotions in Man and Animals," just published, and some account of which is given in the present number of The Popular Science Monthly.

EDITOR'S TABLE.

TYNDALL'S LECTURES IN NEW YORK.

PROF. TYNDALL'S course of lectures in New York has met with a success that is commensurate with the reputation of the lecturer, and the interest of the subject which he selected for popular elucidation. One of the largest halls in the city has been densely crowded throughout the course of six lectures by the most cultivated and intelligent people of New York and the adjacent towns, and he has been listened to with close and absorbing attention throughout. The first lecture tests a man's reputation, and its degree of success is a measure of the desire to see as well as to hear him. As a result, the first performance often dissipates a reputation. The second lecture tests character and capacity, and an extended course applies the test still more rigorously. Had Prof. Tyndall given but a single lecture, however large may have been his audience, it might have been considered as gathered by curiosity; but when a vast auditorium, like that of the Cooper Institute, is packed to the last by the ablest men in all the professions—science, law, medicine, divinity, and education—with many of our strongest and shrewdest men of business, and a large proportion of our most cultivated ladies, the verdict is unequivocal and assured, and the highest compliment possible is paid to the genius and power of the teacher. No such assemblages as have greeted Prof. Tyndall, and followed him with sustained enthusiasm through his course, have ever before been gathered in New York.

But one interpretation can be given to this success, and that is the growing interest in matters of science, and the increasing appreciation of ability in its expounders. If it be said that the auditors were in search of mere pleasurable excitement, it comes to the same thing, for the pleasurable excitement is derived from a prolonged scientific demonstration. Something was due to the attractiveness of the experiments, and much to the felicity of the professor's manner, but there were abundant and gratifying indications of an earnest desire to comprehend the argument, and get a thorough understanding of the phenomena presented. The strength of this feeling has been put to a significant test in the present case. Just before sailing, Prof. Tyndall had exposed himself to the reprobation of a large class of the community by consenting to introduce to the public Dr. Thompson's paper proposing the so-called prayer-gauge. He thus became an object of bitter attack from religious quarters, and so considerable was the feeling aroused that it was said by many the step he had taken would cost him his American audiences. But the strength of public prejudice was over-estimated, and the progress of liberal feeling forgotten. Twenty-five years ago it would have been different; but such has been the conquest of prejudice, and the enlargement of ideas, that Prof. Tyndall's lecture-rooms, in all the cities where he has spoken, have been filled to overflowing with those who are prepared to accept science on its own merits, without mixing up with it questions of theology.

Another circumstance deserves mention in relation to the success of Prof. Tyndall's lectures in New York. His audience came together upon the bare announcement that he would give them a course of lectures. There were none of the usual trumpetings of managers—puffs, placards, show-bills, portraits in the windows, staring sensational advertisements, and the customary arts and tricks by which notoriety is manufactured and "success" secured. It is to the credit of New York intelligence, and evinces a growing appreciation of the intrinsic claims of science, that the customary clap-trap of agents, whose maxim is, "The public must have a certain amount of humbug, you know," was entirely dispensed with in the present instance.

Prof. Tyndall's course of lectures was any thing but child's-play for his audience. Boston, indeed, has complained that they were *elementary*, if not *rudimentary*; but Boston is in many things exceptional—there has been no such complaint in other cities. In New York the prevailing criticism has been rather of an opposite kind—not, perhaps, that the lecturer's presentations had been too abstruse for ordinary intelligent apprehension, but that they have been too incomplete to be satisfactory. The phenomena shown have been out of proportion with their explanations, a defect which could only be remedied by giving thirty-six lectures in the place of six. But this was impossible, as Prof. Tyndall's time to tarry with us was short. The method that he has followed, we think, has been very skilfully adapted to the circumstances. There has been a great amount of general reading in books and magazines, and of study in our schools and colleges, upon the subjects he has selected, but the ideas acquired have been vague and unsatisfactory, from lack of observing the actual phenomena that have been read about. The lecturer assumed this state of mind in his hearers, and that the literature of the subject is everywhere accessible for further reference, and he accordingly constructed his course so as to bring under direct observation a wide range of the actual phenomena he had chosen to deal with. These were presented in their beauty and variety, with consummate skill and impressiveness, and as much of elucidation as time allowed. The ideas of many upon the subject of Light, the theory of its nature, and its various complex affections, were clarified and rendered more precise, while many others for the first time witnessed a series of marvellous effects, which gave them a new conception of the exquisite and wonderful play of natural forces, and which will incite them to further study and prepare them for it.

The triumph of Prof. Tyndall, so far from being his first lecture with all its advantages of novelty, was really his last lecture, and what is more, the concluding part of it, which was without experiments. He closed his course by an estimate of the work, and a statement of the claims of original investigators, and this was listened to by his vast audience with a close and almost breathless attention, which attested both the intellectual quality of the assemblage and their interest in the highest scientific objects and themes.

MRS. SOMERVILLE.

To the question "Who is the most intellectual woman that has yet appeared?" a variety of answers will probably be returned; but to the question "Who is the most scientific woman that has yet appeared?" but one answer will be given; it is—"Mary Somerville." Not only was she a woman of eminent capacity, but, what is very remarkable, her mental vigor was prolonged to a period surpassing by many years the allotted life of man. The first work that made her name known to the world was in 1826, and her last book, an able treatise in two volumes, was published forty-three years later, in 1869, and that long interval was fruitful in works of ability in different departments of science.

Mrs. Somerville died at Naples November 29th, within rather less than a month of the ninety-second anniversary of her birth. Her maiden name was Mary Fairfax; she was of Scotch ancestry and an admiral's daughter. She was twice married, first to Captain Greig, of the Russian Navy, an officer of scientific accomplishments, and to whom she is said to have owed the mathematical and physical culture which subsequently made her name illustrious as the wife of Dr. William Somerville. She became first known by a paper in the Philosophical Transactions, printed in 1826, describing her experiments on the magnetizing power of the more refrangible solar rays. "In her experiments, sewing-needles were rendered magnetic by exposure for two hours to the violet ray, and the magnetic virtue was communicated in still shorter time when the violet rays were concentrated by means of a lens. The indigo rays were found to possess a magnetizing power almost to the same extent as the violet; and it was observed, though in a less degree, in the blue and green rays. It is wanting in the yellow, orange, and red. Needles were likewise rendered magnetic by the sun's rays transmitted through green and blue glass." Such is the statement made by Dr. Turner in his old chemistry, but he adds that "the accuracy of the experiments had been doubted, and that the result must therefore be regarded as one of the disputed points in science." Dr. J. W. Draper went over the subject in 1835, with the sunlight of Virginia, and, although adopting far more delicate methods than Mrs. Somerville, failed to produce the alleged effects.

In 1831 Mrs. Somerville published "The Mechanism of the Heavens," an abridgment and attempted popularization of Laplace's "Mécanique Céleste," which she was induced to undertake by Lord Brougham. The "Connection of the Physical Sciences," perhaps her most valuable work, was issued in 1834, and her "Physical Geography" in 1838. Her last work, on "Molecular and Microscopical Science," published when she was near ninety years of age, is beyond doubt the most remarkable exploit of her life. It is a survey of what has recently been done in the field of Molecular Physics, describes the brilliant discoveries in dialysis and atmolysis, the crystalline and colloid states of matter, spectrum analysis in its celestial applications, the microscopical structure of the vegetable world, and the physics of organization, and all in a constantly clear and often an attractive style. Mrs. Somerville was the recipient of many honors on account of her scientific labors. She received a pension from the Government, was made an honorary fellow of the Royal Astronomical Society, at the same time with Miss Caroline Herschel, received a gold medal from the Royal Geographical Society, and had her bust placed in the library of the Royal Society. She maintained her interest in the movements of the scientific world, was supplied with the latest works in various branches of knowledge, and kept up her correspondence with many of the leading mathematicians and physicists, to within a few weeks of her death. It has to be added that Mrs. Somerville did not neglect the lighter accomplishments and tastes of her youth, but continued her painting, and music, and even her lace-work and other feminine trifles.

If it be asked how she contrived to do these things which are such consumers of time, while also making such extensive scientific acquisitions, the reply is, first, that she was a woman of great capacity and great industry; and, second, that her scientific work was by no means of that highest or creative kind which is produced only by genius and requires the concentration of a life within a narrow sphere of effort. We prefer, however, to abstain from estimating Mrs. Somerville's intellectual character, but will quote the opinions expressed upon this subject by her own countrymen. The *Saturday Review* says:

"A final lesson of importance is forced upon us by the retrospect of so exceptional a career. We may hear it asked how, in the face of powers of intellect and capacity for brain-work such as these, it can be pretended that the minds of women are essentially inferior to those of men. There are, it may be, those among us who would see in this highly-endowed and eloquent expositor of Nature a female Humboldt or Laplace. Far be it from us to speak disparagingly in a case in which the estimate of undoubted merit is enhanced by the sense of recent loss. Still in the balance of truth we must not allow affectionate regard to prevail over judicial candor, or gallantry outweigh critical and sober sense. No one would have been more prompt than Mrs. Somerville herself to disown any idea of intellectual rivalry between the sexes. It was in no sense as a rival to the great discoverers in science, or even as the author or setter-forth of truths novel and original, but simply as the interpreter and expounder in a popular form of what the masters of scientific truth, each in his own province of research, had brought to light, that she set herself her distinctive task. What the laureate has said of the passions of mankind and womankind applies, as experience shows, no less truly to their respective intellects. It is not invidious, still less discourteous, in us to say that the one is to the other as moonlight is to sunlight. Receptive, bright, and keen, the mind of woman may give back or diffuse the rays of knowledge for the source or emanation of which a stronger and more originative power is necessary. The knowledge of mathematics displayed in the 'Mechanism of the Heavens' took the world by surprise because it was that of a woman. Women have made themselves names before now in exact science, even among its higher branches. Maria Agnesi, we cannot forget, was Professor of Mathematics at Bologna in the last century, and Sophie Germain, whose works in pure and applied mathematics won her the Academy's medal, excited the esteem and wonder of the leading *savants* of France. But the high places of science, the seats of supreme authority and prime origination, exalted and few, are for a class apart."

A writer in the London *Athenæum* remarks:

"It is not too much to say that the chief value of her version of Laplace's masterpiece resides in the fact that the work exhibits an unmistakable proof of her mathematical power. It is difficult to conceive that any student of science could profit by the study of the work. As a first introduction to celestial mechanism it fails, because all the portions which present any difficulty are left uninterpreted: while to the more advanced student the work is useless, because such explanations as are given relate to the simpler parts of the subject. But it is impossible to rise from the perusal of the work without feeling that Mrs. Somerville herself had fully grasped the meaning of the great mathematician, and had followed his reasoning even where it had led him to the highest range of the modern methods of analysis. At the same time, it must be admitted that nothing in this work suggests the idea that Mrs. Somerville possessed in any considerable degree the inventive power which is the distinguishing attribute of great mathematicians. When we consider her work in other branches of science, a similar quality of mind is discernible. We cannot recall any experimental researches of hers which were characterized by originality, or any passage in her writings suggesting new ideas on the scientific questions which she discussed. She possessed but little power of generalization; and we believe it is this peculiarity of mind rather than any want of distinctness in expression which has led to the defect characterizing her attempts to popularize science. It is not commonly recognized, but is nevertheless the fact, that the perfect concatenation of ideas throughout a chapter or section of a science treatise is altogether more important than distinctness of expression in individual sentences, desirable though the latter quality necessarily is. But in Mrs. Somerville's science writings there is a want of sequence; and this is seen not merely in her general treatment of her subjects, but even in paragraphs and sentences. We may take the following sentence from her latest work, 'Molecular and Microscopic Science,' as a noteworthy instance. Endeavoring to prove the eternity of the soul, she says: 'To suppose that the vital spark is evanescent while there is every reason to believe that the atoms of matter are imperishable, is admitting the superiority of mind over matter; an assumption altogether at variance with the result of geological sequence; for Sir Charles Lyell observes that sensation, instinct and sensation of the higher mammalia bordering on reason, and lastly, the improvable reason of man himself, presents us with a picture of the ever-increasing dominion of mind over matter.' The readers whom the popularizer of science addresses are more apt to be perplexed by a *non sequitur* such as this than by mere verbal peculiarities."

LITERARY NOTICES.

Transactions of the Wisconsin Academy of Sciences, Arts, and Letters (1870–'72). Atwood & Culver: Madison, Wis.

The State of Wisconsin is but just of age, having emerged from its Territorial infancy and entered upon its sovereignty only twenty-two years ago. This is but a short period in the lifetime of an independent political community, yet much has been done within that period to give the State an impulse in the direction of civilized development. Taking journalism as a standard, the number of newspapers and periodicals printed in Wisconsin, in 1870, was no less than 174—of which 6 were monthly, 1 semi-monthly, 14 daily and weekly, and 153 weekly. In 1870, was organized, at Madison, the capital, the Wisconsin Academy of Sciences, Arts, and Letters, devoted to the material, intellectual, and social advancement of the State. This association numbers at present 55 annual members, 29 corresponding members, and 12 life-members. The first volume of the proceedings, now before us, is a very interesting document, the first part of which is a report to the Legislature by Dr. J. W. Hoyt, President of the Academy, which gives an account of its establishment, and a valuable inventory of the contributions to philosophy, political science, social science, natural science, and the useful and the fine arts, by distinguished citizens of the State, within the last few years. The remainder of the volume of proceedings is filled with a series of original papers in the several departments, many of which are able and instructive. The plan of the institution is comprehensive, and if it is sustained, as it ought to be, it cannot fail to be of great service in promoting the higher prosperity of the State.

Physics and Politics; or, Thoughts on the Application of the Principles of "Natural Selection" and "Inheritance" to Political Society. By Walter Bagehot,[1] Esq., author of "The English Constitution." D. Appleton & Co.

The second volume of the "International Scientific Series" is now issued, and it is but just to say that it ably sustains the character of the enterprise. It was no easy task to follow Prof. Tyndall, the clearest of our scientific thinkers, and most elegant and eloquent of our scientific writers; and, had a similar subject been chosen, we could have hardly expected a monograph so finished as the "Forms of Water." But Mr. Bagehot's theme is widely dissimilar from that of Prof. Tyndall, and, although treating of a subject at the opposite pole of science (if we may so speak), is not less attractive, and is presented with great literary skill, keenness of analysis, and originality of view. The author is unknown in this country, except through various essays in the *Economist*, of which he is the editor, and in the periodicals; but he takes a high rank among the thinkers of England. His book on "The English Constitution," which will shortly be republished here, is unquestionably the ablest work on the philosophy of modern politics that has appeared in a long time, and at once placed its author in the front rank of writers upon the science of government.

The volume now issued is not only from the latest point of view, and stamped with all the freshness of recent inquiry, but it is a pioneer discussion which clears a path of investigation that is certain to be followed up in the future with the most marked and valuable results.

If any one were asked to name that field of thought which is at present most chaotic and discordant, where there are the fewest settled principles, and the most arbitrary assumptions, in which everybody can dabble with equal claims to attention, and where scientific knowledge is utterly scouted as of no manner of use or application—it would of course be that of politics. In almost every other field where the human mind requires to be used, a certain amount of knowledge is regarded as indispensable; but in politics the charlatan and the ignoramus put forth equal claims with the trained and painstaking thinker. This state of things cannot last. The advance of knowledge is irresistible, and it will as certainly produce a revolution in politics as it has already produced revolutions in so many other departments of thought. This pestifer-

[1] Pronounced Bá-jote.

ous swamp of humbugs and impostures is bound to be drained and reclaimed to the higher uses of civilization.

"Physics and Politics" has been written to show that the noble field of political thought and activity is not necessarily the chaos it is generally supposed, but that it involves great natural laws, which it is the destiny of science to trace out and formulate, just as it has done with other branches of knowledge which have been made scientific by modern inquiry. In what does the progress of political communities consist, and how has it arisen? What were the first conditions and steps of social advancement? What are the uses of slavery, war, and other barbarities in the early tutelage of races? And when the rude stages of barbarism and violence are passed, what are the recent agencies which take up the work of amelioration and carry it up to still better and finer results? These are the questions which Mr. Bagehot answers in his successive disquisitions on "The Preliminary Age," "The Use of Conflict," "Nation-Making," "The Age of Discussion," and "Verifiable Progress Politically considered." In treating these questions, the author brings out the action of those laws of Nature and of human nature that precede the age of legislation, and are a thousand times more potent than the edicts of kings or the enactments of congregated law-makers.

To the cultivated reader who enjoys literary excellence, fine analysis, fresh and striking views, with many passages of picturesque eloquence, and all vivifying and illuminating a current of close and vigorous reasoning, this little treatise on "Physics and Politics" will prove a rare treat. We had marked several passages for quotation, but lack of space prevents their insertion.

Deductive and Inductive Training. An Address before the Chemical Society of the Lehigh University, by B. Silliman, M. A., M. D. Printed by the Society.

In this discourse, which was given at the first annual celebration of a young chemical society, Prof. Silliman regards the problem of higher education from the modern and American point of view—not as a radical innovator, but as a friend of rational progress and judicious reform. He says:

"Public opinion, however, has made itself felt by the outward pressure it has exerted, and the demand, which has grown up for men better trained in general science, and in its several departments, has brought about a change, visible on every hand, alike in the modification of the studies, as in the development of new departments with separate Faculties devoted to science-training; as also occasionally in the establishment of new institutions, on entirely independent foundations, in some of which only special subjects are taught, while in others the experiment is on trial of a curriculum, in which the modern languages, either wholly, or in part, replace the ancient, and where the student is trained during three or four years by a course of studies in which the inductive sciences have a prominent part."

Prof. Silliman admits the former excess of deductive training in our colleges, and recognizes the necessity of so modifying the curriculum as to introduce a larger amount of inductive science to correct the evil, and afford a sounder and more symmetrical culture. On this point he observes:

"The defect of an education based on the study of the deductive methods of geometry, the pure mathematics, jurisprudence, and ancient literature, will now be readily understood. Intuitive principles, those which underlie geometrical and mathematical studies, or those principles obtained by common consent, and of human authority, which are the foundations of jurisprudence; or again, the study of the historical, poetical, and literary precedents, images, and ideas of ancient writers, and their rendering into English, which is the staple of the ancient classics, leaves completely undeveloped the entire body and soul of ideas connected with the experimental and demonstrative sciences, which have to do with natural phenomena, and the entities of natural history in the broadest sense. In other words, no room is left for the study of the *inductive methods*, the logic of science, by the aid of which we, in this nineteenth century, find ourselves so immeasurably in advance of all former times, in our ability to comprehend and control the powers of Nature, and adapt them not only to the service of our human wants, but, what is more, to the interpretation of cosmical laws, and the hidden mysteries of molecular physics."

The professor protests alike against the narrowness of the traditional culture on one side, and the newer policy of our scientific and technological schools.

"In urging the plea for science-education, let it be remembered that we speak of education in its broad and well-rounded sense, by which *all* the powers of the human mind are to be developed into a symmetry which shall dwarf none of them. We claim, with great reason, the existing system does not do this, and is incapable of doing it, owing to the overshadowing importance attached to the ancient classics, absorbing so much of the time given to education that only a fragment can be grudgingly given to the study of the inductive sciences. But no institution, as we have before remarked, which is confined to the training of men for special professional work can be regarded, in the broader sense of that term, as an educational institution, however ably it may discharge the more limited work which is assigned to it. The want of ethical and literary training and general culture at West Point has always been recognized as a deficiency, in a system in many other respects unsurpassed, and the same is true of all institutions similarly organized."

Recent Discussions in Science, Philosophy and Morals. By Herbert Spencer. New and enlarged edition. D. Appleton & Co., 350 pages.

This volume completes the first collection yet made of Mr. Spencer's miscellaneous essays. It contains thirteen papers, most of which have not before appeared in this country, and there are six more articles added to the present edition. The volume is especially valuable, as containing Mr. Spencer's complete discussion of the system of Comte, the classification of the sciences, the genesis of knowledge, and the work of discovery of general laws. The other articles are "Specialized Administration"—a reply to some views of Prof. Huxley in his articles on "Administrative Nihilism," "What is Electricity?" "The Constitution of the Sun," "The Collective Wisdom," "Political Fetichism," and "Miss Martineau on Evolution." As remarked in the preface to this work, "these several discussions have been drawn from Mr. Spencer at various times to correct misapprehensions and misrepresentations that have been made regarding the doctrines of his system of philosophy. Some of them form valuable extensions of these doctrines, and all will be useful in promoting their right interpretation."

MISCELLANY.

Volcanic Energy.—Mr. Mallet, in a paper read before the British Royal Society, claims that volcanic heat results simply from the secular cooling of a terraqueous globe subject to gravitation. He rejects the chemical theory, on the ground that facts show the chemical energies of the globe almost wholly exhausted prior to the consolidation of its surface. The mechanical theory he also rejects, it being, according to him, proved untenable by the known thickness of the earth's crust. He then points out various relations and points of connection between volcanic phenomena, seismic phenomena, and the lines of mountain elevation, attributing all three to one set of cosmical forces, which decay with time. As our globe contracted, there occurred deformations of the spheroid, forming the ocean-basins; next came the foldings-over and elevations of the thickened crust into mountains; and, lastly, we have volcanic action. The author accepts C. Prevost's theory of mountain elevation, viz., tangential pressures propagated through a solid crust, and produced by the relative rate of contraction of the nucleus and of the crust. As the nucleus shrinks, the crust is partially unsupported. During the very rapid cooling from a high temperature, with a thin crust, we should have mountain elevation as a result; but the same causes give rise, in the present state of things, to volcanic heat. As the solid crust sinks after the nucleus, its crushing together is transformed into heat sufficient to fuse the rock. The access of water then determines volcanic action. Mallet made two series of experiments to test his theory. He first crushed sixteen species of rocks, representing the whole series of formations from oolites to the hardest crystalline rocks. The second series of experiments, conducted on a very large scale, was to ascertain the coefficients of total contraction, between fusion and solidification at existing mean atmospheric temperature, of basic and acid slags, analogous to melted rocks. Mallet thus finds that less than one-fourth of the heat annually lost by our globe is sufficient to account for its total annual vulcanicity. He then shows the accordance of his views with sundry facts of vulcanology and seismology. Finally, he accounts, on his theory, for the elevations on our moon's surface, and the evidence there of former volcanic energy, on a grander scale than on our planet.

The Vibrations produced by Various Explosives.—It is known that the instantaneous combustion of an explosive body is brought about by vibrations, independently of the agency of heat. An interesting inquiry here arises, whether these vibrations are identical for all explosives; and whether we can determine in advance the action of one explosive upon another. Two French *savants*, MM. Champion and Pellet, have investigated this subject, and the following is an account of their experiments: First, they set up an apparatus with eight gas-burners, to give "singing" flames, answering to the eight notes of the gamut. For the first experiment an anvil was placed at a distance of sixteen feet from this apparatus, and on it they placed in succession 0.03 grammes of iodide of nitrogen and fulminate of mercury, both enclosed in sacks of gold-beater's skin. The iodide, on being exploded, had no effect on the flames, while the fulminate caused the following flames to play: *la*, *do*, *mi*, *fa*, and *sol*. The conclusion is, that the vibrations produced by the two agents differ mutually, and further, that the vibrations caused by the fulminate act on some notes, passing over the others. In the second experiment the flame-apparatus and the anvil were placed twelve feet apart. It was now found that the iodide acted on the higher notes, whereas the fulminate affected the entire scale. But, if now we make each charge two decigrammes, and bring the anvil very close to the apparatus, the whole gamut will respond to both explosions. The third experiment was a repetition of the foregoing two, with this exception, that nitro-glycerine was substituted for iodide of nitrogen. The result did not show any difference between these two agents in their action on the flames; and yet it is known that there *is* a difference between their respective vibrations; for the fulminate will explode compressed gun-cotton, but nitro-glycerine will not, under identical conditions. No doubt, if a more perfect flame-apparatus, with a series of low notes, had been employed, a difference would have been manifested in the course of the experiment.

Economy of Fuel.—A self-feeding furnace is now in use in several English manufacturing towns, which is said to effect a great economy in the consumption of coal, besides possessing the additional advantages of burning all the refuse and completely consuming the smoke. A small and uniform amount of fuel, just enough to replace that consumed, is being constantly added to the fire, which is supplied with exactly as much air as is required to carry on the combustion in the most economical and effective manner. The apparatus is known as Vicar's Furnace, and is readily fitted to any kind of boiler, and to reverberatory furnaces of all descriptions.

Ammonia in Snow-water.—Dr. Vogel has an article on ammonia in snow-water in the *Sitzungsberichte der mathematico-physikalischen Classe*, of the Munich Academy of Sciences. The method employed by him is that of Schlösing, for estimating the amount of ammonia in arable soil. The results obtained were as follows, one litre (2.113 pints) being the unit: Freshly fallen snow, caught in a porcelain basin, at zero, gave 0.003 grammes; at −3° gave 0.002; at from −9° to −15° gave no ammonia. Water from snow which had stood 24 hours on a piece of manured garden-ground, contained 0.012 grammes; from snow which had stood on a meadow for 24 hours, 0.009 grammes; from a zinc roof, 0.004 grammes. Dr. Vogel observes that the quantity of ammonia in snow depends on a variety of conditions, and that, since snow, owing to its porosity, absorbs ammonia (and the same is true of snow-water), it is necessary to melt it in closed vessels. The amount of ammonia in snow is also dependent on the temperature at which it falls. At a rather ow temperature (—15°), the author could not detect ammonia in snow.

Cultivation by Steam.—At an agricultural meeting, recently held in Scotland, some interesting statements were made respecting the origin, progress, and results of cultivation by steam in Europe. In 1855, a Mr. John Fowler, of Essex County, England, started his first steam-plough. Now, in Great Britain, there are single establishments for manufacturing steam-ploughs, so extensive that they furnish constant employment for not less than 1,200 men. In England, between 400 and 500 sets of steam-ploughs, held, some by companies and others by individual owners, are worked for hire, and are found to be a profitable investment. A tract of 500 acres, near London, so unproductive that it could not be rented for $3 per acre, was bought by an enterprising farmer, who removed the fences, under-drained, and, with a steam-plough, put the whole into grain-crops. Last year, after allowing 10 per cent. on the money invested in the land, his clear profits were $18,000. The soil he thus improved by deep steam-ploughing is a stiff clay that could not be profitably worked by horse-power. Another tract of 5,000 acres, that had been regarded as worthless, was bought by a farmer who ploughed it with steam-power to the depth of 3 feet, and was rewarded by crops of astonishing thrift. In Scotland, cultivation by steam is becoming general, and producing results equally marvellous. Joint-stock companies are investing in land and steam-machinery, and securing large dividends, while individual farmers have invested from $6,000 to $10,000 in steam-machinery with very profitable results. In Germany also steam-power is working a revolution in agriculture.

It was also stated that the Pasha of Egypt now employs on his extensive domain 400 steam-ploughs, and is building "on his farm" 400 miles of railway, and, for transporting and manufacturing the raw material produced, has ordered thirty locomotive-engines and $3,000,000 worth of sugar-machinery.

Perhaps the most successful cultivator by steam in America is Mr. E. Lawrence, of Magnolia Plantation, parish of Plaquemine, Louisiana. In a letter to the Agricultural Department, he speaks of the results of his trial of the steam-plough as follows:

"Two hundred and twenty acres of my cane-crop, 140 acres of which were plant-canes, and 80 acres first-year rattoons, were, I believe, as thoroughly ploughed and cultivated by steam as could be desired. The 80 acres of first-year rattoons, grown from the stubbles of the *steam-ploughed cane* planted in a similar manner last year, were barred off and well dug in the month of March, then subsoiled and cultivated by steam precisely as the plant-canes. The yield was over 2,500 pounds of sugar to the acre."

Mr. Lawrence closes his letter with the prophecy:

"Necessity will soon compel us to take a 'new departure.' The constant increase of immigration and population in the grain-growing States of our country will soon demand a better cultivation and increased production. In England, steam-ploughing has increased the yield of wheat from 16 bushels to 28 bushels to the acre.

"I do not believe the agricultural interest of our country can much longer turn a deaf ear to this last and greatest achievement of steam—its successful application to the cultivation of the soil. It has broken the yoke and lifted the burden which, for ages, held both man and beast in bondage, ameliorating their condition by making that which was most onerous easy and attractive; it has elevated labor, and dignified the plough."

Ozone by a New Process.—An apparatus for manufacturing ozone, patented by Dr. Loew, is mentioned in the *Journal of the Franklin Institute*. Some time since Dr. Loew observed that cold air blown through a flame is in part converted into ozone, and his apparatus is constructed with a view to turn this observation to practical account. It consists of a number of Bunsen burners, set up in a row, with an equal number of horizontal tubes at some distance above the burners. The cold air is blown through the tubes against the flames, and is then collected, in the shape of ozone, by a number of funnels placed on the opposite side of the flames. The ozone is to some extent contaminated by acetylen and nitrous acid.

The English Sparrow.—In a paper lately read before the Long Island Historical Society, by Mr. E. Lewis, Jr., and since published in the *Brooklyn Union*, we find the following interesting particulars concerning the importation into this country of the English sparrow, and the valuable service it has since rendered in clearing our city trees of insect-pests. As many are aware, the trees of Brooklyn some years ago were overrun by a species of caterpillar (*Ennomos subsignaria*), which, commencing when the leaves were young and tender, devoured them so rapidly that in a short time the branches were completely bared, making the tree an unsightly object, and greatly injuring its health and growth. The creatures also had the disgusting habit of suspending themselves from the limbs, whence they would drop in great numbers both upon the pavements and passing pedestrians. The maple, horse-chestnut, elm, and willow, were thus attacked, and their destruction, or that of the caterpillars, was the alternative presented to the Brooklyn people. All sorts of expedients were proposed, and among them the introduction of the English sparrow. In spite of the failure of a previous attempt, a second was decided on, and in the fall of 1856 Mr. Thomas Woodcock, of Brooklyn, at the instance of the Brooklyn Institute, brought over from Manchester about a dozen sparrows, which were liberated in the following spring, when they flew away toward Brooklyn Heights. Nothing more was heard of them until the spring of 1858, when two pair were observed among the ivies of Grace Church, where it is probable that one or more nests were built, as during the summer young sparrows were noticed in the vicinity. Since that time their increase has been enormous, and almost solely through their agency the caterpillar nuisance has been completely removed.

According to Mr. Lewis, though feeding largely on seeds, and in cities upon almost every article of human food, the sparrows feed their young chiefly with worms, larvæ, the soft portions of coleoptera, moths, and other tender animal food. "By this means the number of devouring worms has been greatly diminished. The leaf-rolling caterpillar of the sycamore and the currant-bush are known to be taken and devoured by sparrows. The inch-worm, too, is taken when young, as is the Japanese silk-worm, which feeds upon the ailantus-leaf.

"But the sparrows destroy the caterpillar family in a more effectual way than this. The large female moths of the *Samia cynthia*, or Japanese silk-worm, are seized for the eggs which they contain, torn to pieces, and the eggs devoured. So persistent are the sparrows in watching for and catching these moths, that a gentlemen in this city has been unable to raise either worms or moths unless protected from the birds.

"The moths, both male and female, of the inch-worm or tree-caterpillar, are eaten by sparrows. After seizing the moth, they will beat off its head and wings and feed to their young the soft parts of the insect.

"The destruction of the female moths arrests the increase of the caterpillars in a most effective way. But this is not all. We have referred to the sparrows feeding upon the eggs of moths after being deposited upon branches of trees. I have watched them at this frequently during the winter. These eggs are usually deposited in places where they are sheltered by raised or fractured fragments of the old bark, and are covered with a glutinous substance. The sparrow labors until fairly weary in breaking away the old bark and laying bare the eggs, which it removes with some difficulty, but which it nevertheless removes and devours.

"It is thus apparent that the chance for a full crop of caterpillars is small where sparrows are abundant. Indeed, the disgusting tree-caterpillar has disappeared from our city altogether."

The Brooklyn Institute has also attempted the introduction of English song-birds, but as yet with indifferent success. Among those brought over are the skylark, woodlark, goldfinch, robin, and thrush. Some are known to have survived and produced young; but the general impression is that our winters are too severe for them to do well in this climate. "The sparrows," says Mr. Lewis, "seem to be well acclimated, although many have been found dead, after severe frosts and snow. It is evident that the severity of the climate, or some other cause, has somewhat arrested their growth, as persons, who are competent to judge, say they are a little smaller than in the English towns."

The Uses of Asbestos.—The mineral formation called asbestos—which term denotes rather a peculiar form assumed by sundry minerals than any particular species—is coming to be used very largely in practical mechanics and manufactures. The name *asbestos*, signifying indestructible, was given by the ancients to various amphibolic and augitic minerals, which occur in long, hair-like crystals, placed side by side, forming a fibrous mass. These crystals may easily be taken apart, and, as they are very elastic and pliant, have been used to manufacture a sort of cloth. The Romans used sometimes to envelop the bodies of their dead in a wrapping of this fabric, thus keeping their ashes separate from the ashes of the funeral-pile, for fire does not consume asbestos. We even read of napkins and articles of dress being made of this material—when soiled they were cleansed by being subjected to the action of fire. In ancient times the wicks of the ever-burning lamps in temples and shrines were often of asbestos, and at the present time the Greenlanders make a like use of it. A few years ago a Mr. Audesluys, proprietor of a large asbestos-deposit in the vicinity of Baltimore, commenced the manufacture of a paper containing about 30 per cent. of asbestos. Characters written on such paper, in common ink, are still legible after it has been subjected to the action of fire, and it is likely that advantage will be taken of this property of asbestos to manufacture a paper for important records. The great objection to all the asbestos paper so far made is its want of toughness, its friability. The *Journal of the Society of Arts* makes mention of an asbestos paper covering for roofs, but, as this mineral is not proof against moisture as it is against fire, experience alone could determine its value for that purpose. But, perhaps, the most important service yet rendered by asbestos is the furnishing us with a fire-resisting packing for piston and pump rods, the necks of revolving retorts, etc. Asbestos packing was used for the piston of a locomotive on the Caledonian Railway from July 27 to November 18, 1871, and was then as good as when it was first put in; while the best common packing would have lasted not above two months. It is better to make rings of asbestos, and put them on the piston, than to wind it round. There are very extensive deposits of this important mineral within the limits of the United States, that found on the eastern slope of the Green Mountains and of the Adirondacks being of the best quality for fineness and tensile strength. The fibre of New York and Vermont asbestos varies in length from two to forty inches, and resembles unbleached flax, when found near the surface; but when taken at a greater depth it is pure white, and very strong and flexible. It is found also in considerable quantities in the Tyrol, in Hungary, Corsica, and Wales.

British Scientific Expedition.—The enlightened liberality of the British Government in fitting out the steam-corvette Challenger, 2,306 tons, for a scientific voyage around the globe, receives the heartiest commendation from the English press, and from the whole world of science. The commander of the corvette, Captain Nares, R. N., is a distinguished seaman and explorer, and the second in command, Commander J. P. Maclear, R. N., is scarcely less eminent. We have space only for the names of a few of the scientific men who go out on this cruise. The director is Prof. Wyville Thompson, and he has under him J. J. Wild, of Zurich; J. Y. Buchanan, of Edinburgh, chemist; H. N. Mosely, naturalist; Dr. Von W. Suhm, do.; John Murray, Edinburgh University, do. The vessel has been thoroughly repaired and fitted for her work, with auxiliary screw, two engines of 400 horse-power each, boats, 40 dredges, etc. She carries an abundance of traps, harpoons, scientific apparatus, etc. The route of the vessel will probably be, first, to Gibraltar and the Bay of Biscay; thence to Madeira, St. Thomas, the Bahamas, Bermuda, and the Azores. From the Azores she will sail for Bahia, touching at Fernando Noronha. Thence she crosses to the Cape of Good Hope, from which point her course is southward to the Crozetts and Marion Islands and Kerguelen's Land. Thence her direction will still be southward, as far as the ice will permit, and then the vessel will steer for Sydney, New Zealand, the Camp-bell and Auckland Groups, Torres Straits, New Guinea, and New Ireland. A cruise among the Pacific Islands will probably take up a twelvemonth, when the expedition, passing between Borneo and Celebes, and visiting Luzon and its neighborhood, will make for Japan, there to remain for a couple of months. Kamtchatka will next be visited, whence a run will be made northward through Behring's Straits; thence through the Aleutian Islands, southward to Vancouver's Island, and so through the deep eastern region of the Pacific by Easter Island, and possibly to the Horn, through the Galapagos, and home. The voyage will take between three and four years, and from it results of the highest importance for science may be expected.

The Venomous Snakes of India.—A new book has been recently published by Dr. Fayrer on the venomous snakes of India, and the treatment of their poisonous bites. In Bengal the people suffer terribly from these reptiles. Dr. Fayrer says: "The frightful scourge of these animals is shown by the fact that the recorded deaths in 1869 were 11,416. But it is more than probable, considering the imperfection of Indian records, that 20,000 was nearer the true mortality." He has given a description of some new species of *Hydrophidæ* or poisonous sea-snakes which infest the Indian seas. These elegant creatures, with small heads and tiny jaws, will bite a man while bathing, inflicting an almost imperceptible wound, unnoticed at the time, but of which he dies in a day or two. About the most poisonous of the Indian reptiles is the cobra de capello, or hooded snake. The elevated skin of the back of the neck presents, when the animal is viewed in front, much the appearance of a hood. It is also sometimes called the spectacle snake, from a singular mark on the back of its neck, closely resembling a pair of old-fashioned spectacles. The cobra is some three or four feet long, of a pale, rusty-brown color above, and bluish or yellowish-white below. Its venom is extremely powerful, the bite sometimes causing death in less than two hours. This venom, though so exceedingly poisonous when introduced into the system, is comparatively harmless when taken into the stomach. It has a sharp taste, but no odor. Usually the cobra is a sluggish creature, and is easily killed. It seldom uses its fangs except for the purpose of obtaining food. One of its most disagreeable habits is an evident liking for the habitations of men, being frequently found near houses, and not rarely in the dwellings themselves.

In regard to cures for the bite of the cobra, Dr. Fayrer's experiments, no less than universal experience, bear testimony to the efficacy of the ligature, if applied promptly and tightly, near the wound, between it and the heart, and followed by excision of the wounded part and the application of the actual cautery. In case a finger or toe is bitten, amputation should immediately be performed at the next joint. Dr. Fayrer's principal snake-man was once bitten by an echis. Immediate excision and cauterization fortunately saved him. When the virus is once in the blood no known agent is capable of neutralizing it.

Some of Dr. Fayrer's results are extremely interesting and of great practical value. He finds that these snakes have the greatest repugnance to carbolic acid, which acts as a powerful and fatal poison to them. The practical advantage of using carbolic acid freely in and about houses in India must therefore be great. The practice of sucking a bite is not so absolutely safe as has been hitherto supposed. The poison may be absorbed through the buccal mucous membrane, or the lining membrane of the stomach, when it will produce its fatal effects.

The most venomous of these snakes seem to possess a perfect immunity from the poison of their own species, and considerable immunity from the poison of other species. Dr. Fayrer says: "In many of the various experiments I have performed, the cobra, daboia, and krait, did not appear to be able to poison themselves or each other. This result was not absolutely invariable, but sufficiently constant to be remarkable." On this point Dr. Fayrer's observations confirm those made by Dr. Russel. Snake-poison acts with most vigor on warm-blooded animals; birds die very quickly. The power of resistance is generally in proportion to the size of the animal, but not invariably so. For instance, a cat will resist the poison as long as a dog three or four times its size. Cold-blooded animals, fish, non-venomous snakes, and invertebrate animals, all die when bitten. There seems to be a certain difference in the action of the colubrine and viperine snakes. In poisoning by the colubrine snakes, the blood coagulates firmly, but in death by the viperine it remains permanently fluid—at least this was the case in many of Dr. Fayrer's experiments.

A New Fire-Escape.—At the International (London) Exhibition of 1872, Major E. R. Wethered exhibited a fire-escape, consisting of a canvas cradle, with a guard-band to be passed beneath the arms, a strong rope, and a pulley furnished with a clamp, which can be worked by the hand, as the fugitive descends. At an alarm of fire, the sashes of the window are to be thrown into close correspondence at the top. The rope is then thrown around them at one side and hitched with a hook. The lateral pull of the weight will jam the sashes in the frame. The pulley, having five friction rollers, between which the rope runs sinuously, and a clamp worked by lever and handle, is fixed a little above the cradle. The free end of the rope is coiled on a reel, and is thrown out of the window, unwinding as it falls. In addition to the clamp, the descent of the cradle may be governed by the left hand of the fugitive, running along the rope.

Necessity of Carefulness in Old Age.—An old man is like an old wagon; with light loading and careful usage it will last for years; but one heavy load or sudden strain will break it, and ruin it forever. Many people reach the age of fifty, sixty, or even seventy, measurably free from most of the pains and infirmities of age, cheery in heart, and sound in health, ripe in wisdom and experience, with sympathies mellowed by age, and with reasonable prospects and opportunities for continued usefulness in the world for a considerable time. Let such persons be thankful, but let them also be careful. An old constitution is like an old bone—broken with ease, mended with difficulty. A young tree bends to the gale, an old one snaps and falls before the blast. A single hard lift; an hour of heating work; an evening of exposure to rain or damp; a severe chill; an excess of food; the unusual indulgence of any appetite or passion; a sudden fit of anger; an improper dose of medicine—any of these, or other similar things, may cut off a valuable life in an hour, and leave the fair hopes of usefulness and enjoyment but a shapeless wreck.

NOTES.

The friends of Prof. Huxley will be glad to learn that the latest reports of his health are most encouraging. He broke down last year, and went to Egypt to recuperate, but returned but little better than he left. He seemed to have been very hard hit, and his friends feared that it might be long before he would recover himself. He has lately been elected Lord Rector of Aberdeen University, for three years, which is significant, as showing the way the currents of thought and sympathy are setting.

It is reported that a cargo of Australian beef, in the fresh state, has been brought to New Orleans without damage, notwithstanding the fact that the temperature of the atmosphere, for a large part of the distance, ranged as high as 90 degrees. The carcasses were packed in ice, also produced in Australia, by a process so economical that it is thought this method of transportation may be made a pecuniary success.

A very good liquid glue is got by dissolving glue in nitric ether. It is more tenacious than that made with hot water, and may be rendered almost damp-proof, by introducing a few pieces of caoutchouc, and letting the solution stand a few days, with frequent stirring. As the ether will dissolve only a fixed amount of glue, the mixture cannot be made too thick.

The *Mechanics' Magazine* notes the casting, at Woolwich, of an enormous steam-hammer, consuming 100 tons of metal. The anvil-block, to serve as a *pièce de résistance* for this enormous engine, after cooling off for three months, was not yet cold enough to be removed.

An apparatus has been recently devised in Germany for obtaining specimens of water at any desired depth of the ocean. A strong, heavy vessel, entirely closed and empty, has a valve through which water may be admitted, but which is only put in motion by means of powerful electro-magnets connected therewith. These magnets are also connected with a wire which accompanies the rope, by means of which the apparatus is lowered from the ship. When the empty vessel, which is in fact a plummet, has reached the required depth, an electric current is sent from the battery on shipboard to the coils below; the magnetism thus generated opens the valves, and the vessel is filled and ready to be drawn up.

In his evidence before the Royal Commission on the water-supply of London, Dr. Parkes states that where the population of any town shows a considerable amount of diarrhœa, and also of typhoid fever, it would lead him to regard the water-supply with suspicion; for the health of the population, as regards these diseases of the intestines, seems to be very much influenced by the purity or impurity of the water consumed.

It is proposed to employ tin-foil in place of paper for decorating walls. The foil for this purpose is cut in sheets about 16 feet long and 40 inches wide. After having been painted and dried at a high temperature, the sheets receive the ornamental figures, and are then varnished and again dried. The hanging is done much like paper-hanging, varnish being applied to the wall instead of paste. The foil excludes damp, and can be laid as readily on an irregular as on an even surface, and thus the highest artistic effects can be produced at pleasure.

A writer in *Hardwicke's Science Gossip* tells of a water-wagtail which he saw acting as purveyor to a young cuckoo. The wagtail was seen, again and again, to fly down from a tree, and run along the rail on which the cuckoo was perched, bringing each time to the latter some insect to supply its hunger.

Orange Cultivation in Louisiana.—There is a steady increase, in the orange district of Louisiana, of this species of husbandry. In Plaquemine Parish some 2,000 acres are occupied by orange-groves. Usually, there are one hundred trees to the acre, and a healthy tree will bear from 500 to 2,000 oranges, 1,000 being a fair average field. They bring, on an average, $10 per thousand.

The iron mountains of Missouri, according to Prof. Waterhouse, contain enough ore above the surface, to afford, for 200 years, an annual supply of 1,000,000 tons. Shepherd Mountain is 600 feet high, and its ore contains a large percentage of iron. Pilot Knob rises 1,114 feet above the Mississippi; its base, 581 feet from the summit, is 300 acres, and the upper section of 141 feet is judged to contain 14,000,000 tons of ore. Iron Mountain has an elevation of 228 feet, and an area of 500 acres at its base. The soild contents of the cone are 230,000,000 tons. At the depth of 150 feet, the artesian auger was still penetrating solid ore. The iron from all these mountains is strong, tough, and fibrous.

Died, October 28th, aged sixty-five, Dr. Friedrich Welwitsche, the distinguished African botanist. He got his first lesson in his favorite science from a village apothecary, and so an interest was awakened for botanical studies. The "Flora of Tropical Africa" has received from him very important contributions. He acquired distinguished reputation also as an entomologist and zoologist.

In criticising the evidence given by Dr. Letheby before the Royal Commission on the London water-supply, Dr. Hassel, in "Food, Water, and Air," maintains that "it is a fact, notwithstanding Dr. Letheby's evidence, well-established and generally accepted, that cholera is communicable by water, and has, over and over again, been disseminated by the water contaminated by cholera-discharges. It is also a fact that on more than one occasion that dreadful disease has been communicated by Thames-water."

A recent issue of French coin, made from Australian gold, has been found so brittle as to break easily under ordinary use; it has accordingly been recalled. The brittleness is supposed to be due to the presence of a small percentage of antimony and arsenic, both extremely difficult to remove. These substances are said to produce a like effect in all metals or alloys which are subjected to the molecular changes induced by the pressure and heat developed under the action of the dies in the copying-press.

The archives of the Paris Jardin des Plantes contain 6,000 volumes and over 1,500 manuscripts that have hitherto been huddled away as so much lumber. Recently M. Milne-Edwards has arranged for examining, cataloguing, and placing at the disposition of the scientific world this valuable collection. There are several MS. by Buffon, Cuvier, and Daubenton, and a series of pen-and-ink drawings by the last-named naturalist, representing the various types of merinoes; also many albums filled with drawings of plants and flowers.

Dr. Günther shows that the whitebait, a fish highly esteemed by epicures, is nothing but the fry or young of the herring, and this he proves by showing that both fish have the same number of vertebræ and of lateral scales, as also the same arrangement of fins and teeth. This statement is further confirmed by the fact that an adult whitebait in roe has never been found.

THE

POPULAR SCIENCE MONTHLY.

MARCH, 1873.

EARTHQUAKE-PHENOMENA.

By ELIAS LEWIS, Esq.

IN the afternoon of the 1st day of June, 1638, 18 years after the landing of the pilgrims, there occurred the first earthquake in New England, of which we have an authentic record.

It is 234 years since that event, and, according to a catalogue prepared by W. T. Brigham, published in the Memoirs of the Boston Society of Natural History, it appears that, down to October 20, 1870, 231 earthquakes are recorded as having taken place in New England. From this able paper we learn that, in 1663, portions of Canada, New England, and New York, were convulsed by earthquake-shocks.

In 1727, at Newbury, and near the mouth of the Merrimac River, an earthquake took place during the evening when the atmosphere was perfectly calm and clear. The sound preceded the shock. The earth opened, and a sulphurous blast threw up mounds of calcined dust. Several days previous to the earthquake, water in the wells became fœtid, and of a pale brimstone color. In 1755, on the 18th day of November, a hollow, roaring noise was heard in various parts of New England. In a minute the earth seemed to undulate as if a wave were passing. This was followed by a vibratory and jerking motion, familiar in earthquake countries. The first shock of this earthquake occurred 17 days after the terrible one at Lisbon, the vibrations of which had not yet ceased.

The great earthquake at New Madrid, in Missouri, took place in 1811–'12. The shocks here were vertical, proving, as we shall see hereafter, that the centre of energy was directly underneath. At other times, the shocks, which continued many months, were undulatory. The ground rose in huge waves, which burst, and volumes of water, sand, and pit-coal, were thrown high as the tops of the trees. The forests waved like standing corn in a gale of wind, and an area 70 miles long by 30 miles wide was submerged, and became a swampy lake.

On the 13th of August, 1868, a fearful earthquake took place in Peru, which laid waste much of the country lying between the Andes and the Pacific. The shocks were felt through a distance of 1,400 miles north and south, and three important cities were destroyed. At Arequipa, in Peru, 40 miles from the sea, a slight undulatory shock was felt, followed by others so violent that in five minutes not a house was standing in that city of 44,000 inhabitants. A subterranean rumbling, like the rush of an avalanche, was heard above the crash, and a cloud of dust rose in the still air over the city. On the sea-coast were situated Iquique and Arica—both were destroyed by the shocks, and overwhelmed by a tremendous wave. The ocean thus took up the vibrations of the land, and waves of tremendous volume were put in motion, which rolled, not only upon the coast, but away from it with a velocity in the deep ocean of not less than 400 miles an hour. The great wave—for one was of much greater volume than the others—has been estimated at upward of 200 miles breadth, with a length along its curved crest of 8,000 miles. This rolled into the harbor of Yokohama, in Japan, 10,500 miles distant, and was felt at Port Fairy, in South Victoria, distant nearly one-half of the earth's circumference.

In 1797, a province of Ecuador, about 100 miles south of Quito, was visited by what is described by Humboldt as "one of the most fearful phenomena recorded in the physical history of our planet." The shocks were vertical, and occurred as "mine-like explosions." The town of Riobamba was over the central area, and many of its inhabitants were thrown 100 feet into the air.

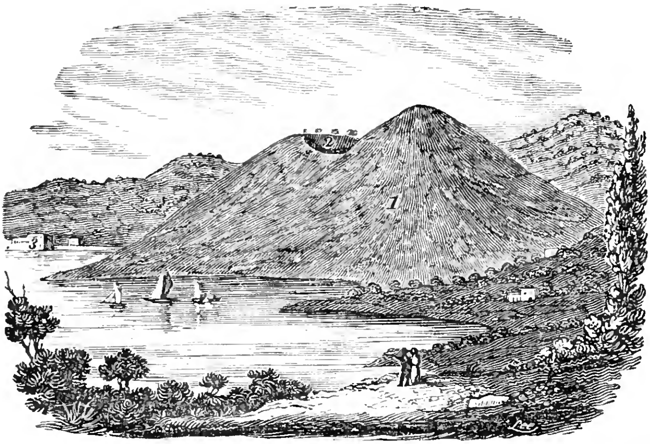
The shocks, in this instance, were not announced by any subterranean thunder, but, just 18 minues after, a terrific roar was heard beneath Quito. It thus appears that shocks are not always preceded by sounds, nor do the sounds increase with the violence of the shock.

Sometimes, says Humboldt, there is a "ringing noise, as if vitrified masses were struck; again, a continuous rumbling and hollow roar; at others, a rattling and clanking as of chains or near thunder." With the lightning's flash we know that the danger is over, and await the coming thunder without alarm; but thunder, rolling deep in the earth, announces possible if not certain calamity.

Throughout the region of the Andes a connection between volcanic and earthquake action has been recognized by the people. It was supposed by Strabo that volcanoes are safety-valves, and scientific observation suggests that they may relieve the pressure and tension which would otherwise lay the earth in ruins.

For two years previous to 1538 earthquakes had been violent and frequent at Pozzuoli on the Bay of Baiæ, and elsewhere in the vicinity of Naples. On the 27th and 28th of September they did not cease day or night. On the night of the 29th, flames issued from the ground near the baths of Nero, the earth rose and burst at the top with tremendous roar, and discharged steam, gas, pumice, mud, and ashes. A mountain 1,000 feet high was formed, known as Monte Nuovo, which, at the present time, is 8,000 feet in circumference, and 440 feet above

FIG. 1.



MONTE NUOVO.

the bay. The present aspect of Monte Nuovo is represented in Fig. 1, and the region around is shown in the frontispiece, from the last edition of Lyell's "Principles of Geology."

The Phlegræan Fields, of which Monte Nuovo now forms a part, have, in the opinion of Sir Charles Lyell, a "mutual relation with Vesuvius—a violent disturbance in one district serving as a safety-valve to the other—both never being in full activity at once."

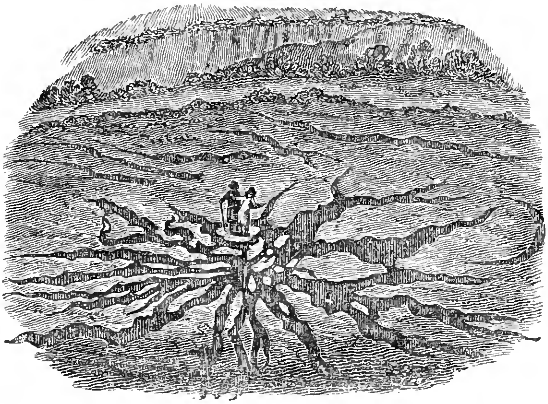
In the Sandwich Islands, in 1868, Mauna Loa and the craters of Kilhauea on its flank were in active eruption. The valleys of the mountains were filled with rivers of fire, and a cloud of smoke and vapor arose, it is said, over the mountain, to a height of eight miles. During these fearful phenomena, which continued more than a month, 1,500 earthquake-shocks occurred, 300 of which were counted in five days. But whether shocks occur in the immediate vicinity of volcanoes during eruptions, or whether activity of the one diminishes the violence of the other, it is certain that they have a mutual relation, and probably a common origin.

The opening and closing of fissures and chasms in the ground during earthquakes is a common phenomenon. Men, animals, and dwellings, are sometimes swallowed in them, and forever disappear. In 1848 an earthquake shook a large portion of New Zealand, and a fissure of great depth opened along a chain of mountains from 1,000 to 4,000 feet high, extending 60 miles, but of not more than 18 inches in average width.

During the Calabrian earthquake of 1783 the surface of the ground opened and closed in immense fissures, by means of which new lakes were formed and others drained or were dried up.

At Jerocarne the earth is described, by Sir Charles Lyell, as lacerated in an extraordinary manner. "Fissures ran in every direction, like cracks in a broken pane of glass."

Fig. 2.



Fissures near Jerocarne, in Calabria.

In another instance, several dwellings were engulfed in a fissure, and were found to be jammed with their contents into a compact mass. Chasms of immense length and depth were formed. Some were crescent-shaped, and a mile in length.

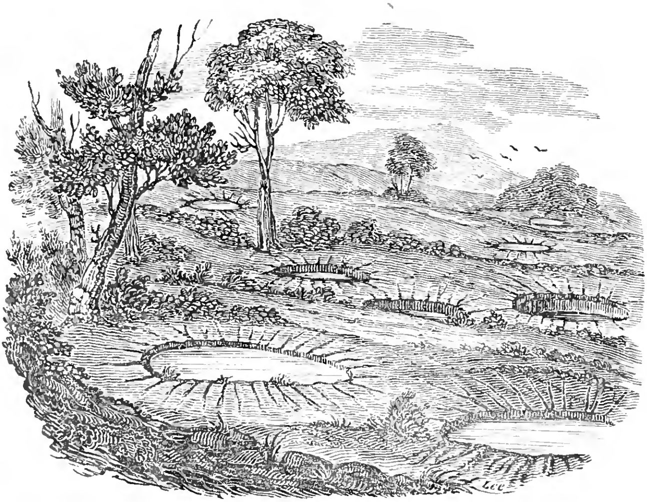
The plains of Calabria were covered in many places with circular hollows from one foot to three or four feet in diameter. Some of these were filled with water, others with dry sand.

Fig. 4 is a section of one of these circular holes, which appears to be funnel-shaped.

But changes in the earth's crust occur during earthquakes, on a still grander scale. Evidences of local disturbance, however disastrous it may have been, are often effaced if not forgotten in a few centuries frequently in a few years. But the slow upheaval of mountain-chains and the dislocation of strata through profound depths are results which alter at last the physical aspect and contour of the surface of the globe. It would not be proper, however, to say that these changes are caused by earthquakes, but rather that the earthquake vibration is a concomitant of the displacement by which they are produced.

Humboldt, Lyell, Dana, and other authorities, consider earth quakes to be the dynamic result of action of the earth's heated interior upon its cooled exterior. Whether the central portions of the earth be fluid or not, it is quite certain that heat increases as we descend; and it is estimated by Sir Charles Lyell that the heat at a depth of 25 miles would be sufficient to melt granite, and at 34 miles to render fluid or incandescent every known substance. We have no means of knowing the condition of matter under the enormous pressure which prevails at a depth of 34 miles, and are most concerned with the fact that the heat of fusion exists at no very great depth beneath the surface. The earth's crust is, therefore, its cooled exterior.

Fig. 3.



Circular Hollows in the Plain of Rosarno.

It is found that nearly all rocks contract by cooling and expand by heat. Lyell estimates that sandstone a mile in thickness, and heated to 200° Fahr., would expand so as to lift a mass of rock upon it 10 feet above its former level; and if a mass of the earth's crust equally expansible, 50 miles in thickness, be heated to 800°, it would rise 1,500 feet. From cooling we have the reverse effect—shrinkage, contraction, lateral pressure, and ultimately bending of the strata.

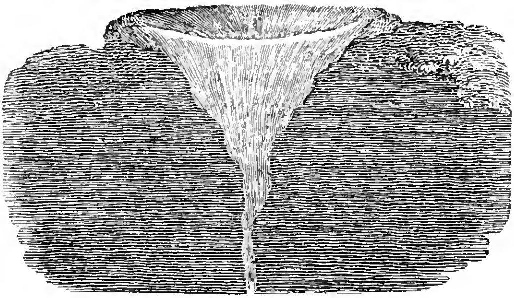
The strain thus produced will at last cause fracture, and the vibration that results is an earthquake. In Fig. 5 we have an illustration of fracture and displacement.

This form of tension is being continually and everywhere produced in the earth's crust, and there is probably no instant of time when that crust is entirely free from vibrations.

"There is nothing," observes Darwin, "not even the wind that blows, so unstable as the level of the crust of the globe."

Prof. Tyndall observes that, "where the acting force is small and the time great, the result is a slow and almost inappreciable change." Thus, great areas of land may be elevated or depressed. "But where the intensity is great and the time small, sudden convulsion must ensue." Thus, in an instant, mountains may undergo a change of elevation, or be shaken to fragments, or tracks of land sunken and overflowed. In the delta of the Indus are extensive areas of level ground, over which native villages were scattered, with fortifications and other defences. Of these, the fort at Sindree is shown in Fig. 7 as it was

Fig. 4.



Section of one of the Circular Hollows.

before the disastrous earthquake of 1819. 2,000 square miles of the delta sank from six to 12 feet, and was thus overflowed by the sea. The village of Sindree and its fortifications were upon the sunken area.

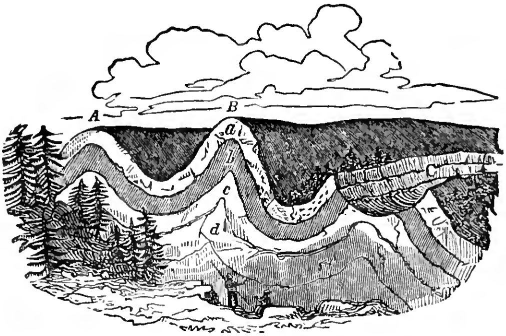
Northward, about 5½ miles from Sindree, a range of very low hills was elevated during the earthquake. It was seen over the expanse of waters, and extended about 50 miles, with a breadth in places of 16 miles, and was called by the natives, "Ulla Bund, or the Mound of God."

In 1822, just half a century ago, an earthquake occurred in Chili, of terrific violence, even for that region of convulsions. It was estimated that 100,000 square miles of land were elevated from two to seven feet, the rise being greatest inland, and probably included a portion of the Chilian Andes. The location of the force must have been at great depth, perhaps not less than 20 miles below the base of the Andes; and it is probable that the entire superincumbent mass underwent a change of level of from two to seven feet of perpendicular elevation.

The earthquake at Lisbon, in 1755, has impressed the public mind more than any other in modern times. The shocks, one of which exceeded all the others in violence, continued six minutes. The mountains near were shaken to their foundations, and everywhere split and rent. No part of the city was seriously injured which was built on the limestone or basaltic formations; but the shocks were most violent and disastrous in the tertiary and blue clay on which the ruined portion of the city stood.

The sea-wave put in motion by this earthquake exceeded in volume all others of which we have a record, except the one already noticed, which traversed the Pacific Ocean in 1868. It was observed, during this convulsion, that the sea retired from the shore before the great wave rolled in.

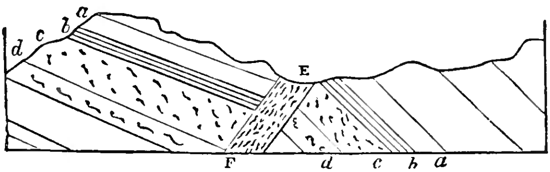
Fig. 5.



Curved Strata, as seen in the Swiss Jura.

It was Darwin who first suggested that waves first draw the waters from the shore on which they are advancing to break. He calls attention to the familiar fact that waves thrown up by the paddles of a steamer, as they approach the shore, are alway preceded by a receding of the water. An under-draught seems to first suck the water back, and such actually is the fact. Now, in the sea-wave raised by the earthquake, what takes place? We have remarked that an

Fig. 6.

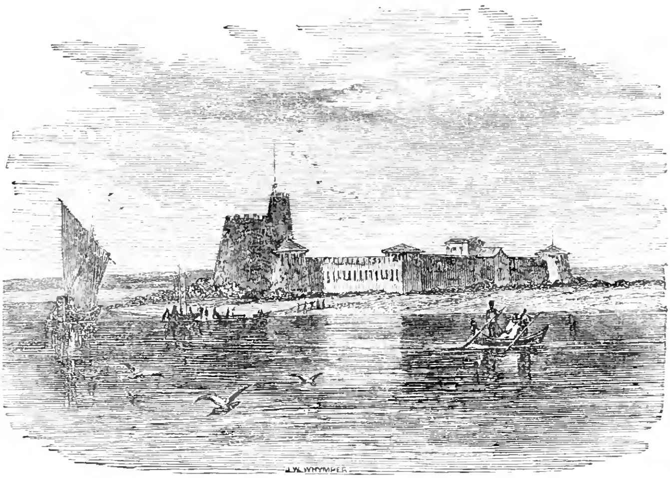


Strata broken and displaced.

earthquake is a vibration of the earth's elastic crust, and moves with tremendous velocity. When it occurs beneath the sea, or when the undulations reach the surface beneath the sea, the motion is communicated to the water, which it elevates in a wave. Simultaneously with this lifting of the water, an under-draught toward that point takes place. Were it not so, the elevation of the wave could not be sustained. Directly the great wave moves from the area of disturbance at the rate before stated, of 400 miles an hour, or about $6\frac{1}{2}$ miles in a minute, in the deep ocean. It is described by Mallet as "a low, broad swell of the sea. It might pass beneath the vessel unobserved." Approaching the shore, the front becomes elevated. The under-draught has continually preceded it, and has withdrawn the water from the shore, so that vessels at anchor are frequently grounded, and the wave seems to stand upon the bottom like a gigantic wall. At Arica it was unbroken by a ripple, and "shone in the sun like burnished silver."

A notion prevails that earthquakes are always preceded by unusual conditions of the atmosphere, but careful observations have shown that they occur during all kinds of weather. The Lisbon earthquake,

Fig. 7.



Fort of Sindree, on the Eastern Branch of the Indus, before it was submerged by the Earthquake of 1819.

which took place in the morning of the 1st of November, was preceded by a "period of clear autumnal weather," but the morning was calm, foggy, and warm. At Arica, as we have learned, the sky was serene and the atmosphere tranquil. Some of the greatest convulsions have been preceded by a close, hazy sky. Sir Charles Lyell observes that "irregularities in the seasons frequently precede and follow shocks. Sudden gusts of wind interrupted by dead calms, violent rains at unusual seasons, or in countries where they seldom occur, are phenomena often attending earthquakes."

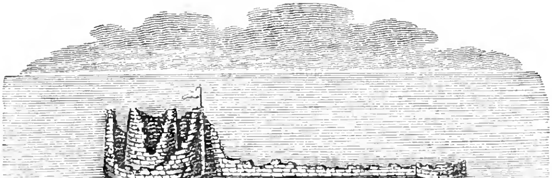
The number of important earthquakes up to the year 1861, of which we have a reliable account, is, according to Prof. Ansted, 7,000. So meagre are early records that only 787 of these are spoken of previous to the year 1500. There is a catalogue of 3,340 which occurred from

1800 to 1850, or one in about five days. The means of detecting and recording shocks are now so perfected, that, when applied in all parts of the globe, they will, doubtless, fully justify our statement that in no instant of time is the earth's crust free from vibrations. The seismograph is an instrument for the "automatic registration of earthquake-shocks."

An interesting account of this instrument, by George Forbes, was published in the September number of THE POPULAR SCIENCE MONTHLY.

Earthquakes have been defined to be a "travelling zone of vibration." The movement is in every direction from the area of disturbance, and the velocity depends on the substance and structure of the material through which it is transmitted. In New Zealand, in 1848, people on the shore witnessed the disastrous progress of the earthquake along the mountains before they felt the shocks. At Messina, during the Calabrian earthquake, the terrified inhabitants saw villas overthrown upon the coast by shocks which they had not felt, but which in a moment laid in ruins a portion of their own city. The velocity with

FIG. 8.



VIEW OF THE FORT OF SINDREE FROM THE WEST, IN MARCH, 1838.

which the vibrations travel has been a subject of careful investigation. The Lisbon earthquake moved about 20 miles in a minute; that which occurred in 1819, in the delta of the Indus, appears to have moved at the rate of 53 miles in a minute, or nearly 5,000 feet in a second. Other observations show that the movement may be from 1,000 to 5,000 feet per second. It has been ascertained that in blasting rocks the vibrations move in a second from 1,000 to 1,700 feet. The sound-waves move more rapidly, and, for this reason, shocks are usually preceded by subterranean rumbling. The velocity of sound through uniform strata is ascertained to be from 8,000 to 10,000 feet in a second. Tyndall found that sound-waves moved through burnt clay nearly ten times more rapidly than through air at a temperature of 32° Fahr. From this the phenomena of earthquake movement might occur in the following order: Supposing the centre of the disturbance to be beneath the ocean, as at Lisbon, an observer on the shore might expect to experience—

1. The underground rumble, moving at the rate of 8,000 to 10,000 feet per second.

2. The shock, moving from 1,000 to 5,000 feet per second.

3. The sea-wave, moving about 528 feet per second.

4. Sound, through the air moving at the rate of 1,090 feet per second. It should be noted, however, that the velocity of the sea-wave depends on *depth* of water.

The vibrations of an earthquake, it is evident, differ in no respect from those produced by other causes, excepting in intensity. The jar arising from a discharge of artillery, by a carriage rolling over pavements, or slamming of heavy doors, puts in motion a series of moving waves just as truly as does the rending of rocks, or an explosion of steam or gas in a fracture thus produced. But, a question arises, What moves when the earthquake is progressing. The phenomena may be explained thus: Around the source of disturbance the rock is pressed outward in every direction as air is pressed outward around a vibrating bell, forming what is called a zone or shell of compressed rock. The extent of this compression is the width of the earthquake-wave, and depends on the force exerted and the elasticity of the rock. In each zone or shell there is always a point of maximum density—and that is where the energy of compression and the rock's elastic force are equal.

As the wave passes, another zone is formed, and the particles behind return by their elasticity to their former position. From this it is obvious that, as the wave is passing, the individual particles of the rock have first a forward and then a backward motion—a swing or excursion to and fro. The extent of this motion is the amplitude of vibration, and may be very small compared with the breadth of the wave.

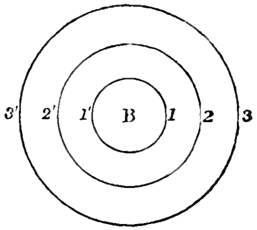
Mallet found by computation that, given a certain depth of fissure, and a certain heat of steam, the expansive force would produce a wave of nine inches amplitude at the surface. His observations of the Neapolitan earthquake of 1857 show that the maximum amplitude at the surface was only 2.5 inches. In his elaborate and beautiful volume on the eruption of Vesuvius, in 1872, just published, Mr. Mallet reaffirms a statement previously made by him, that "it is the vibration of the wave itself, i. e., the motion of the wave-particles, that does the mischief, *not* the transit of the wave from place to place on the surface."

We understand, then, that there is motion of particles as well as a transit-wave; that the "travelling zone or shell of vibration" is a zone or shell of "elastic compression."

Fig. 9 illustrates the "shells" as they move away from B, the focus of disturbance. The transit-wave, with its interstitial vibrations, reaches the surface in the manner shown in the diagram Fig. 10.

The diagram shows the waves radiating from the earthquake focus A to *c d e f* and *g* successively, and reaching the surface at B, where the shocks would be vertical. At 1 2 3 they become more and more oblique, and at greater distances appear almost horizontal.

FIG. 9.



CONTINUOUS WAVES FROM A SINGLE SHOCK.

Now, while the movement of the transit-wave may be very rapid, that of the particles of matter is surprisingly small. At Lisbon the velocity of the wave was 20 miles a minute, or 1,200 miles an hour. According to Mallet, where the velocity of the transit wave was 1,000

FIG. 10.

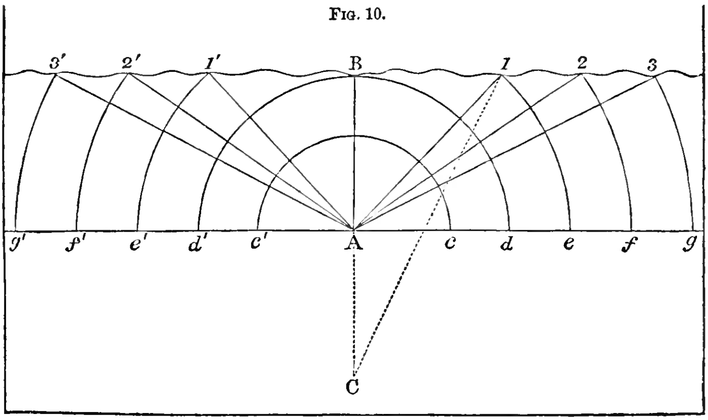


DIAGRAM SHOWING THE MOVEMENT OF WAVES FROM THE CENTRE OR FOCUS.
B, point where the shocks would be vertical. 1 2 3 and 1' 2' 3' are points where the waves would reach the surface.

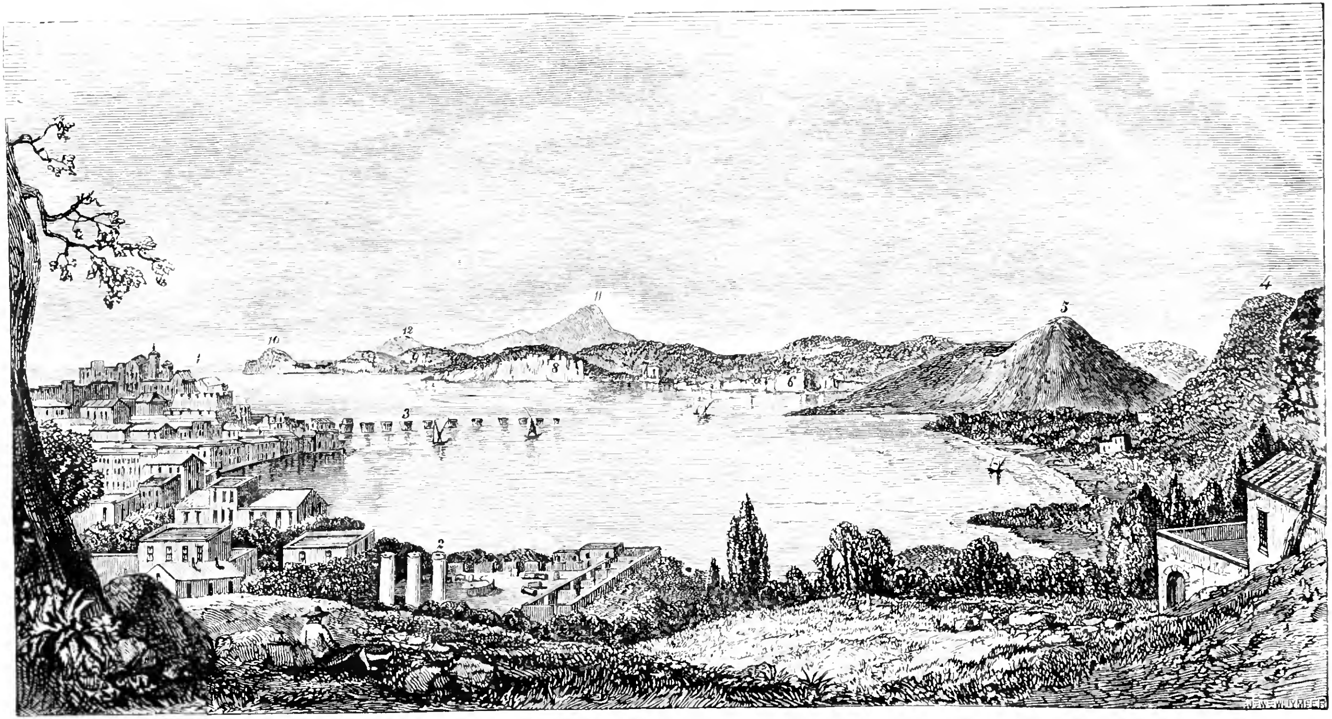
feet per second, the movement of the particles was only 12 feet per second, or eight miles an hour, and he states that three columns of the Temple of Serapis, on the shore of the Bay of Baiæ (*see* frontispiece), a region subject to earthquake-shocks, would be overthrown by a shock "whose wave-particles had an horizontal velocity of 3½ feet per second." The shock which threw human beings 100 feet in the air, at Riobamba, must have had a velocity of 80 feet per second. The theory of Mr.

Hopkins, published in 1847, was that the disastrous results of earthquakes were caused by the velocity of the wave of translation, and that theory is probably accepted by many who will distrust the conclusions of Mr. Mallet. But it is obvious to every observer that the enormous velocity of 1,200 miles an hour is not communicated to objects on the surface as the wave passes. They are rarely thrown to any considerable distance. Buildings are overthrown, but they fall where they stood.

We have already remarked that objects standing directly on the uniform strata are seldom injured by earthquake-shocks. Such was the case, as we have seen, with that portion of Lisbon which was built on the limestone and basalt. But where the surface, perhaps hundreds of feet deep, is of loose unelastic material, the transit-wave, *with its vibrations*, in passing through it, becomes broken into oscillations, its force is dissipated and motion reduced, but the vibratory swing which it communicates is sufficient to fissure the earth's surface and strew it with ruins.

On the coast of Dublin Bay, Mallet exploded gunpowder buried several feet beneath the surface, in the sand, and ascertained the intensity and velocity of the shock by a delicate seisometer. Other experiments gave the rate and intensity of movement in more compact formations with the following results: In sand, 824.9 feet in a second; in divided granite, 1,306.4 feet; in compact granite, 1,664.6 feet. It is found by observation that objects, as walls and chimneys, fall backward or forward, but generally in a line with the direction in which the wave travels, while fractures of walls occur in a line transverse to the direction of the wave. And by diagram, Fig. 10, it will be obvious that, given the position of the ruins over an extended area, not only the centre but depth of disturbance may be ascertained. If the focus be C, as shown in the diagram, the wave would reach the surface at an angle other than if the focus be at A, and the result would appear in the manner of displacement on the surface. By the principle here indicated, Mallet was able to locate the central area and depth of the Neapolitan earthquake of 1857, and states that the great fissure, the forming of which caused the first shock, was 7½ miles in length, and 5¾ miles in average depth.

The filling of the fissure with water, and its conversion into superheated steam, may have produced the subsequent shocks. By calculation, the same author shows the enormous pressure and rending power of steam if admitted without limit into such a fissure. "If the temperature increase 1° Fahr. for 60 feet depth, then, at the focal centre of the fissure, the temperature would be 883.4° Fahr., and the pressure on the walls of the cavity not less than 640,528,000,000 tons. But the pressure would be vastly increased if the temperature be near that of melted rock." That this may be the case is rendered probable from recent investigations of Mallet, by which he shows that the heat



BAY OF BALÆ, NEAR NAPLES. A SCENE OF REMARKABLE TERRESTRIAL CONVULSIONS.

1. *Puzzuoli*, where the relative level of land and sea has changed, twice since the Christian era, from 20 to 30 feet. 2. *Temple of Serapis*, built long before Christ; three columns still standing. 3. *Caligula's Bridge*, 1,800 years old; several piers and arches still standing. 5. *Monte Nuovo*, thrown up by an earthquake (see page 515).

which melts the great lava-beds, and fills cavities in the earth's crust with steam and gases, may not arise directly from the earth's central heat, but from the crushing of strata as it contracts and settles upon the cooling interior.

By a series of experiments and observations made by Mr. Mallet, it is shown that the "annual loss of heat into space of our globe at present is equal to that which would liquefy, at 32° Fahr., about 777 cubic miles of ice; and this is the measuring unit for the amount of contraction of our globe now going on."

The amount of shrinking depends, therefore, on the amount of heat lost—a view long since insisted on by Prof. Dana; and this, according to Mallet, is sufficient to account for all the phenomena. To this cause, then, we refer the never-ending oscillations of the earth's cooled exterior, and the enormous lateral strain by which it is bent and fractured, and its broken ridges made to grind and crush with terrific vibrations.

In many areas the earthquake energies of former times have been long at rest, but, according to Sir Charles Lyell, the total energy may not have diminished.

He finds evidence of convulsions as great and obvious in recent as in earlier time. Mallet, however, remarks that "seismic energy may be considered as possibly constant during historic time, but is probably a decaying energy viewed in reference to much longer periods."

Everywhere we see, in exposed portions, crevices open or filled—ejections of trap and basalt; and wall-like dikes stand out upon the slopes of mountains. These are legible and significant chapters in the earth's dynamic history.

Do earthquakes occur with any order or system, so that their coming may be foretold?

Prof. Palmieri, in his observatory on Mount Vesuvius, is able, says George Forbes, "to predict eruptions." "This is a small eruption," remarked the professor, "but there is going to be a greater one; it may be a year hence, but it will come." "In almost exactly a year," continues Mr. Forbes, "the great eruption did come."

From Mallet's catalogue of European earthquakes it appears that, during 15½ centuries, 1,157 took place during the winter, against 875 in the summer months.

Although science has cleared up some of the mystery which hung over earthquakes in less enlightened times, it has not divested them of their sublimity and terrible reality.

Their work of destruction is done in a moment. The great battles of the world have scarcely been so destructive of human life.

We read that 250,000 persons perished during the earthquake at Antioch in 526. At Lisbon 60,000 people were destroyed. During one of the Calabrian earthquakes 35,000; and during the one at Arequipa in 1868, 40,000 persons perished. Pestilence, famine, and fire, add to the fatality. Visitations so severe and disastrous permanently affect the inhabitants of earthquake regions. Their minds lose their calm equipoise—they become nervous, and the first considerable shock sends them to the street or cathedral for safety.

Humboldt remarks that, when "we feel the ground move beneath us, our deceptive faith in the repose of Nature vanishes, and we feel ourselves transferred into a realm of unknown and destructive forces. Every sound, the faintest motion of the air, arrests attention. To man, the earthquake conveys the idea of unlimited danger." And Von Tschudi adds his testimony, that "no familiarity with earthquakes can blunt this feeling of insecurity. The traveller from the north of Europe waits with impatience to feel the movement of the earth, and with his own ear to listen to the subterranean sounds, but, soon as his wish is gratified, he is terror-stricken, and is prompted to seek safety in flight." Thus it is that physical phenomena aid in moulding the mental and moral character of a people. The earthquake records itself, not only on the inorganic world, but in man's spiritual nature.

ELECTRICITY AND LIFE.

By FERNAND PAPILLON.

TRANSLATED BY A. R. MACDONOUGH, ESQ.

GALVANI discovered, in 1794, that the muscles of animals experience contractions in contact with certain metals. In his view, this contact merely calls out the discharge of a fluid inherent in the animals themselves. The fact was not to be contested, but its explanation was. Lively discussions in the schools of physiology followed—fortunately, with a clear understanding that the difficulty could only be determined by experiments. A vast number were made, the name of Volta being connected with the most remarkable of them. Alexander Volta maintained, in opposition to Galvani, that the electricity which produces contractions in the muscles, far from originating in those organs, is introduced by the metals used in the process. In proof of this he constructed, in 1800, the pile that bears his name, and which is an arrangement in which the connection of two different metals becomes an abundant source of the electric fluid. Galvani and Volta were two men of distinguished genius, who thoroughly understood physics and physiology, and advanced nothing heedlessly. Their discoveries were the point of departure for one of the most admirable movements in all the history of science, a movement which is still most active, and is the more remarkable because it resulted but yesterday, as it were, in the complete demonstration that Galvani and Volta were both in the right. Science to-day proves that there is an electricity peculiar to animals, as Galvani declared. It decides also that electricity produced by external causes has an influence over animals, as Volta taught. From profound study of the two orders of phenomena, it deduces a system of procedure for the cure of very many maladies by electricity. Consequently, an exposition of the relations between electricity and life must begin with examining the electricity that exists naturally, in the same way that heat does in animals, and then go on to explain the action of the fluid on the organism, whether in a healthy or a morbid state. Such a description will complete what has been written in the *Review* respecting the relations of life with light and heat—relations that we may to-day consider as forming the features of a new science.

I.

The most authentic witnesses to the existence of animal electricity are fish. The torpedo, the silurus, the gymnotus, the ray, and other fishes, develop spontaneously a more or less considerable quantity of electricity. This fluid, the production of which depends upon the animal's will, is identical with that of common electrical machines; it gives the like shocks and sparks at a certain tension. The apparatus for its formation consists of a series of small disks of a peculiar substance, kept apart by cells of laminated tissue. Fine nerve-end fibres are scattered over the surface of these disks, and the whole represents a sort of membranous pile, usually placed in the region of the head, sometimes toward the tail.

These fishes are the only animals provided with an apparatus specially devoted to the production of electricity; but all animals are electric, in this sense, that a certain quantity of that fluid is constantly forming within their organs. The existence of electricity peculiar to the nerves and muscles, and independent of their special modes of action, has been settled by numerous experiments, particularly by those of Nobili, Matteucci, and Dubois-Reymond. To prove the currents of nervous electricity, it is sufficient to prepare a frog's muscle, and touch it at two different points with the two ends of a nerve-filament of the same animal. The muscle then undergoes contraction under the influence of the nervous current. Another experiment, as simple, proves the existence of the muscular current. In an animal living or just killed, a muscle is exposed and cuts made in it perpendicularly to the course of the fleshy fibres, and communication effected by the two wires of a very sensitive galvanoscope between the natural surface of the muscle and the surface made by incision. The needle of the instrument then betrays the passage of a current. This muscular electricity may be obtained in tolerable quantity by placing a number of slices of muscle together in the form of a pile. The positive pole of the system will be the natural surface of one of the terminal slices, and the negative pole the cut surface of the other. Such a battery acts upon galvanic instruments, and can even excite contractions in other muscles.

Independent of these nervous and muscular electric currents, other sources of this fluid exist in the animal economy. Currents are produced between the outer and inner surfaces of the skin, in the blood, in the secreting vessels—in fine, almost throughout the whole organism. The experiments, as delicate as original, to which Becquerel has for several years devoted all the activity of his green old age, authorizes him now to assert the preponderance of electro-capillary phenomena in animal life. According to this accomplished physicist, two solutions of different nature, both conductors of electricity, separated by a membrane or a capillary space, compose an electro-chemic circuit; and, if we reflect on the anatomical elements of the various tissues, cells, tubes, globules, etc., in their connections with the fluids that moisten them, we find that they give rise to an infinite number of pairs constantly evolving electricity. The blood of the arteries with that of the veins forms a pair, having an electro-motive power of 0.57, that of a pair with nitric acid being 100. Becquerel explains, by the intervention of these currents, many physiological phenomena hitherto imperfectly understood. Granting the reality of such actions, yet it must be acknowledged that the general doctrine which combines them each with the other, and links the whole together with the various modes of action of the organism, is far from being clear and precise. We need to know how these currents are distributed and circulate, what lines and courses they follow. It is now time for experimental physiology to attack these difficult problems, the solution of which is absolutely necessary for accurate knowledge of vital determinations, that is, for the computation and the estimate of those various factors which are terms in all the equations of organic movement.

Vegetables, too, develop electricity. Pouillet has clearly demonstrated that vegetation throws it off. Other physicists, particularly Becquerel, have proved the existence of currents in the fruits, stems, roots, and leaves of plants. Becquerel took a branch of young poplar full of sap, introduced a platinum wire into the wood and another into the bark, and brought the two ends of the conductors together in a galvanoscope—the needle at once showed the passage of a current. Buff has lately made experiments, taking care not to injure the organs. Two vessels containing mercury receive platinum wires; over the mercury stood water containing the vegetables to be examined as to their electric condition. Taking the leaves and roots, Buff proved a current passing through the plant from the roots to the leaves; in a branch severed from the stem the current passed toward the leaves, too. To sum up, the existence of vital electricity is incontestable, though we do not yet precisely understand the conditions of this internal excitement, and know nothing of its true relations with the unity of physico-chemical operations in the living organism.

The latter are, at all events, exceedingly complex. There is in us, and in every organized being, an infinite world of the most various actions going on. The forces penetrating us are as manifold as the materials we are moulded from. In every point of our bodies, and at every moment of our existence, all the energies of Nature meet and unite. Yet, such order rules in the course of these wonderful workings, that harmonious blended action, instead of bewildering confusion, characterizes beings endowed with life. Every thing in them commands and answers, with balance and counterpoise. Buffon long ago felt and expressed this. "The animal," he said, "combines all the forces of Nature: his individuality is a centre to which every thing is referred, a point reflecting the whole universe, a world in little." A deep saying, coming from the great naturalist as the flash of an intuition of genius, rather than the result of rigid investigation—words which the movement of science confirms with ever stronger proofs, while borrowing from them light for its path.

Having determined that living bodies are in themselves sources of the electric fluid, we next inquire into the nature of the effects produced in the animal organism by electricity under different forms. The atmosphere contains a variable quantity of positive electricity; the earth itself is always charged with negative electricity. It is not yet precisely known how this diffused and silent force originates. Physicists suppose that it proceeds from vegetation and the evaporation of water. Becquerel has quite lately set forth a number of reasons, more or less plausible, for the belief that the chief part of atmospheric electricity is derived from the sun, and diffused by it into space together with light. Whether this be true or not, while the sky is clear this fluid has no visible effect on human beings; but, whenever it accumulates in the clouds, and gives rise to storms, it produces effects that are the most manifest proofs of the influence exerted over life by electricity. Persons killed by lightning present a great variety of appearances. Sometimes one struck by lightning is killed outright on the spot, the body remaining standing or sitting; sometimes, on the contrary, it is thrown to a great distance. Sometimes the flash tears off and destroys the victim's dress, leaving the body untouched, and sometimes the reverse is the case. In some instances the destruction is frightful, the heart is torn apart and the bones crushed; in others the organs are observed entirely uninjured. In certain cases flaccidity of the limbs occurs, softening of the bones, collapse of the lungs; in others, contractions and rigidity are remarked. Sometimes the body of the person struck decomposes rapidly, but at times it resists decay. Lightning, which shatters trees and overturns walls, seems not to produce mutilations in animals at all readily. When the stroke does not produce death, it creates at least serious disturbances—sometimes temporary, but oftener beyond remedy. Besides the burns and various eruptions noticed on the skin of those struck with lightning, they often suffer, very curiously, a complete loss of hair; they are affected with paralysis, dumbness, deafness, amaurosis, or imbecility. In brief, the destructive attacks of atmospheric electricity touch all the functions of the nervous system.

The action of electric fishes may be likened to that of lightning, in being independent of our intention. The shocks of the gymnotus are particularly formidable. Alexander Humboldt relates that, having put both his feet on one of these fish, just taken from the water, he experienced so violent a shock that he felt pains in all his joints the rest of the day. These shocks throw the strongest animals down, and it is necessary to avoid rivers frequented by the gymnotus, because, in attempting to ford them, horses or mules might be killed by the discharges. To capture these fish the Indians drive wild horses into the water, stirring the eels up out of the mud by their trampling. The yellowish livid creatures press against the horses under their bellies, throw down the greater part and kill some of them, but, exhausted in their turn, they are then easily taken with the aid of small harpoons. The savages employ them to cure paralysis. Faraday compares the shock of a gymnotus, which he had an opportunity to study, to that of a strong battery of fifteen jars. A live eel out of water, when touched by the hand, communicates a shock strong in proportion to the extent of surface in contact, and the stroke is felt up to the shoulder, and followed by a very unpleasant numbness. It may be transmitted through twenty persons in a chain, the first one touching the back, and the last the belly of the eel. The fishermen discover the presence of an eel in their nets by experiencing a shock in throwing pailfuls of water on, to wash them. Water is a good conductor, and this fish kills or benumbs the animals it feeds on by delivering a discharge through the water.

Other sources of electricity are known to exist, besides thunderstorms and fishes. Friction-machines, batteries, and induction instruments, yield three kinds of currents that act on vital functions, sometimes in a similar way, but oftener with marked differences, which have only recently been clearly distinguished. The action of static electricity, and that of electricity of induction, more sudden and violent, is particularly marked by mechanical effects so striking that they have long distracted experimenters from examining with due attention those effects of another sort, produced by the galvanic current. Yet, the latter in reality affects the animal tissues in a deeper way, and its resulting phenomena deserve the liveliest interest from a theoretical point of view, as well as from their applied uses.

Dutrochet proved, by remarkable experiments, that, when a tube closed below by a membrane, and containing gum-water, is placed in a vessel containing pure water, the level of the gum-water rises little by little through the gradual introduction of pure water into the tube, while a certain quantity of the gum-water inside mingles with the pure water outside. In a word, a mutual exchange takes place between these two fluids, communicating by the membrane, and the current, passing from the thinner liquid toward the denser one, is ascertained to be more rapid than that moving in the opposite direction.

This experiment reveals one of the most important phenomena of life in plants and animals, noted by the word endosmosis. Now, Dutrochet had before observed that if the positive pole of a battery be inserted in the pure water, and the negative pole in the gum-water, the acts of endosmosis are effected more energetically. Onimus and Legros discovered further, that, if the contrary arrangement be adopted, that is, if the positive pole be placed in the gum-water, and the negative pole in the pure, the level of the liquid in the tube descends noticeably, instead of rising. Electricity, therefore, can reverse the usual laws of endosmosis. It exerts an influence not less distinct on all the other physico-chemical movements, taking place deep in the organs. In them it decomposes the salts, coagulates the albuminoid elements of the blood and the tissues, just as it does in the vessels of the laboratory. Take a very curious instance: In chemistry, on decomposing the iodide of potassium, iodine is freed, and betrays itself by the tinge of intense blue which it develops on contact with starch. Now, if an animal be injected with a solution of iodide of potassium, and then electrified, it is noticed, after a few minutes, that all the parts near the positive pole of the battery turn blue in presence of the starch, proving that they are impregnated with iodine. The iodide has been almost instantly decomposed, and the iodine carried by the current toward the positive pole.

It is not surprising, then, that the action of electricity influences the whole system of the nutritive operations. Onimus and Legros found that ascending continuous currents quicken the twofold movement of assimilation and diassimilation. Animals electrified under certain conditions throw off a greater proportion of urea and carbonic acid, proving a higher energy of the vital fire. On the other hand, if young individuals, in growing development, are subjected to the action of the current, they grow tall and large more quickly than in ordinary circumstances, furnishing the proof of an increase in the quantity of substances assimilated. To show how far vital phenomena are stimulated by electricity, we will cite another experiment made by Robin and Legros on noctilucæ. These are microscopic animals, which, when existing in great numbers in sea-water, render it almost as white as milk, and at certain times phosphorescent. Now, a current, directed into a vessel filled with such water, suffices to bring out a trace of light marking all its course. Electricity stimulates the phosphorescence of all the noctilucæ met on its passage between the two poles.

Interrupted currents, or currents of induction, contract the blood-vessels and slacken the circulation in almost every case: if they are intense, they even effect its complete check by a strong contraction of the little arterial branches. Continuous currents do not act in this way; usually they quicken the circulation, while occasioning an enlargement of the vessels, at least, this has been established by Robin and Hiffelsheim, in the microscopic examination of the flow of blood under electric stimulus. Onimus and Legros afterward proved that these movements are governed by the following law: The descending current dilates the vessels, and the ascending current contracts them. A striking experiment proves the value of this law: A part of the skull of a vigorous dog is removed, so as to expose the brain. The positive pole of a pretty strong battery is then placed on the exposed brain, and the negative pole on the neck. The slender and superficial vessels of the brain contract visibly, and the organ itself seems to collapse. Arranging the poles in the contrary order, the reverse is remarked; the capillary vessels swell and distend, while the substance of the brain protrudes through the opening made in the walls of the skull. This experiment proves the possibility of increasing or lessening at will the intensity of circulation in the brain, as indeed in any other organ, by means of electric currents. Onimus lately made an equally interesting experiment. Many persons know that the famous physiologist Helmholz introduced into medicine the use of a simple and convenient instrument called the ophthalmoscope, by means of which the bottom of the eye may be quite distinctly seen, that is to say, the net formed by the nerve-fibres, and the delicate vessels of the retina. Now, on examining this net, while the head is put under electric influence, the little blood-tubes are plainly seen to dilate and grow of a more lively crimson.

Let us now study the effect of the electric current on the functions of the motor system, and on sensibility. Aldini, a nephew of Galvani, undertook the first investigations of this kind upon human beings. Convinced that the proper study of the effects of electricity on the organs required the human body to be taken at the immediate instant after the extinction of life, he believed he would do well, as he relates himself, to take his place beside the scaffold, and under the axe of the law, to receive from the executioner's hand the blood-stained bodies which were the only really suitable subjects for his experiments. In January and February, 1802, he availed himself of the occasion of the beheading at Boulogne of two criminals, whom the government willingly gave up to his scientific inquiry. Subjected to electric action, these bodies presented so strange a sight as to terrify some of the assistants. The muscles of the face contracted in frightful grimaces. All the limbs were seized with violent convulsions. The bodies seemed to feel the first stir of resurrection, and an impulse to spring up. For several hours after decapitation, the vital centres of movement retained the power of answering to the electric excitement. At Glasgow, Ure made some equally noted experiments on the body of a criminal, which had remained on the gallows nearly an hour. One of the poles of a battery of 270 pairs having been connected with the spinal marrow, below the nape of the neck, and the other pole touching the heel, the leg, until then bent back, was forcibly thrown forward, almost oversetting one of the assistants, who had a strong hold on it. Placing one of the poles on the seventh rib, and the other on one of the nerves of the neck, the chest rose and fell, and the abdomen underwent the like motion, as in the act of breathing. On touching a nerve of the eyelid at the same time with the heel, the muscles of the face contracted, "rage, horror, despair, anguish, and fearful grins, combined in hideous expressions on the dead man's face." At the terrible sight one person fainted, and several were obliged to leave the room. Afterward, by exciting convulsive movements of the arms and fingers, the corpse was made to seem to point at one or another of the spectators.

Later researches have precisely fixed the conditions of this influence of electricity upon the muscles. Continuous currents, led directly to these organs, produce contractions at the moments of opening and of closing the circuits; but the shock produced on closing is always the strongest. While the continuous current is passing, the muscle remains persistently in a half-contracted state, as to the nature of which physiologists disagree. Influenced by excitements rapidly repeated and prolonged for a short time, the muscles assume a state of contraction and shortening, like that seen in tetanus. In this state, as Helmholz and Marey have shown, the muscle suffers a repetition of very slight shocks. Contraction is the result of the fusion of these elementary vibrations, indistinguishable by the eye, but capable of recognition and measurement by certain contrivances. Currents of induction produce more powerful contractions, but not lasting ones, which are succeeded, if electrization is prolonged, by corpse-like rigidity. Muscular contraction effected in such a case is attended by a local rise in temperature, proportioned to the force and length of the electric action. This increase of heat reaches its maximum, which may in some cases be four degrees, during the four or five minutes following the cessation of the electric impulse, and is due to the muscular contraction, which always gives rise to disengagement of heat.

The effect upon the nerves is very complex, and betrayed by movements and sensations very variable in intensity. Onimus and Legros state in general its fundamental laws thus: In acting on the nerves of motion, we see that the direct or descending current works more energetically than the other, with the reverse result on the nerves of sensation. The excitability of those nerves of a mixed kind is lessened by the direct and increased by the inverse current. This is true as to battery-currents, but currents of induction behave differently. While the sensation called out by the first is almost insignificant, the others, besides the permanent muscular contraction, produce a pain lasting as long as the nerve retains its excitability. The spinal marrow is one of the most active parts of the system. In the form of a thick, whitish cord, lodged inside the vertebral column, it constitutes a real prolongation of the brain, of which, under some circumstances, it takes the place. The unconscious depositary of a part of the force animating the limbs, by means of the nerves sent out from it, it transmits to them their direction and power to move, while the brain is unaware of its action. This takes place in what are called reflex motions, and these occur in beheaded animals, through the simple excitement, direct or indirect, of the spinal marrow. Experiments may be cited, showing the action of electricity on those phenomena which have their seat in the spinal marrow. If a frog is plunged into lukewarm water, at a temperature of 40°, it loses respiration, feeling, and motion, and would die if kept in it a long time. When taken out of the water, and placed in this state under the action of the current, it contracts strongly when its vertebral column is electrified by an ascending charge; but no motion follows if the descending current is applied. On the other hand, if the latter is sent into a beheaded animal, stimulated to reflex motions, by the excitement of the spine, it tends, as experiment shows, to paralyze these motions. In general, this is the law discovered by Onimus and Legros—the ascending battery-current, directed on the spine, increases the excitability of that organ, and consequently its power of producing reflex phenomena; the descending current, on the contrary, acts in the reverse way.

When the brain of animals is directly electrified, the modifications in circulation already spoken of result, but no special phenomena are observed. The animal shows no pain, and makes no movement, experiencing a tendency toward sleep, a sort of calm and stupor. Some physicians have gone so far as to propose electrization of the brain as a means of developing and perfecting the mental powers. Nothing hitherto justifies the belief that such a course could have the slightest influence for good over the functions of thought. On the contrary, it is very certain that the electric agent must be applied only with extreme caution to the regions of the head, and that it very easily occasions mischief in them. A strong current might readily cause rupture of the vessels, and dangerous hæmorrhage in consequence.

Again, electricity stimulates all the organs of sense. Directed upon the retina, it excites it, producing sensations of glare and dazzling. When sent through the organ of hearing, it produces there a peculiar buzzing noise, and, if brought in contact with the tongue, it calls forth a very characteristic metallic and styptic sensation. And in the olfactory mucous membrane it creates a sneezing irritation, and also, it seems, an odor of ammonia.

The currents not only act on the cerebro-spinal nerves, and the muscles concerned in life, as related outwardly, but affect also the parts of the nervous and muscular systems devoted to the functions of nutritive life. Electricity by induction, applied to these muscles, causes contraction in them at the point of contact with the poles, while the part situated between the poles remains without motion. Continuous currents produce, at the instant of closing the circuit, a local contraction at the junction with the poles, and then the organ becomes quiet; if it is previously in action, motion ceases. In the case of the intestine, for instance, peristaltic movement is checked; and by means of electricity contractions of the uterus may be suspended in an animal, during parturition. In general, the fluid suppresses spasms of all the involuntary muscles.

All these facts relating to electric action upon the muscles and nerves have been the occasion, particularly in Germany, of laborious investigations, with which are connected the names of Dubois-Reymond, Pflüger, and Remak. The doctrines of these learned physiologists, regarding the molecular condition of the nerves in their various modes of electrization, are still very much disputed. It must be said that they are not supported by any experimental certainty, and perhaps the ideas developed by Matteucci supply better means for the general solution of these difficulties. This eminent experimenter opposed, to the German theories about the electrotonic faculties of the nerves, certain evident phenomena of electrolysis, that is, of chemical decompositions effected by the currents. He supposed that the modifications of excitement in the nerves, brought about by the passage of electricity, depended on the acids and the alkalies resulting from the separation of the salts contained in animal tissues. To this first class of phenomena may be added those electro-capillary currents lately observed by Becquerel. Here must be sought the deeper causes of that complicated and as yet obscure mechanism of the strife between electricity and life.

The effects of electricity on plants have been much less studied, experiments made on this subject being neither accurate nor numerous enough. We know that electricity causes contractions in the various species of mimosa, particularly in the sensitive-plant, that it checks the flow of sap in certain plants, etc. Becquerel has studied its action on the germination and development of vegetables. Electricity decomposes the salts contained in the seed, conveying the acid elements to the positive pole, and the alkaline ones to the negative. Now, the former injure vegetation, while the latter benefit it. Quite lately, the same experimenter has made a series of researches upon the influence of electricity on vegetable colors. Employing strong discharges obtained from friction-machines, he has noticed very remarkable alterations of color, usually due to the rupture of the cells containing the coloring-matter of the petals. This matter, freed from its cellular covering, disappears on simply washing with water, and the flower becomes almost white. In leaves showing two surfaces of different shades, as the *begonia discolor*, a kind of mutual exchange of colors between the two surfaces has been noticed.

II.

The physiological phenomena just spoken of are usually confounded in books with the facts of electric medical treatment, and it seems better to distinguish the two classes. The true method consists in first explaining the phenomena displayed in the healthy organism, as the only way of understanding afterward those that are peculiar to disorders. Electric treatment forms a group of methods to be classed among the most efficacious in medicine, provided they are applied by a practitioner well trained in the theory of his art. Indeed, the most thorough physiological knowledge is essential for the physician who would make the electric current serviceable. Mere experimenting, even the most sagacious, must here be barren of good results—a fact of which it is well to remind those who impute to the method itself the failures it meets with in unskilful hands. It is true that, since the days of Galvani and Volta, physicians have used galvanism in the treatment of many diseases. Early in the century, galvanic medicine was much talked of, and supposed to be the universal panacea. Galvanic societies, journals, and treatises, undertook to spread its usefulness. The fashion lasted a certain time, and would perhaps have grown indifferent, when the discovery of induced electricity, due to Faraday, in 1832, called professional attention once more to the virtues of the electric fluid, and led to a new and interesting range of experiments. Yet it is likely that the true systems of electric medical treatment, after the extraordinary illusions of their earlier days had vanished, would at length have sunk into disuse, had they not escaped from the ruts of empiricism. With its usual boldness, it had at first gained them a high rank, which it had no power to maintain. It was experimental physiology, with its exact analysis of the mechanical effects of this fluid upon the springs of the organism, which made its application in the healing art sure, true, and solid, as it now is. In this, as in all things, blind art has been the impulse to scientific research, which in turn steadily enlightens and perfects art.

It is singular that induction-currents have met with much better fortune than galvanic ones. The latter, the use of which introduced electric treatment, have gained real importance in physiology and medicine only within a few years, and after the reputation of induction-currents was well established, thanks chiefly to the efforts of Duchenne. A German physiologist and anatomist, Remak, who died six years ago, was the first to urge the singular remedial virtues of the voltaic current. Remak, after devoting twenty years to the study of the most difficult questions in embryology and histology, undertook, in 1854, the systematic examination and ascertainment of the action of continuous currents on the vital economy. He soon gained remarkable dexterity in dealing with the electric agent, and detecting with the readiest insight the proper points for applying the battery-poles in each malady. Those who, with us, witnessed in 1864 his practice at the hospital, will remember it clearly. The methods of Duchenne were almost the only ones accepted in practice in France, till Remak came to prove to Paris physicians the powers of electrization by constant currents, in cases where Faraday's currents had been without effect. The teaching of the Berlin practitioner bore its fruits. A rising young physician, Hiffelsheim, was beginning to spread throughout Paris the use of the constant current as a healing agent, when death removed him in 1866, in the flower of his age. Another physician, who benefited by the lessons of Remak, Onimus, resumed the interrupted labors of Hiffelsheim, and is now busy in completing the system of the methods of electric medical practice, by subjecting them to an exact knowledge of electro-physiological laws. A few instances, from the mass of facts published on the subject, will serve to show how far the efficiency of these methods has actually been carried.

Experiment proves that, under certain conditions, the electric current contracts the vessels, and thus checks the flow of blood into the organs. Now, a great number of disorders are marked by too rapid a flow of blood, by what are known as congestions. Some forms of delirium and brain-excitement, as also many hallucinations of the different senses, are thus marked, and these are entirely cured by the application of the electric current to the head. No organ possesses a vascular system so delicate and complex as the brain's, nor is there any so sensitive to the action of causes that modify the circulation. For this reason, disorders seated in the brain are peculiarly amenable to electric treatment, and, when carefully applied, it is remedial in brain-fevers, mental delirium, headaches, and sleeplessness. Physicians who first employed the current were quite aware of this benign influence of the galvanic fluid over brain-disorders, and even had the idea of utilizing it in the treatment of insanity. Experiments in that direction have not been continued, but the facts published by Hiffelsheim justify the belief that they would not be barren. These facts testify to the benefits that electric currents (we mean only continuous ones) may some day yield in brain-diseases—a point worth the attention of physicians for the insane. Till lately it was thought that electricity was a powerful stimulant only, but what is true of interrupted currents is not true as to currents from the battery. Far from being always a stimulant, the latter may become in certain cases, as Hiffelsheim maintained, a sedative and calming agent. This control over circulation, joined with the electrolytic power of the galvanic current, allows its employment in the treatment of various kinds of congestions. A congested state of the lymphatic ganglia, the parotid glands, etc., may be relieved by this means, the current acting in such cases both on the contractility of the vessels, and the composition of the humors.

In cases of paralysis, more than any others, electricity displays all its healing power. Paralysis occurs whenever the motor nerves are separated from the nervous centres by any injuring cause, or by any modification of texture impairing their sensitiveness. With a destroyed nerve, paralysis is incurable, but, in case of its disease only, its functions can almost always be restored by electric treatment. As there is always some degree of muscular atrophy in the case, electricity is directed upon the nerves and the muscles at once, and the battery and the induction current usually employed together. As a rule, the first modifies the general nutrition, and restores nervous excitability, while the last stimulates the contractile power of the muscular fibres. The difference of action between the two kinds of currents is clear in certain paralyses, in which the muscles show no contraction under induction-currents, while under the influence of constant currents they contract better than the uninjured muscles. Experiments made some years ago in Robin's laboratory, on the bodies of criminals executed, proved that, after death, muscular contraction can still be produced by Volta's currents, though Faraday's current has no such effect.

When the motor nerves are in a state of morbid excitement, they compel either muscular contractions that are lasting, as tonic spasms, or intermittent ones. The different motor nerves most commonly excited are the facial nerves, the nervous branches of the forearm or the fingers, which are affected in "writer's cramp," and the branches of the spinal nerve, whose irritation occasions tic-douloureux, chronic wryneck, etc. Now, electricity cures, or at least noticeably benefits these different morbid states, and exerts the like influence over neuralgic and neuritic affections, wherever these disorders are not the symptoms of other deeper maladies. Currents restore the normal activity of nutrition in the diseased nerves, and the corresponding muscles; they act on rheumatism, too, in the most beneficial way, modifying the local circulation, quieting the pain, and stimulating reflex phenomena, which are followed by muscular contractions. Erb, Remak, Hiffelsheim, and Onimus, have proved beyond question this salutary action on swellings of the joints, either in acute or chronic cases.

The discoveries respecting the influence of electricity over the spinal marrow have been used with advantage in the treatment of such disorders as arise from unduly-excited activity in this organ, such as chorea, St. Vitus's dance, hysteria, and other nervous convulsions, more or less similar. We cite two instances of this sort published by Dr. Onimus, giving an idea of the mode of applying the current in such cases. A child, twelve years old, was seized with a frightful attack. Every five or six minutes it lost consciousness, rolled on the ground, its eyes turned upward, then grew so rigid that none of its limbs could be bent. The attack over, it regained its senses, but the least impression, at all vivid, sufficed to bring on a new attack. Ascending currents were first applied to the spinal marrow. The child was at once seized with a violent crisis. Descending currents were then used for fifteen days in succession, after which the little patient regained health. A young girl aged seventeen, in an hysteric condition, presented very strange symptoms in the larynx, the velum of the palate, and the facial muscles, among others a sort of barking, followed by vehement sniffing and horrible grimaces. By placing the positive pole in the patient's mouth against the arch of the palate, and the negative pole on the nape of the neck, all these morbid affections were completely subdued. The disposition of the poles in the reverse order, on the other hand, aggravated them. After sixteen repetitions of electric treatment, the young girl was almost completely cured, retaining only a muscular twitch of little importance, compared with her former ailments. Several cases of tetanus also were treated with complete success by similar methods. This terrible disease, the most fearful of all surgical complications, is due to an acute inflammation of the spinal marrow. It is followed by such an alteration of the motor nerves, that all the muscles of the body experience general contraction, and a painful rigidity that by degrees attacks the vitally essential organs. When an attack of this kind reaches the muscles of the chest and heart, death occurs, through asphyxia. In such a case the continuous current restores the motor nerves to their normal state. Two other chronic diseases of the spine, the first being particularly serious—progressive muscular atrophy and locomotive ataxy—often yield to the rational use of electricity, or at least are checked in their progress, the natural issue of which is death. It is worth remarking that these two disorders were discovered and described by Duchenne, in the course of his researches into this method of treatment. Electricity served his purposes of diagnosis, as it serves in physiology as a means of study, taking in that science the place of a kind of reactive agent, and revealing functional differences that no other process could have detected. To it alone, according to the way in which it affects a nerve or a muscle, belongs the power, under certain circumstances, of determining the nature and even the degree of alteration in nervous or muscular elements.

Aldini said that galvanism afforded a powerful means of restoring vitality when suspended by any cause. Several physicians, at the beginning of this century, restored life by this means to dogs, after they had undergone all the processes of drowning, and seemed dead. Hallé and Sue proposed at that period to place galvanic machines in the different quarters of Paris, particularly near the Seine. This wise and useful plan has not yet been put into execution, though all experiments made since that time confirm the proof of the efficiency of electricity in cases of asphyxia and syncope, produced either by water or by poisonous gases. The galvanic current also restores respiration in cases of poisoning by ether or chloroform, even when recovery seems hopeless. Surgeons who understand this effect, remember it whenever chloroform seems dangerous to the patient under its influence.

Electricity is transformed into heat with great ease. If an intense current is passed through a very short metallic wire, it heats, reddens, and sometimes vaporizes it. This property has been taken advantage of by surgeons for the removal of various morbid excrescences. They introduce a metallic blade at the base of the tumors or polypi to be extirpated, and when this kind of electric knife becomes incandescent, under the influence of the galvanic current, they give it such a movement that the diseased part is separated by cauterization, as neatly as with a cutting instrument. This method, which avoids effusion of blood, and is attended by only slight pain, has yielded excellent results in the hands of Marshall, Middeldorpf, Sédillot, and Amussat. Besides this application, in which heat plays the chief part, electricity has been used to destroy tumors, by a kind of chemical disorganization of their tissue. Crusell, Ciniselli, and Nélaton, have made decisive experiments of this nature. Pétrequin, Broca, and others, suggest the same method to coagulate the blood contained in sacs, in aneurisms. If this novel surgery is not so widely known and used as it deserves to be, the reason is that the manipulation of electric instruments requires much practice and dexterity, and surgeons find the classic use of the scalpel more convenient.

This rapid historical view shows that the method of treatment by electricity is useful in very many diseases. Whether resorted to to modify the nutritive condition, to quicken or check circulation in the small vessels, to calm or excite the nerves, to relax or stimulate the muscles, to burn or detach tumors, electricity, if managed rationally, is destined to do distinguished service in the healing art. The range of treatment by heat is less considerable, yet of some extent. The examination of the medical value of treatment by light has scarcely begun, nor has much been done toward the study of weight or pressure, in their relations to medical science. At all events, there is now forming and gaining increased development, alongside of the medicinal use of bodies, a medicinal use of forces—besides the physic of drugs, a physic of powers. It is impossible to say at present which of the two will definitely prevail—more probably both will be called on to render valuable services to art.

The first *savants* who studied the action of galvanic electricity on dead bodies, and saw them recover motion, and even an appearance of sensation, supposed they had touched the secret of life, likening to the vital principle that other force which seems to warm again the frozen organs, and restore their springs. Slight reflection on the facts collected in the foregoing pages reveals the thorough illusiveness of such a hope. Not only is electricity far from being the whole of life, but it cannot even be regarded as one of the elements of life, or be compared, for instance, with nerve-force. In fact, the experiments of Helmholz have proved conclusively that such a comparison contradicts the truth. What is the peculiar sign of the vital forces and of vital unity, or the definite expression of their simultaneous action in one organism, is, precisely, organization. But electricity has no causal relation with organization proper. That is the work of some higher activity. That power in action, whatever it be, takes to itself all the forces of Nature, but it links them, coördinates them, and, fixing them into special conditions, compels their service to the purposes of life. Gravitation, heat, light, electricity, all these forces are maintained within living beings—only they are there disguised under a new phenomenal unity, just as the oxygen, hydrogen, carbon, nitrogen, and phosphorus, that make up a nerve-cell, vanish in it into a new unity of substance, without ceasing to exist in it as distinct chemical elements. The inorganic powers of Nature are as essential to life as lines and colors are in the composition of the painter's picture. What would the picture be without the painter's soul and labor? The picture is his peculiar work: the physico-chemical forces are the lines and colors of that homogeneous and harmonious composition, which is life. In it they would want meaning or power, if they did not in it, by the operation of a mysterious artist, undergo a transformation which raises them to a dignity not theirs before, and assigns their place in the supreme harmony. Thus, in the infinite solidarity of things, there is, as Leibnitz dreamed, a constant uprising of the lower toward the higher, a steady progress toward the best, a ceaseless aspiration toward a fuller and more conscious existence, an immortal growth toward perfection.—*Revue des Deux Mondes.*

PHYSICAL CHARACTERS OF THE HUMAN RACES.

By Prof. A. DE QUATREFAGES.

TRANSLATED FROM THE FRENCH BY ELIZA A. YOUMANS.

GENTLEMEN: I have already given you three lectures on the history of man. They have all been devoted to the examination of general questions, the solution of which can alone throw light on the study of the human races, and guide us in the midst of thousands of facts of detail involved in it.

These three lectures constitute the first part of the collection of facts and ideas that I have undertaken to expound to you. In these lectures, you know, I considered man in his relation to the universe and to the earth he inhabits. We found that there exists only one species of man; that this species, much more ancient than was formerly believed, was the contemporary of the elephant and rhinoceros on the soil of France. Although spread everywhere at present, the human species, like other organic and living beings, had its special centre of creation. It must have appeared at first on a particular and circumscribed part of the globe, situated probably in the centre of Asia. Our earth then was peopled by way of migration. In the varied journeyings performed to reach all points of his domain, man has encountered thousands of conditions of existence. He has accommodated himself to them all—in other words, he has become acclimated everywhere.

There is another question we had to meet, because it was seriously put to us, but, to answer which, we had to confess the insufficiency of present knowledge: it is the question of the first origin of man. Our answer to this question was founded on science alone. I have made this declaration many times; I repeat it every time I speak before a new audience. For the most part, the problems we have considered are treated by theologians and philosophers. Neither here, nor at the museum, am I, nor do I wish to be, either a theologian or a philosopher. I am simply a man of science, and it is in the name of comparative physiology, of botanical and zoological geography, of geology and paleontology, in the name of the laws which govern man as well as animals and plants, that I have always spoken.

To-day, however, I shall not need to recur, as much as in preceding lectures, to these terms of comparison. We have to commence the study of man considered in himself; and, in the first place, to account in a general way for the modifications presented by the human type.

These modifications constitute the *characters* which serve to distinguish divers groups of men—the different human races. Before studying these races in detail, we must fix somewhat the extent and the meaning of these modifications of character.

To give order even to the brief study of the characters of the human race, it is necessary to separate them into a certain number of groups. This division is easily made, because of the multiple nature of man, which at the same time connects him with the rest of creation, and gives him a position apart.

Like all organic and living beings, man has a body. This body will furnish a first class of characters—the physical characters. Like animals, man is endowed with instinct and intelligence. Though infinitely more developed in him, these characters are not changed in their fundamental nature. They appear in the different human groups in phenomena, sometimes very different, as for instance the different languages. The differences of manifestation of this intelligence will constitute the second class of characters—the intellectual characters.

Finally, it is established that man has two grand faculties, of which we find not even a trace among animals. He alone has the moral sentiment of good and of evil; he alone believes in a future existence succeeding this actual life; he alone believes in beings superior to himself, that he has never seen, and that are capable of influencing his life for good or evil.

In other words, man alone is endowed with morality and religion. These two faculties are revealed by his acts, by his institutions, by facts that differ from one group to another, from one race to another. From these is drawn a third class of characters—*that of moral and religious characters.*

Let us attend to-day to the physical characters, to those furnished by the body.

In man, as in animals, the body is made up of *organs*. We can not only study the exterior of the body, but we can also penetrate the interior and discover its anatomy. Indeed, this is the only means of finding out its most important organs. In this study we can stop with the form, the arrangement, or we can go further, and seek to understand the actions of the parts, the *functions* they perform. We thus pass from anatomy to *physiology*. But these functions may be disturbed by many maladies that cannot be neglected, and which are the province of *pathology*.

In our present study, we must not neglect any of these orders of facts. You see how we are led to draw, from the body alone, four categories of characters, namely: 1. Exterior characters; 2. Anatomic characters; 3. Physiological characters; 4. Pathological characters.

PHYSICAL CHARACTERS.

I. Exterior Characters.—When we see a man or an animal, the first thing that strikes us is its size. Our domestic species are made of great and small races, and it is the same with man.

The extreme dimensions of the human form, whether great or small, have been very much exaggerated. Everywhere there has been a belief in the existence of races of dwarfs and races of giants. For instance, the Greeks believed in the existence of a people, called by them pigmies, whose country they placed sometimes in one direction, sometimes in another, but always beyond the limits of the world they truly knew. These were little men about fourteen inches in height, who, it was believed, were obliged to pluck down the corn with strokes of the axe, and who passed a part of their time defending themselves against the cranes. In the last century this fable of the pigmies was, so to speak, renewed and applied to the kymos, who were said to inhabit Madagascar. It is needless to add that, since we have seen them more closely, pigmies and kymos have disappeared.

The fables relative to giants are the contrary of the preceding. Among these fables there are some modern ones, for a time believed to be founded on real observation. The first voyagers who doubled

Cape Horn found there the Patagonians, whose dimensions they singularly exaggerated. Pigafetta, the companion of Magellan in the first voyage round the world (1520), pretended that he and his companions scarcely reached to the height of their waists. One of his successors, Jofre Loaysa, with still greater extravagance, declared that the heads of the Christians reached only to the upper part of their thighs. This was, you see, to attribute to these people a height of 13 to 16 feet.

Time and science have done justice to these fables and exaggerations. Let us see what are in reality the extremes presented by the human stature.

It is plain that in this research we must leave out exceptional individuals, of which we see a certain number in the fairs and museums, or anywhere, for money. It is a question neither of General Tom Thumb, whom you have perhaps met sometimes in the Champs Elysées, nor of the French or Chinese giants, recently exhibited in Paris. I will only remark, in passing, that these individual exceptions appear among all nations, although more rarely, perhaps, in the midst of savage populations.

The smallest known race is that of the Bushman, which inhabits the southern part of Africa; the greatest is the Patagonian, of which we just named the country. An English traveller, Barrow, measured all the inhabitants of a tribe of the first; a French traveller, Alcide d'Orbigny, took the exact measure of a great number of individuals belonging to the second of these two extreme races.

It results from these measurements that the mean height of the Bushman is 4 feet 3½ inches, and that of the Patagonian 5 feet 8 inches. The mean difference between the greatest and the smallest human race is then 16½ inches.

The smallest Bushman measured by Barrow was a woman who was only 3 feet 10½ inches. The largest Patagonian measured by D'Orbigny attained 6 feet 3 inches. The greatest difference existing, then, between normal human individuals is 2 feet 8½ inches. The ratio between the extremes of height just named is nearly as 1 to 0.6. These figures signify much and lead to important consequences.

First, the difference in size among our domestic animals is much greater than that above indicated. From the great dogs that promenade in our court-yards, down to certain dogs which have figured at dog-shows, the ratio is 1 to 0.3. The difference is also as great between the large brewers' horses of London and horses from Shetland, which are sometimes not larger than a Newfoundland dog. These horses and these dogs are, however, only different races of a single species. One cannot reason, then, from differences of height to sustain the multiplicity of human species.

There is another consideration not less important:

From all the data I can gather, it results that the mean stature of men, the world over, is about 5 feet 3 inches. But this mean, like that given above, results from very numerous and very diverse heights. If in thought we place all men in one line according to their height, it is easy to see that we should obtain a series in which the difference from one to the next will not be, perhaps, the $\frac{1}{2500}$th of an inch.

But this is not all. In this graduated series, the men of the same race will be far from being placed together. There will be in this respect the strangest mixture. All the Patagonians are not nearly 6 feet 3 inches in height, nor all the Bushmen as short as 3 feet $10\frac{1}{2}$ inches. Among our cuirassiers and the hundred guards of the emperor many individuals would be found with the first; the Lapps of the north of Europe and the Mincopees of the isles of Andaman in the Gulf of Bengal would mix with the second.

Now, in no other kind of animal, with numerous species and of limited growth, is there any thing parallel. The domestic races alone present something like its analogue. So that, by themselves, these considerations drawn from the height furnish excellent proof of the unity of the human species.

The study of proportions would show us like facts and conduct to similar conclusions. But I leave considerations of this kind, to pass to other characters almost as striking as those of height. I wish to speak of those drawn from the complexion, and first of all from the color of the skin. The general coloration of the body is a well-defined character; but we need not exaggerate its value.

If you observe several portraits representing individuals of the white race, you may see that their tint is sometimes as dark as that of the Guinea negro. In the portrait of Rammohun-Roy, the celebrated Bramin reformer, the fineness and regularity of his profile attest that he is of the purest Aryan blood, and his color is that of a negro just a little blanched. Again, there are Abyssinians whose features recall the fine Semitic type, and yet few negroes surpass them in blackness. So all black men are not negroes. Reciprocally, Livingstone has found in the centre of Africa negroes of the color of *café au lait*.

The color of the human race varies from white, such as is seen in Dutch and Danish women, to violet or yellow, to yellow-citron or smoke, to copper-red or brick. By appealing to your recollections, you can establish a series passing from light to dark by insensible shades such as could scarcely be reproduced upon the palette of a painter.

Recollect that some of these extremes of color are frequent among domestic animals, and are sometimes much greater. With black hens, it is not the skin alone that is colored. All the great interior membranes, the sheaths of the muscles, the aponeuroses, as well as the flesh of the wings, present an aspect very little appetizing. So it is sought to weed them out of the poultry-yard; and still in certain parts of the globe they are constantly produced and would evidently soon become a race if left to multiply. Here, again, in the case of animals, the difference from race to race is much greater than in the case of man.

Sometimes, in the presence of variations of color like these we have described, we ask if, between the negro and the white, there do not exist anatomical differences in the skin? The minute study of this organ answers us in the negative.

The skin is composed of three layers, which together constitute a true organ having its proper functions. So it is often called the *cutaneous organ.* On the exterior is the *epidermis*, that dry and insensible layer which covers the entire body, and protects it against the action of outer agents.

Interiorly, and immediately above the greasy body, is the true skin—it is the essential and living part of the cutaneous organ; it is this which receives the blood-vessels and nerves.

Between the true skin and the epidermis is a dark layer, composed of distinct cells. It is the mucous membrane of Malpighi, so named from the anatomist who first described it. The cells that form it are a simple secretion of the true skin. It is this layer which is the seat of color. It exists in all men, but the cells that it contains are more or less colored according to race. In whites themselves, in certain parts of the body, around the nipples, in the specks of freckles, in the beauty-spots, etc., we sometimes see them as deep as in the negro.

You see that the color in different human races is, when developed, only a phenomenon of local coloration, of exactly the same nature as those we encounter in races of domestic animals. If time permitted me to enter more fully into the subject, I could make this fact much more evident, but the hour advances and I must hasten.

To the skin are attached a certain number of organs, which may be considered as adjuncts to the cutaneous organ. These are chiefly the villosities or hairs, the sebaceous glands, and the sweat-glands. Between these annexed organs there exists a certain balance which physiology easily explains. So in glabrous races, that is, races with little or no villosities on the body, the sebaceous apparatus is much more developed. This fact is very marked in the African negro, whose skin sometimes bears slight prominences, sketching a sort of arabesque by the extraordinary development of these little organs.

It is to the development of the sebaceous apparatus that the odor developed by the negro is due. This odor is so strong, so persistent, that it suffices to the identification of a negro-ship a long time after it has left the trade. But it is not negroes alone that are characterized by malodorous exhalations. It is the same with the whites themselves. You all know that a dog follows his master by the scent. Savage people, whose senses are more exercised than ours, distinguish very quickly the general odor which characterizes a race; and, in Peru, they give special names to that of the white and of the black as well as to their own.

As to the hair which may be seen on different parts of the body, a special mention is due to that of the head. All people have more or less hair on the head, and this gives also very good characters. Among these the most essential are drawn from the form presented by the transverse cut when examined under the microscope. In the yellow people, the Americans and the white allophyles, this cut is more or less circular. In the Aryans, of which we are a part, it is oval; in the negroes it takes the form of an elongated ellipse. It is evident that a circular cut indicates a cylindrical hair. Such hair is very coarse and stiff, and never curling or frizzled; an oval cut indicates a slight and regular flattening. In this form the hairs are finer, and may be made into curls or waves more or less marked. Finally, the elliptical cut can only appear when the hair is much flattened, almost like a thick ribbon. These are the finest, and these alone have the aspect of wool which characterizes the head of the negro.

Crosses between these different races sometimes produce very remarkable heads of hair. The negro crossed with the Brazilian produces the Cafuso, whose hair, forming an immense wig, is at the same time long, stiff, and kinked.

I would further enlarge upon these exterior characters, as being the ones of which we can most easily give account, but time fails me, and I pass to the second class of characters, to those which we must seek in the interior.

II. Anatomic Character.—The anatomic character may be drawn from the solid parts of the body, that is, the skeleton, from the soft parts, and even from the liquids. I shall at first confine myself particularly to those drawn from the head.

In the head itself we must distinguish the cranium from the face. The first encloses the brain, whence proceed the organs of sense, with the exception of those of touch, properly speaking. Above all, it is the seat of intelligence; on these various accounts it merits a separate examination.

The general form of the cranium, that is, the relation between the longitudinal and transverse diameter, furnishes an excellent character. When this relation is less than that of 100 to 78, the cranium is considered as elongated from front to back: it is *dolichocephalic*. When the relation varies from 100 to 78 or 80, the cranium is medium or average; we say it is *mesocephalic*. Finally, when the relation is from 100 to 80, and above, the cranium is considered short, and is said to be *brachycephalic*.

These forms sometimes characterize very large human groups. So almost all the negroes are dolichocephalic; nearly all the yellow people, and most of the Americans, are brachycephalic or mesocephalic. Among the whites, and even sometimes in two populations belonging to the same branch of the white race, we find the two extremes. The Germans of the north are dolichocephalic, the Germans of the south brachycephalic.

While recognizing the importance of the characters drawn from these general forms, we must guard ourselves against exaggerating their import or giving them a wrong signification. Some authors, belonging to the dolichocephalic races, have pretended that the elongation of the head behind is a sign of intellectual superiority. The fact I have just stated suffices to refute this conclusion, and nothing justifies it. The Germans of the south are noways inferior to their countrymen of the north. In the Academy of Sciences in Paris, the brachycephalic crania, or at most the mesocephalic, are in very great majority; and still, what association of men is superior, in an intellectual point of view, to this philosophical body?

Analogous indications have been drawn from the greater or less capacity of the cranium. It has been supposed that this exactly corresponded in measure to the volume of the brain, and this volume has been regarded as a sort of measure of intellectual power.

That there is some truth at the bottom of the idea that a brain sufficiently developed is necessary to give the power to fulfil its functions, is what all the world admits. But that intellectual power is measured by the quantity of cerebral matter entering into the composition of the organ is in contradiction to the observations and the figures of many anatomists, among others, of R. Wagner.

In considerations of this nature we do not generally take account of the stature. Now, although the head does not enlarge in the same proportion as the rest of the body, it is not the less true that its form has an influence on its dimensions and on those of the cranium.

Besides, with organized and living beings, the volume, the mass of organs, is not all. Their special energy is much more. Certainly you all know small persons, of slender aspect, who are more active and strong than some of their comrades who are larger and more muscular. Well, how is it that what is true of flesh, of muscle, is not also true of brain?

After the cranium we come to the face. But I will only speak of a single order of characters drawn from the jaws and teeth.

Observe a negro, and a European. Look at the jaws and teeth of the first. You see them project in front. In the second, on the contrary, teeth and jaws are equally vertical. The first of these is called *prognathism*, and the peoples or individuals who present them are said to be prognathous; the second takes the name of orthognathism and characterizes the orthognathous races or individuals.

Prognathism has long been considered as characterizing the negro races. Since, we have found it in people who could not be affiliated with the negro; and, finally, looking closely into the matter, we have found it in the heart of white populations. At Paris, even, it is frequent enough, particularly among women. This is a fact of which you can convince yourself, as I have often done during my rides in the omnibus.

Judging by the crania that we possess, prognathism is characteristic of a population incontestably European which lives at the south of the Baltic, the Esthonians. This people is, furthermore, the remains of the most ancient race of Western Europe. It is this race, without doubt, which, mixing its blood with new-comers, has left in the midst of our great cities those indications of a prognathous race to which I have just referred.

After studying the cranium and face separately, we must examine the head in its *ensemble*. From this also we draw important characters. I will only mention one, which has a certain real value, but the signification of which some have exaggerated and falsified.

Camper, an anatomist of Holland, studied comparatively the Greek and Roman medallions and statues, and struck with the air of majesty, presented by the Greeks, gave for a reason that the *facial angle* was greater than in the Romans. This angle is formed by two lines which meet at the extremity of the front teeth, and of which one passes by the middle of the orifice of the ear, while the second is tangent to the forehead.

Pushing these researches much further, Camper believed that he discovered a regular decrease of the facial angle in the human race, so that he could characterize a race by its facial angle. Going further, and applying it to animals, he placed in a descending scale, man, monkeys, carnivora, birds, all characterized by smaller and smaller angles. Whence, to conclude that the facial angle measures, so to say, the intelligence, is but a step, which was taken without hesitation.

As this conclusion gives great interest to the measurement of the facial angle, many processes and many instruments have been proposed to obtain it with all possible exactitude. The *goniometre*, invented by my assistant M. Docteur Jacquart, attained this end better than any other.

Jacquart did not stop with making this instrument. He used it; and, in a beautiful work, he shows among other things that the right angle exists in the white race, contrary to what Camper believed; that we may observe it, without doubt, in intelligent persons, but who are, however, not sensibly superior to others whose angle is much less considerable. The facial angle cannot, then, be considered as measuring the intelligence, the reach of the mind.

M. Jacquart shows, besides, that, in the single population of Paris, the angular differences of which we are speaking are much more considerable than those that Camper regarded as characterizing races. He shows that here, again, there is from race to race that entanglement of characters which I have so many times pointed out. Yet, here as elsewhere, the average furnishes good characters to determine human groups.

Again, the skeleton presents important characters. We ought, at least, to examine the breast, the pelvis, the bones of the limbs, etc.; but we must leave this subject, to say a word on the soft parts.

Regarded in the two extremes of humanity, the white European and the negro, the nervous system presents a fact which it is important to point out. With the first, the nervous centres—the brain and spinal cord—are relatively more voluminous. In the second, on the contrary, it is the expansions from the centres—the nerves—which are more voluminous.

The circulatory apparatus presents a balance somewhat analogous. With the white, the arterial apparatus, which carries the blood to the organs, is relatively more developed than the venous apparatus that draws the blood toward the heart.

The blood of the negro, studied in his native country, is more viscous and darker colored than that of the white. That of the creole negro of New Orleans is, on the contrary, paler and more aqueous, and recalls the blood of the anæmic. So, a simple change of habitat sometimes modifies a human race in this most profound character—in this liquid pabulum destined to penetrate and nourish all parts of the body.

III. Physiological Characters.—I shall dwell briefly on the physiological characters, and only point out two general facts, of which you will easily see the importance:

As regards all the great periods of life and all the great functions, there is an almost complete identity among all men, to whatever race they belong.

When this resemblance is not apparent, the cause is not in the nature of the races, but in the influence of conditions of existence. This is well proved by the fact that races the most widely separated resemble each other completely when they are exposed to identical conditions through a change of habitat. So, the precocity of the negro has been cited as distinguishing this race from European nations; but, when white people live for generations in hot countries, they take on the same peculiarity. The negress and the English creole of the isles of the Gulf of Mexico are just alike in precocity.

On the contrary, the study of secondary functions shows that they vary from one group to another, and sometimes very widely. But, then, also, we see that the environment, the manners, the habits, etc., are the cause of these variations; and, again, we see races the most unlike come to resemble each other so much as to be confounded together. There are hunters of English and French descent who have the senses of sight and hearing as quick and sharp as the red-skins.

In concluding, the study of physiological characters strongly attests the fundamental unity of the human race, by throwing light on the marvellous flexibility of our organism.

IV. Pathological Characters.—The study of diseases presents entirely similar facts, and conducts to the same conclusions.

All the human races are accessible to the same diseases. If any circumstances—isolation, for instance—have preserved some one of them from affections common to the others, a simple coming together suffices for the propagation of the disease. The eruptive maladies seem to have been implanted in America by the Europeans; but, once implanted among the indigenous races, they have raged with a violence that we know not—a violence which is accounted for by the kind of life led by these people.

Yet immunities, at least relative, have been proved. For instance, the negro race is much less sensible to the emanations of marshes, to the miasms from stagnant waters, than the white race. In return, it is much more easily affected by phthisis.

Other more complete immunities have been observed, and some have even wished, in consequence, to justify the admission of a distinct human species. But these immunities, even the best marked, disappear with time, and still more under the influence of conditions of existence. I will give you a curious example:

Elephantiasis is a hideous malady, peculiar to certain warm countries, which swells and deforms, sometimes in the strangest way, the parts of the body it attacks. In one of the Antilles, in Barbadoes, this disease was seen from the first among the negroes, but had constantly spared the whites, till 1704. That year a white person was seized, and since then the malady has extended in this race; but it never attacks any but creoles. Up to the present time, Europeans, who settle in this isle, enjoy the ancient immunity. You see it is only a question of complete acclimation.

Gentlemen, I believe I have sketched, in this one lecture, a body of facts and ideas which, at the museum, occupied at least ten lectures, each as long as this to-day. So, you see how many things I have been compelled to omit. Incomplete as I have been compelled to make this presentation, it is sufficient, I think, to establish clearly some general facts, and prepares the way for an important conclusion.

You have seen that, considering man from the point of view of his height and color, we may form a graduated series which passes from one extreme to the other by insensible shades. You have seen further that, in this series, groups the most distinct by other characters—the most separated by their habitat—are found intermixed.

Permit me to add that we should get the same result, whatever the exterior or anatomical character upon which we establish our series.

The study of functions, whether performed in a normal manner, in a state of health, or under the perturbing influence of disease, shows us identical fundamental facts revealing the unity of human nature.

Even apparent exceptions come under the general facts when we take account of the influence of the environment which, as you have seen, effaces some of the most marked differences.

In this examination of the physical man, every thing leads to the conclusion which we had already reached in our earlier lectures; and we can repeat with redoubled certainty: the differences among human groups are characters of race, and not of species; there exists only one human species; and, consequently, all men are brothers—all ought to be treated as such, whatever the origin, the blood, the color, the race.

Gentlemen, the lectures I have given here require a special preparation, and are not always easy to prepare; but I shall not regret either my time or my pains, if I am able, in the name of science, and that alone, to render a little more clear and precise for you this great and sacred notion of the brotherhood of man.

ON THE EQUALITY OF THE SEXES.[1]

SIR: In the foregoing letter I have examined the theory of the connection between equality and justice, with the view of showing that the only real connection between the two ideas is to be found in the fact that, as justice implies general rules, it also implies an impartial application of those rules to all the particular cases to which they may apply. I also showed that when equality is spoken of as being just or unjust in any more general sense than this, the expression can mean nothing else than that it is or is not generally expedient. The doctrine upon this subject which I deny, and which I am disposed to think Mr. Mill affirms—though, if he does, it is with somewhat less than his usual transparent vigor and decision—is that equality is in itself always expedient, or, to say the very least, presumably expedient, and that in every case of inequality the burden of proof lies on those who justify its maintenance.

If I had time to do so, I might give in proof or illustration of this the whole of his essay on the "Subjection of Women," a work from which I dissent from the first sentence to the last, but which I will consider on the present occasion only with reference to the particular topic of equality, and as the strongest distinct illustration known to me of what is perhaps one of the strongest, and what appears to me to be by far the most ignoble, contemptible, and mischievous of all the popular feelings of the age.

The object of Mr. Mill's essay is to explain the grounds of the opinion that "the principle which regulates the existing social relations between the two sexes, the legal subordination of one sex to the other, is wrong in itself, and now one of the chief hindrances to human

[1] From the letters of "F.," in the *Pall Mall Budget*.

improvement; and that it ought to be replaced by a principle of perfect equality, admitting no power or privilege on the one side, nor disability on the other."

Mr. Mill is fully aware of the difficulty of his task. He admits that he is arguing against "an almost universal opinion," but he urges that it and the practice founded on it is a relic of a by-gone state of things. "We now live—that is to say, one or two of the most advanced nations of the world now live—in a state in which the law of the strongest seems to be entirely abandoned as the regulating principle of the world's affairs. Nobody professes it, and, as regards most of the relations between human beings, nobody is permitted to practise it. . . . This being the ostensible state of things, people flatter themselves that the rule of mere force is ended." Still they do not know how hard it dies, and in particular they are unaware of the fact that it still regulates the relations between men and women. It is true that the actually existing generation of women do not dislike their position. The consciousness of this haunts Mr. Mill throughout the whole of his argument, and embarrasses him at every turn. He is driven to account for it by such assertions as that "each individual of the subject class is in a chronic state of bribery and intimidation combined," by reference to the affection which slaves in classical times felt for their masters in many cases, and by other suggestions of the same sort. His great argument against the present state of things is that it is opposed to what he calls "the modern conviction, the fruit of a thousand years of experience"—

"That things in which the individual is the person directly interested never go right but as they are left to his own discretion, and that any regulation of them by authority except to protect the rights of others is sure to be mischievous. . . . The peculiar character of the modern world . . . is that human beings are no longer born to their place in life and chained down by an inexorable bond to the place they are born to, but are free to employ their faculties and such favorable chances as offer, to achieve the lot which may appear to them most desirable. Human society of old was constituted on a very different principle. All were born to a fixed social position, and were mostly kept in it by law or interdicted from any means by which they could emerge from it. . . . In consonance with this doctrine it is felt to be an overstepping of the proper bounds of authority to fix beforehand on some general presumption that certain persons are not fit to do certain things. It is now thoroughly known and admitted that if some such presumptions exist no such presumption is infallible. . . . Hence we ought not . . . to ordain that to be born a girl instead of a boy shall decide the person's position all through life."

The result is that "the social subordination of women thus stands out as an isolated fact in modern social institutions." It is in "radical opposition" to "the progressive movement, which is the boast of the modern world." This fact creates a "*prima-facie* presumption" against it, "far outweighing any which custom and usage could in such circumstances create" in its favor.

I will not follow Mr. Mill through the whole of his argument, much of which consists of matter not relevant to my present purpose, and not agreeable to discuss, though many of his assertions provoke reply. There is something—I hardly know what to call it, indecent is too strong a word, but I may say unpleasant in the direction of indecorum—in prolonged and minute discussions about the relations between men and women, and the characteristics of women as such. I will therefore pass over what Mr. Mill says on this subject with a mere general expression of dissent from nearly every word he says. The following extracts show the nature of that part of his theory which bears on the question of equality:

"The equality of married persons before the law . . . is the only means of rendering the daily life of mankind in any high sense a school of moral cultivation. Though the truth may not be felt or generally acknowledged for generations to come, the only school of genuine moral sentiment is society between equals. The moral education of mankind has hitherto emanated chiefly from the law of force, and is adapted almost solely to the relations which force creates. In the less advanced states of society, people hardly recognize any relation with their equals. To be an equal is to be an enemy. Society, from its highest place to its lowest, is one long chain, or rather ladder, where every individual is either above or below his nearest neighbor, and wherever he does not command he must obey. Existing moralities, accordingly, are mainly fitted to a relation of command and obedience. Yet command and obedience are but unfortunate necessities of human life; society in equality is its normal state. Already in modern life, and more and more as it progressively improves, command and obedience become exceptional facts in life, equal association its general rule. . . . We have had the morality of submission and the morality of chivalry and generosity; the time is now come for the morality of justice."

In another part of the book this doctrine is stated more fully in a passage of which it will be enough for my purpose to quote a very few lines:

"There are many persons for whom it is not enough that the inequality" (between the sexes) "has no just or legitimate defence; they require to be told what express advantage would be obtained by abolishing it. To which let me first answer, the advantage of having all the most universal and pervading of all human relations regulated by justice instead of injustice. The vast amount of this gain to human nature it is hardly possible by any explanation or illustration to place in a stronger light than it is placed in by the bare statement to any one who attaches a moral meaning to words."

These passages show what Mr. Mill's doctrine of equality is, and how it forms the very root, the essence, so to speak, of his theory about the subjection of women. I consider it unsound in every respect. I think that it rests upon an unsound view of history, an unsound view of morals, and a grotesquely distorted view of facts, and I believe that its practical application would be as injurious as its theory is false.

The theory may be shortly restated in the following propositions, which I think are implied in or may be collected from the extracts given above. They are as follows:

1. Justice requires that all people should live in society as equals.

2. History shows that human progress has been a progress from a "law of force" to a condition in which command and obedience become exceptional.

3. The "law of the strongest" having in this and one or two other countries been "entirely abandoned" in all other relations of life, it may be presumed not to apply to the relation between the sexes.

4. The notorious facts as to the nature of that relation show that in this particular case the presumption is, in fact, well founded.

I dissent from each of these propositions. In the present letter I shall examine the first and the fourth, which may be regarded as an illustration of the first. On a subsequent occasion I shall consider the second and third. First, as to the proposition that justice requires that all people should live in society as equals. I have already shown that this is equivalent to the proposition that it is expedient that all people should live in society as equals. Can this be proved? for it is certainly not a self-evident proposition.

I think that if the rights and duties which laws create are to be generally advantageous, they ought to be adapted to the situation of the persons who enjoy or are subject to them. They ought to recognize both substantial equality and substantial inequality, and they should from time to time be so moulded and altered as always to represent fairly well the existing state of society. Government, in a word, ought to fit society as a man's clothes fit him. To establish by law rights and duties which assume that people are equal when they are not is like trying to make clumsy feet look handsome by the help of tight boots. No doubt it may be necessary to legislate in such a manner as to correct the vices of society, or to protect it against special dangers or diseases to which it is liable. Law in this case is analogous to surgery, and the rights and duties imposed by it might be compared to the irons which are sometimes contrived for the purpose of supporting a weak limb or keeping it in some particular position. As a rule, however, it is otherwise. Rights and duties should be so moulded as to clothe, protect, and sustain society in the position which it naturally assumes. The proposition, therefore, that justice demands that people should live in society as equals may be translated thus: "It is inexpedient that any law should recognize any inequality between human beings."

This appears to me to involve the assertion, "There are no inequalities between human beings of sufficient importance to influence the rights and duties which it is expedient to confer upon them." This proposition I altogether deny. I say that there are many such differences, some of which are more durable and more widely extended than others, and of which some are so marked and so important that, unless human nature is radically changed, we cannot even imagine their removal; and of these the differences of age and sex are the most important.

The difference of age is so distinct a case of inequality that even Mr. Mill does not object to its recognition. He admits, as every one must, that perhaps a third or more of the average term of human life—and that the portion of it in which the strongest, the most durable, and beyond all comparison the most important impressions are made on human beings, the period in which character is formed—must be passed by every one in a state of submission, dependence, and obedience to orders the objects of which are usually most imperfectly understood by the persons who receive them. Indeed, as I have pointed out in previous letters, Mr. Mill is disposed rather to exaggerate than to underrate the influence of education and the powers of educators. Is not this a clear case of inequality of the strongest kind, and does it not at all events afford a most instructive precedent in favor of the recognition by law of a marked natural distinction? If children were regarded by law as the equals of adults, the result would be something infinitely worse than barbarism. It would involve a degree of cruelty to the young which can hardly be realized even in imagination. The proceeding, in short, would be so utterly monstrous and irrational that I suppose it never entered into the head of the wildest zealot for equality to propose it. Upon the practical question all are agreed; but consider the consequences which it involves. It involves the consequence that, so far from being "unfortunate necessities," command and obedience stand at the very entrance to life, and preside over the most important part of it. It involves the consequence that the exertion of power and constraint is so important and so indispensable in the greatest of all matters that it is a less evil to invest with it every head of a family indiscriminately, however unfit he may be to exercise it, than to fail to provide for its exercise. It involves the consequence that, by mere lapse of time and by following the promptings of passion, men acquire over others a position of superiority and of inequality which all nations and ages, the most cultivated as well as the rudest, have done their best to surround with every association of awe and reverence. The title of Father is the one which the best part of the human race have given to God, as being the least inadequate and inappropriate means of indicating the union of love, reverence, and submission. Whoever first gave the command or uttered the maxim, "Honor thy father and thy mother, that thy days may be long in the land," had a far better conception of the essential conditions of permanent national existence and prosperity than the author of the motto "Liberty, Equality, and Fraternity."

Now, if society and government ought to recognize the inequality of age as the foundation of an inequality of rights of this importance, it appears to me at least equally clear that they ought to recognize the inequality of sex for the same purpose, if it is a real inequality. Is it one? There are some propositions which it is difficult to prove, because they are so plain, and this is one of them. The physical differences between the two sexes affect every part of the human body, from the hair of the head to the sole of the feet, from the size and density of the bones to the texture of the brain and the character of the nervous system. Ingenious people may argue about any thing, and Mr. Mill does say a great number of things about women which, as I have already observed, I will not discuss; but all the talk in the world will never shake the proposition that men are stronger than women in every shape. They have greater muscular and nervous force, greater intellectual force, greater vigor of character. This general truth, which has been observed under all sorts of circumstances and in every age and country, has also in every age and country led to a division of labor between men and women, the general outline of which is as familiar and as universal as the general outline of the differences between them. These are the facts, and the question is, whether the law and public opinion ought to recognize this difference. How it ought to recognize it, what difference it ought to make between men and women as such, is quite another question. The first point to consider is, whether it ought to treat them as equals, although, as I have shown, they are not equals, because men are the stronger. I will take one or two illustrations. Men, no one denies, may, and in some cases ought to, be liable to compulsory military service. No one, I suppose, would hesitate to admit that, if we were engaged in a great war, it might become necessary, or that if necessary it would be right, to have a conscription both for the land and for the sea service. Ought men and women to be subject to it indiscriminately? If any one says that they ought, I have no more to say, except that he has got into the region at which argument is useless. But if it is admitted that this ought not to be done, an inequality of treatment founded on a radical inequality between the two sexes is admitted, and, if this admission is once made, where are you to draw the line? Turn from the case of liability to military service to that of education, which in Germany is rightly regarded as the other great branch of state activity, and the same question presents itself in another shape. Are boys and girls to be educated indiscriminately, and to be instructed in the same things? Are boys to learn to sew, to keep house, and to cook, as girls unquestionably ought to be, and are girls to play at cricket, to row, and be drilled like boys? I cannot argue with a person who says Yes. A person who says No admits an inequality between the sexes on which education must be founded, and which it must therefore perpetuate and perhaps increase.

Follow the matter a step further to the vital point of the whole question—marriage. Marriage is one of the subjects with which it is absolutely necessary both for law and morals to deal in some way or other. All that I need consider in reference to the present purpose is the question whether the laws and moral rules which relate to it should regard it as a contract between equals, or as a contract between a stronger and a weaker person involving subordination for certain purposes on the part of the weaker to the stronger. I say that a law which proceeded on the former and not on the latter of these views would be founded on a totally false assumption, and would involve cruel injustice in the sense of extreme general inexpediency, especially to women. If the parties to a contract of marriage are treated as equals, it is impossible to avoid the inference that marriage, like other partnerships, may be dissolved at pleasure. The advocates of women's rights are exceedingly shy of stating this plainly. Mr. Mill says nothing about it in his book on the "Subjection of Women," though in one place he comes very near to saying so, but it is as clear an inference from his principles as any thing can possibly be, nor has he ever disavowed it. If this were the law, it would make women the slaves of their husbands. A woman loses the qualities which make her attractive to men much earlier than men lose those which make them attractive to women. The tie between a woman and young children is generally far closer than the tie between them and their father. A woman who is no longer young, and who is the mother of children, would thus be absolutely in her husband's power, in nine cases out of ten, if he might put an end to the marriage when he pleased. This is one inequality in the position of the parties which must be recognized and provided for beforehand if the contract is to be for their common good. A second inequality is this: When a man marries, it is generally because he feels himself established in life. He incurs, no doubt, a good deal of expense, but he does not in any degree impair his means of earning a living. When a woman marries, she practically renounces in all but the rarest cases the possibility of undertaking any profession but one, and the possibility of carrying on that one profession in the society of any man but one. Here is a second inequality. It would be easy to mention others of the deepest importance, but these are enough to show that to treat a contract of marriage as a contract between persons who are upon an equality in regard of strength and power to protect their interest is to treat it as being what it notoriously is not.

Again, the contract is one which involves subordination and obedience on the part of the weaker party to the stronger. The proof of this is, to my mind, as clear as that of a proposition in Euclid, and it is this:

1. Marriage is a contract, one of the principal ones of which is the government of a family.

2. This government must be vested either by law or by contract in the hands of one of the two married persons.

3. If the arrangement is made by contract, the remedy for breach

of it must either be by law or by a dissolution of the partnership at the will of the contracting parties.

4. Law could give no remedy in such a case. Therefore the only remedy for breach of the contract would be dissolution of the marriage.

5. Therefore, if marriage is to be permanent, the government of the family must be put by law and by moral rules in the hands of the husband, for no one proposes to give it to the wife.

Mr. Mill is totally unable to meet this argument, and apparently embraces the alternative that marriage ought to be dissoluble at the pleasure of the parties. After much argument as to contracts which appear to be visionary, his words are these: "Things never come to an issue of downright power on one side and obedience on the other except where the connection has been altogether a mistake, and it would be a blessing to both parties to be relieved from it."

This appears to me to show a complete misapprehension of the nature of family government, and of the sort of cases in which the question of obedience and authority can arise between husband and wife. No one contends that a man ought to have power to order his wife about like a slave, and beat her if she disobeys him. Such conduct in the eye of the law would be cruelty, and ground for a separation. The question of obedience arises in quite another way. It may, and no doubt often does, arise between the very best and most affectionate married people, and it need no more interfere with their mutual affection than the absolute power of the captain of a ship need interfere with perfect friendship and confidence between himself and his first-lieutenant. Take the following set of questions: "Shall we live on this scale or that? Shall we associate with such and such persons? Shall I, the husband, embark in such an undertaking, and shall we change our place of residence in order that I may do so? Shall we send our son to college? Shall we send our daughters to school or have a governess? For what profession shall we train our sons?" On these and a thousand other such questions the wisest and the most affectionate people might arrive at opposite conclusions. What is to be done in such a case? for something must be done. I say the wife ought to give way. She ought to obey her husband, and carry out the view at which he deliberately arrives, just as, when the captain gives the word to cut away the masts, the lieutenant carries out his orders at once, though he may be a better seaman and may disapprove them. I also say that, to regard this as a humiliation, as a wrong, or as an evil in itself, is a mark not of spirit and courage, but of a base, unworthy, mutinous disposition—a disposition utterly subversive of all that is most worth having in life. The tacit assumption involved in it is that it is a degradation ever to give up one's own will to the will of another, and to me this appears the root of all evil, the negation of that which renders any combined efforts possible. No case can be specified in which people unite for a common object, from making a pair of shoes up to governing an empire, in which the power to decide does not rest somewhere; and what is this but command and obedience? Of course the person who for the time being is in command is of all fools the greatest if he deprives himself of the advantage of advice, if he is obstinate in his own opinion, if he does not hear as well as determine; but it is also practically certain that his inclination to hear will be proportioned to the degree of importance which he has been led to attach to the function of determining.

To sum the matter up, it appears to me that all the laws and moral rules by which the relation between the sexes is regulated should proceed upon the principle that their object is to provide for the common good of two great divisions of mankind who are connected together by the closest and most durable of all bonds, and who can no more have really conflicting interests than the different members of the same body, but who are not and never can be equals in any of the different forms of strength.

This problem law and morals have solved by monogamy, indissoluble marriage on the footing of the obedience of the wife to the husband, and a division of labor with corresponding differences in the matters of conduct, manners, and dress. Substantially this solution appears to me to be right and true; but I freely admit that in many particulars the stronger party has in this, as in other cases, abused his strength, and made rules for his supposed advantage, which, in fact, are greatly to the injury of both parties. It is needless to say any thing in detail of the stupid coarseness of the laws about the effects of marriage on property—laws which might easily be replaced by a general statutory marriage settlement analogous to those which every prudent person makes who has any thing to settle. As to acts of violence against women, by all means make the law on this head as severe as it can be made without defeating itself.

As to throwing open to women the one or two employments from which they are at present excluded, it is rather a matter of sentiment than of practical importance. I need not revive in this place a trite discussion. My object at present is simply to establish the general proposition that men and women are not equals, and that the laws which affect their relations ought to recognize that fact.

In my next letter I shall examine the opinion that laws which recognize any sort of inequality between human beings are mere vestiges of the past, against which as such there lies the strongest of all presumptions.—I am, sir, your obedient servant, "F."

INSTINCT IN YOUNG BIRDS.

BY D. A. SPALDING.

WITH regard to instinct we have yet to ascertain the facts. Do the animals exhibit untaught skill and innate knowledge? May not the supposed examples of instinct be after all but the results of rapid learning and imitation? The controversy on this subject has been chiefly concerning the perceptions of distance and direction by the eye and the ear. Against the instinctive character of these perceptions it is argued that, as distance means movement, locomotion, the very essence of the idea is such as cannot be taken in by the eye or ear; that what the varying sensations of sight and hearing correspond to, must be got at by moving over the ground by experience. The results, however, of experiments on chickens were wholly in favor of the instinctive nature of these perceptions. Chickens kept in a state of blindness by various devices, from one to three days, when placed in the light under a set of carefully-prepared conditions, gave conclusive evidence against the theory that the perceptions of distance and direction by the eye are the result of associations formed in the experience of each individual life. Often, at the end of two minutes, they followed with their eyes the movements of crawling insects, turning their heads with all the precision of an old fowl. In from two to fifteen minutes they pecked at some object, showing, not merely an instinctive perception of distance, but an original ability to measure distance with something like infallible accuracy. If beyond the reach of their necks, they walked or ran up to the object of their pursuit, and may be said to have invariably struck it, never missing by more than a hair's-breadth; this, too, when the specks at which they struck were no bigger than the smallest visible dot of an *i*. To seize between the points of the mandible at the very instant of striking seemed a more difficult operation. Though at times they seized and swallowed an insect at the first attempt, more frequently they struck five or six times, lifting once or twice before they succeeded in swallowing their first food. To take, by way of illustration, the observations on a single case a little in detail: A chicken, at the end of six minutes, after having its eyes unveiled, followed with its head the movements of a fly twelve inches distant; at ten minutes, the fly, coming within reach of its neck, was seized and swallowed at the first stroke; at the end of twenty minutes it had not attempted to walk a step. It was then placed on rough ground within sight and call of a hen, with chickens of its own age. After standing chirping for about a minute, it went straight toward the hen, displaying as keen a perception of the qualities of the outer world as it was ever likely to possess in after-life. It never required to knock its head against a stone to discover that there was "no road that way." It leaped over the smaller obstacles that lay in its path, and ran round the larger, reaching the mother in as nearly a straight line as the nature of the ground would permit. Thus it would seem that, prior to experience, the eye—at least the eye of the chicken—perceives the primary qualities of the external world, all arguments of the purely analytical school of psychology to the contrary, notwithstanding.

Not less decisive were experiments on hearing. Chickens hatched and kept in the dark for a day or two, on being placed in the light nine or ten feet from a box in which a brooding hen was concealed, after standing chirping for a minute or two, uniformly set off straight to the box in answer to the call of the hen which they had never seen and never before heard. This they did struggling through grass and over rough ground, when not able to stand steadily on their legs. Again, chickens that from the first had been denied the use of their eyes, by having hoods drawn over their heads while yet in the shell, were, while thus blind, made the subject of experiment. These, when left to themselves, seldom made a forward step, their movements were round and round and backward; but, when placed within five or six feet of the hen-mother, they, in answer to her call, became much more lively, began to make little forward journeys, and soon followed her by sound alone, though of course blindly. Another experiment consisted in rendering chickens deaf for a time by sealing their ears with several folds of gum-paper before they had escaped from the shell. These, on having their ears opened when two or three days old, and being placed within call of the mother, concealed in a box or on the other side of a door, after turning round a few times ran straight to the spot whence came the first sound they had ever heard. Clearly, of these chickens it cannot be said that sounds were to them at first but meaningless sensations.

One or two observations favorable to the opinion that animals have an instinctive knowledge of their enemies may be taken for what they are worth. When twelve days old, one of my little *protégés*, running about beside me, gave the peculiar chirp whereby they announce the approach of danger. On looking up, a sparrow-hawk was seen hovering at a great height overhead. Again, a young hawk was made to fly over a hen with her first brood of chickens, then about a week old. In the twinkling of an eye, most of the chickens were hid among grass and bushes. And scarcely had the hawk touched the ground, about twelve yards from where the hen had been sitting, when she fell upon it, and would soon have killed it outright. A young turkey gave even more striking evidence. When ten days old it heard the voice of a hawk for the first time, and just beside it. Like an arrow from the bow it darted off in the opposite direction, and, crouched in a corner, remained for ten minutes motionless and dumb with fear. Out of a vast number of experiments with chickens and bees, though the results were not uniform, yet, in the great majority of instances, the chickens gave evidence of instinctive fear of these sting-bearing insects.

But to return to examples of instinctive skill and knowledge, concerning which I think no doubt can remain, a very useful instinct may be observed in the early attention that chickens pay to their toilet. As soon as they can hold up their heads, when only from four to five hours old, they attempt dressing at their wings, that, too, when they have been denied the use of their eyes. Another incontestable case of instinct may be seen in the art of scraping in search of food. Without any opportunities of imitation, chickens begin to scrape when from two to six days old. Most frequently the circumstances are suggestive; at other times, however, the first attempt, which generally consists of a sort of nervous dance, was made on a smooth table. The unacquired dexterity shown in the capture of insects is very remarkable. A duckling one day old, on being placed in the open air for the first time, almost immediately snapped at, and caught, a fly on the wing. Still more interesting is the instructive art of catching flies peculiar to the turkey. When not a day and a half old I observed a young turkey, which I had adopted while yet in the shell, pointing its beak slowly and deliberately at flies and other small insects without actually pecking at them. In doing this its head could be seen to shake like a hand that is attempted to be held steady by a visible effort. This I recorded when I did not understand its meaning. For it was not until afterward that I observed a turkey, when it sees a fly settle on any object, steals on the unwary insect with slow and measured step, and, when sufficiently near, advances its head very slowly and steadily until within reach of its prey, which is then seized by a sudden dart. In still further confirmation of the opinion that such wonderful examples of dexterity and cunning are instinctive and not acquired, may be adduced the significant fact that the individuals of each species have little capacity to learn any thing not found in the habits of their progenitors. A chicken was made, from the first and for several months, the sole companion of a young turkey. Yet it never showed the slightest tendency to adopt the admirable art of catching flies that it saw practised before its eyes every hour of the day.

The only theory in explanation of the phenomena of instinct that has an air of science about it is, the doctrine of Inherited Association. Instinct in the present generation of animals is the product of the accumulated experiences of past generations. Great difficulty, however, is felt by many in conceiving how any thing so impalpable as fear at the sight of a bee should be transmitted from parent to offspring. It should be remembered, however, that the permanence of such associations in the history of an individual life depends on the corresponding impress given to the nervous organization. We cannot, strictly speaking, experience any individual act of consciousness twice over; but as, by pulling the bell-cord to-day we can, in the language of ordinary discourse, produce the same sound we heard yesterday, so, while the established connections among the nerves and nerve-centres hold, we are enabled to live our experiences over again. Now, why should not those modifications of brain-matter that, enduring from hour to hour and from day to day, render acquisition possible, be, like any other physical peculiarity, transmitted from parent to offspring? That they are so transmitted is all but proved by the facts of instinct, while these, in their turn, receive their only rational explanation in this theory of Inherited Association.—*Nature.*

THE STUDY OF SOCIOLOGY.

By HERBERT SPENCER.

VIII.—*The Educational Bias.*

IT would clear up our ideas about many things, if we distinctly recognized the truth that we have two religions. Primitive humanity has but one. The humanity of the remote future will have but one. The two are opposed; and we who live midway in the course of civilization have to believe in both.

These two religions are adapted to two conflicting sets of social requirements. The one set is supreme at the beginning; the other set will be supreme at the end; and a compromise has to be maintained between them during the progress from beginning to end. On the one hand, there is the necessity of social self-preservation in face of external enemies. On the other hand, there is the necessity of coöperation among fellow-citizens, which can exist only in proportion as fair dealing of man with man creates mutual trust. Unless the one necessity is met, the society disappears by extinction, or by absorption into some conquering society. Unless the other necessity is met, there cannot be that division of labor, exchange of services, consequent industrial progress and increase of numbers, by which a society is made strong enough to survive. In adjustment to these two antagonist necessities, there grow up two antagonist codes of duty; which severally acquire supernatural sanctions. And thus we get the two coexisting religions—the religion of enmity and the religion of amity.

Of course, I do not mean that these are both called religions. Here I am not speaking of names; I am speaking simply of things. Nowadays, men do not pay the same nominal homage to the religion of enmity that they do to the religion of amity—the religion of amity occupies the place of honor. But the real homage is paid in large measure, if not in the larger measure, to the religion of enmity. The religion of enmity nearly all men actually believe. The religion of amity most of them merely believe they believe. In some discussion, say, about international affairs, remind them of certain precepts contained in the creed they profess, and the most you get is a tepid assent. Now, let the conversation turn on the "tunding" at Winchester, or on the treatment of Indian mutineers, or on the Jamaica business; and you find that, while the precepts tepidly assented to were but nominally believed, quite opposite precepts are believed undoubtingly and defended with fervor.

Curiously enough, to maintain these antagonist religions, which in our transitional state are both requisite, we have adopted from two different races two different cults. From the books of the Jewish New Testament we take our religion of amity. Greek and Latin epics and histories serve as gospels for our religion of enmity. In the education of our youth we devote a small portion of time to the one, and a large portion of time to the other. And, as though to make the compromise effectual, these two cults are carried on in the same places by the same teachers. At our Public Schools, as also at many other schools, the same men are priests of both religions. The nobility of self-sacrifice, set forth in Scripture-lessons and dwelt on in sermons, is made conspicuous every seventh day; while during the other six days the nobility of sacrificing others is exhibited in glowing words. The sacred duty of blood-revenge, which, as existing savages show us, constitutes the religion of enmity in its primitive form—which, as shown us in ancient literature, is enforced by divine sanction, or rather by divine command, as well as by the opinion of men—is the duty which during the six days is deeply stamped on natures quite ready to receive it; and then something is done toward obliterating the stamp, when, on the seventh day, vengeance is interdicted.

A priori, it might be thought impossible that men should continue through life holding two doctrines which are mutually destructive. But their ability to compromise between conflicting beliefs is very remarkable—remarkable, at least, if we suppose them to put their conflicting beliefs side by side; not so remarkable if we recognize the fact that they do not put them side by side. A late distinguished physicist, whose science and religion seemed to his friends irreconcilable, retained both for the reason that he deliberately refused to compare the propositions of the one with those of the other. To speak in metaphor—when he entered his oratory he shut the door of his laboratory; and when he entered his laboratory he shut the door of his oratory. It is because they habitually do something similar, that men live so contentedly under this logically-indefensible compromise between their two creeds. As the intelligent child, propounding to his seniors puzzling theological questions, and meeting many rebuffs, eventually ceases to think about difficulties of which he can get no solutions; so, a little later, the contradictions between the things taught to him in school and in church, at first startling and inexplicable, become by-and-by familiar, and no longer attract his attention. Thus while growing up he acquires, in common with all around him, the habit of using first one and then the other of his creeds as the occasion demands; and at maturity the habit has become completely established. Now he enlarges on the need for maintaining the national honor, and thinks it mean to arbitrate about an aggression instead of avenging it by war; and now, calling his servants together, he reads a prayer in which he asks God that our trespasses may be forgiven as we forgive the trespasses against us. That which he prays for as a virtue on the Sunday, he scorns as a vice on the Monday.

The religion of amity and the religion of enmity, with the emotions they respectively enlist, are important factors in sociological conclusions; and rational sociological conclusions can be produced only when both sets of factors come into play. We have to look at each cluster of social facts as a phase in a continuous metamorphosis. We have to look at the conflicting religious beliefs and feelings included in this cluster of facts as elements in this phase. We have to do more. We have to consider as transitional, also, the conflicting religious beliefs and feelings in which we are brought up, and which distort our views, not only of passing phenomena in our own society, but also of phenomena in other societies and in other times; and the aberrations they cause in our inferences have to be sought for and rectified. Of these two religions taught us, we must constantly remember that during civilization the religion of enmity is slowly losing strength, while the religion of amity is slowly gaining strength. We must bear in mind that at each stage a certain ratio between them has to be maintained. We must infer that the existing ratio is only a temporary one, and that the accompanying bias to this or that conviction respecting social affairs is temporary. And if we are to reach those unbiassed convictions which form parts of the Social Science, we can do it only by allowing for this temporary bias—only by analyzing and criticising the sentiments and dogmas they respectively sanctify, with the view of discovering how far these need qualification.

To see how greatly our opposite religions respectively pervert sociological beliefs, and how needful it is that the opposite perversions they cause should be corrected, we must here contemplate the extremes to which men are carried, now by the one and now by the other.

As from antagonist physical forces, as from antagonist emotions in each man, so from the antagonist social tendencies men's emotions create, there always results, not a medium state, but a rhythm between opposite states. The one force or tendency is not continuously counterbalanced by the other force or tendency; but now the one greatly predominates, and presently by reaction there comes a predominance of the other. That which we are shown by variations in the prices of stocks, shares, or commodities, occurring daily, weekly, and in longer intervals—that which we observe in the alternation of manias and panics, caused by irrational hopes and absurd fears—that which diagrams of these variations express by the ascents and descents of a line, now to a great height and now to an equivalent depth, we discover in all social phenomena, moral and religious included. It is exhibited on a large scale and on a small scale—by rhythms extending over centuries and by rhythms of short periods. And we see it, not only in waves of conflicting feelings and opinions pervading societies as wholes, but also in the opposite excesses gone to by individuals and sects in the same society at the same time. There is never a balanced judgment and a balanced action, but always a cancelling of one another by contrary errors: "Men pair off in insane parties," as Emerson puts it. Something like rationality is finally obtained as a product of mutually-destructive irrationalities. As, for example, in the treatment of our criminals, there alternates or coexists an unreasoning severity with an unreasoning lenity: now we punish in a spirit of vengeance, now we pamper with a maudlin sympathy. At no time is there a due adjustment of penalty to transgression such as the course of Nature shows us—an inflicting of neither more nor less evil than the reaction which the action causes.

The religion of unqualified altruism, coming as it did to correct by an opposite excess the religion of unqualified egoism, exhibits to us this general law on a great scale. Against the doctrine of entire selfishness it sets the doctrine of entire self-sacrifice. In place of the aboriginal creed not requiring you to love your fellow-man at all, but insisting only that certain of your fellow-men you shall hate even to the death, there comes a creed directing that you shall in no case do any thing prompted by hate of your fellow-man, but shall love him as yourself. Nineteen centuries have since wrought some compromise between these opposite creeds. It has never been rational, however, but only empirical—mainly, indeed, unconscious compromise. There is not yet a distinct recognition of what truth each extreme stands for, and a perception that the two truths must be coördinated; but there is little more than a partial rectifying of excesses one way by excesses the other way. By these persons purely-egoistic lives are led. By those, altruism is carried to the extent of bringing on ill health and premature death. Even on comparing the acts of the same individual, we find, not an habitual balance between the two tendencies, but now an effort to inflict great evil on some foreign aggressor or some malefactor at home, and now a disproportioned sacrifice on behalf of one often quite unworthy of it. That altruism is right, but that egoism is also right, and that there requires a continual compromise between the two, is a conclusion which but few consciously formulate and still fewer avow.

Yet the untenability of the doctrine of self-sacrifice in its extreme form is conspicuous enough; and is tacitly admitted by all in their ordinary inferences and daily actions. Work, enterprise, invention, improvement, as they have gone on from the beginning and are going on now, depend on the principle that, among citizens severally having unsatisfied wants, each cares more to satisfy his own wants than to satisfy the wants of others. The fact, that industrial activities proceed on this basis, being recognized, the inevitable implication is that unqualified altruism would dissolve all existing social organizations: leaving the onus of proof that absolutely-alien social organizations would act. That they would not act becomes clear on supposing the opposite principle in force. Were A to be careless of himself, and to care only for the welfare of B, C, and D, while each of these, paying no attention to his own needs, busied himself in supplying the needs of the others, this roundabout process, besides being troublesome, would very ill meet the requirements of each, unless each could have his neighbor's consciousness. And after observing this we must infer that a certain predominance of egoism over altruism is beneficial, and that in fact no other arrangement would answer. Do but ask what would happen if, of A, B, C, D, etc., each declined to have a gratification, in his anxiety that some one else should have it, and that the some one else similarly persisted in refusing it out of sympathy with his fellows—do but contemplate the resulting confusion and cross-purposes and loss of gratification to all, and you will see that pure altruism would bring things to a dead-lock just as much as pure egoism. In truth, nobody ever dreams of acting out the altruistic theory in all the relations of life. The Quaker who proposes to accept literally, and to practise, the precepts of Christianity, carries on his business on egoistic principles just as much as his neighbors. Though, nominally, he holds that he is to take no thought for the morrow, his thought for the morrow betrays as distinct an egoism as that of men in general; and he is conscious that to take as much thought for the morrows of others would be ruinous to him and eventually mischievous to all.

While, however, no one is entirely altruistic—while no one really believes an entirely altruistic life to be practicable, there continues the tacit assertion that conduct *ought* to be entirely altruistic. It does not seem to be suspected that pure altruism is actually wrong. Brought up, as each is, in the nominal acceptance of a creed which wholly subordinates egoism to altruism, and gives sundry precepts that are absolutely altruistic, each citizen, while ignoring these in his business, and tacitly denying them in various opinions he utters, daily gives to them lip-homage, and supposes that acceptance of them is required of him though he finds it impossible. Feeling that he cannot call them in question without calling in question his religion as a whole, he pretends to others and to himself that he believes them—believes things which in his innermost consciousness he knows he does not believe. He professes to think that entire self-sacrifice must be right, though dimly conscious that it would be fatal.

If he had the courage to think out clearly what he vaguely perceives, he would discover that self-sacrifice, passing a certain limit, entails evil on all—evil on those for whom sacrifice is made as well as on those who make it. While a continual giving-up of pleasures and continual submission to pains is physically injurious, so that its final outcome is debility, disease, and abridgment of life, the continual acceptance of benefits at the expense of a fellow-being is morally injurious. Just as much as unselfishness is cultivated by the one, selfishness is cultivated by the other. If to surrender a gratification to another is noble, readiness to accept the gratification so surrendered is ignoble; and if repetition of the one kind of act is elevating, repetition of the other kind of act is degrading. So that, though up to a certain point altruistic action blesses giver and receiver, beyond that point it curses giver and receiver—physically deteriorates the one and morally deteriorates the other. Every one can remember cases where greediness for pleasures, reluctance to take trouble, and utter disregard of those around, have been perpetually increased by unmeasured and ever-ready kindnesses; while the unwise benefactor has shown by languid movements and pale face the debility consequent on disregard of self: the outcome of the policy being destruction of the worthy in making worse the unworthy.

The absurdity of unqualified altruism becomes, indeed, glaring enough on remembering that it can be extensively practised only if in the same society there coexist one moiety altruistic and one moiety egoistic. Only those who are intensely selfish will allow their fellows habitually to behave to them with extreme unselfishness. If all are duly regardful of others, there are none to accept the sacrifices which others are ready to make. If a high degree of sympathy characterizes all, no one can be so unsympathetic as to let another receive positive or negative injury that he may benefit. So that pure altruism in a society implies a nature which makes pure altruism impossible, from the absence of those toward whom it may be exercised!

Equally untenable does the doctrine show itself when looked at from another point of view. If life and its gratifications are valuable in another, they are equally valuable in self. There is no total increase of happiness if as much is gained by one as is lost by another; and if, as continually happens, the gain is not equal to the loss—if the recipient, already inferior, is further demoralized by habitual acceptance of sacrifices, and so made less capable of happiness (which he inevitably is)—the total amount of happiness is diminished: benefactor and beneficiary are both losers.

The maintenance of the individuality is thus demonstrably a duty. The assertion of personal claims is essential; both as a means to self-happiness, which is a unit in the general happiness, and as a means to furthering the general happiness altruistically. Resistance to aggression is not simply justifiable but imperative. Non-resistance is at variance with altruism and egoism alike. The extreme Christian theory, which no one acts upon, which no one really believes, but which most tacitly profess and a few avowedly profess, is as logically indefensible as it is impracticable.

The religion of amity, then, taken by itself, is incomplete—it needs supplementing. The doctrines it inculcates and the sentiments it fosters, arising by reactions against opposite doctrines and sentiments, run into extremes the other way.

Let us now turn to these opposite doctrines and sentiments, inculcated and fostered by the religion of enmity, and note the excesses to which they run.

Worthy of highest admiration is the "Tasmanian devil," which, fighting to the last gasp, snarls with its dying breath. Admirable, too, though less admirable, is our own bull-dog—a creature said sometimes to retain its hold even when a limb is cut off. To be admired also for their "pluck," perhaps nearly in as great a degree, are some of the carnivora, as the lion and the tiger; since when driven to bay they fight against great odds. Nor should we forget the game-cock, supplying as it does a word of eulogy to the crowd who witness the hanging of a murderer, and who half condone his crime if he "dies game." Below these animals come mankind; some of whom, indeed, as the American Indians, bear tortures without groaning. And then, considerably lower, must be placed the civilized man; who, fighting up to a certain point, and bearing considerable injury, ordinarily yields when further fighting is useless.

Is the reader startled by this classification? Why should he be? It is but a literal application of that standard of worth tacitly assumed by most, and by some deliberately avowed. Obviously it is the standard of worth believed in by M. Gambetta, who, after bloodshed carried to the extent of prostrating France, lately reproached the French Assembly by saying, "You preferred peace to honor; you gave five milliards and two provinces." And there are not a few among ourselves who so thoroughly agree in M. Gambetta's feeling, that this utterance of his has gone far to redeem him in their estimation. If the reader needs encouragement to side with such, plenty more may be found for him. The Staffordshire collier, enjoying the fighting of dogs when the fighting of men is not to be witnessed, would doubtless take the same view. In the slums of Whitechapel and St. Giles's, among leaders of "the fancy," it is an unhesitating belief that pluck and endurance are the highest of attributes; and probably most readers of *Bell's Life in London* would concur in this belief. Moreover, if he wants further sympathy to support him, he may find entire races ready to give it; especially that noble race of cannibals, the Feejeeans, among whom bravery is so highly honored that, on their return from battle, the triumphant warriors are met by the women, who place themselves at their unrestricted disposal. So that whoever inclines to adopt this measure of superiority will find many to side with him—that is, if he likes his company.

Seriously, is it not amazing that civilized men should especially pride themselves on a quality in which they are exceeded by inferior varieties of their own race, and still more exceeded by inferior animals? Instead of regarding a man as manly in proportion as he possesses moral attributes distinctively human, we regard him as manly in proportion as he shows an attribute possessed in greater degrees by beings from whom we derive our words of contempt. It was lately remarked by Mr. Greg that we take our point of honor from the prize-ring; but we do worse—we take our point of honor from beasts. Nay, we take it from a beast inferior to those we are familiar with; for the "Tasmanian devil," in structure and intelligence, stands on a much lower level of brutality than our lions and bull-dogs.

That resistance to aggression is to be applauded, and that the courage implied by resistance is to be valued and admired, may be fully admitted while denying that courage is to be regarded as the supreme virtue. A large endowment of it is essential to a complete nature; but so are large endowments of other things which we do not therefore make our measures of worth. A good body, well grown, well proportioned, and of such quality in its tissues as to be enduring, should bring, as it does bring, its share of admiration. Admirable, too, in their ways, are good stomach and lungs, as well as a vigorous vascular system; for without these the power of self-preservation and the power of preserving others will fall short. To be a fine animal is, indeed, essential to many kinds of achievement; and courage, which is a general index of an organization capable of satisfying the requirements, is rightly valued for what it implies. Courage is, in fact, a feeling that grows by accumulated experiences of successful dealings with difficulties and dangers; and these successful dealings are proofs of competence in strength, agility, quickness, endurance, etc. No one will deny that perpetual failures, resulting from incapacity of one kind or other, produce discouragement; or that repeated triumphs, which are proofs of capacity, so raise the courage that there comes a readiness to encounter greater difficulties. The fact that a dose of brandy, by stimulating the circulation, produces "Dutch courage," as it is called, joined with the fact well known to medical men, that heart-disease brings on timidity, is of itself enough to show that bravery is the natural correlative of ability to cope with circumstances of peril. But while we are thus taught that, in admiring courage, we are admiring physical superiorities and those superiorities of mental faculty which give fitness for dealing with emergencies, we are also taught that, unless we rank highest the bodily powers and those powers which directly conduce to self-preservation, we cannot say that courage is the highest attribute, and that the degree of it should be our standard of honor.

That an over-estimate of courage is appropriate to our phase of civilization may be very true. It is beyond doubt that, during the struggle for existence among nations, it is needful that men should admire extremely the quality without which there can be no success in the struggle. While, among neighboring nations, we have one in which all the males are trained for war—while the sentiment of this nation is such that students slash one another's faces in duels about trifles, and are admired for their scars, especially by women—while the military ascendency it tolerates is such that, for ill-usage by soldiers, ordinary citizens have no adequate redress—while the government is such that, though the monarch as head of the Church condemns duelling as irreligious, and as head of the Law forbids it as a crime, yet as head of the army he insists on it to the extent of expelling officers who will not fight duels—while, I say, we have a neighboring nation thus characterized, something of a kindred character in appliances, sentiments, and beliefs, has to be maintained among ourselves. When we find another neighboring nation believing that no motive is so high as the love of glory, and no glory so great as that gained by successful war—when we perceive the military spirit so pervading this nation that it loves to clothe its children in *quasi*-military costume—when we find one of its historians writing that the French army is the great civilizer, and one of its generals lately saying that the army is the soul of France—when we see that the vital energies of this nation run mainly to teeth and claws, and that it quickly grows new sets of teeth and claws in place of those pulled out; it is needful that we, too, should keep our teeth and claws in order, and should maintain ideas and feelings adapted to the effectual use of them. There is no gainsaying the truth that, while the predatory instincts continue prompting nations to rob one another, destructive agencies must be met by antagonist destructive agencies; and, that this may be done, honor must be given to the men who act as destructive agents, and there must be an exaggerated estimate of the attributes which make them efficient.

It may be very needful, therefore, that our boys should be accustomed to harsh treatment, giving and receiving brutal punishments without too nice a consideration of their justice. It may be that, as the Spartans and as the North-American Indians, in preparation for warfare, subjected their young men to tortures, so should we; and thus, perhaps, the "education of a gentleman" may properly include giving and receiving "hacking" of the shins at foot-ball: boot-toes being purposely made heavy that they may inflict greater damage. So, too, it may be well that boys should all in turn be subject to the tender mercies of elder boys, with whose thrashings and kickings the masters decline to interfere; even though they are sometimes carried to the extent of maiming for life. Possibly, too, it is needful that each boy should be disciplined in submission to any tyrant who may be set over him, by finding that appeal brings additional evils. That each should be made callous, morally as well as physically, by the bearing of frequent wrongs, and should be made yet more callous when, coming into power, he inflicts punishments as whim or spite prompts, may also be desirable. Nor, perhaps, can we wholly regret that confusion of moral ideas which results when breaches of conventional rules bring penalties as severe as are brought by acts morally wrong. For war does not consist with keen sensitiveness, physical or moral. Reluctance to inflict injury, and reluctance to risk injury, would equally render it impossible. Scruples of conscience respecting the rectitude of their cause would paralyze officers and soldiers. So that a certain brutalization has to be maintained during our passing phase of civilization. It may, indeed, be that "the Public School spirit," which, as truly said, is carried into our public life, is not the most desirable for a free country. It may be that early subjection to despotism, and early exercise of uncontrolled power, are not the best possible preparations for legislators. It may be that those, who, on the magistrate's bench, have to maintain right against might, could be better trained than by submission to violence and subsequent exercise of violence. And it may be that some other discipline than that of the stick would be desirable for men who officer the press and guide public opinion on questions of equity. But, doubtless, while national antagonisms continue strong and national defence a necessity, there is a fitness in this semi-military discipline, with pains and bruises to uphold it. And a duly-adapted code of honor has the like defence.

Here, however, if we are to free ourselves from transitory sentiments and ideas, so as to be capable of framing scientific conceptions, we must ask what warrant there is for this exaltation of the destructive activities and of the qualities implied by them? We must ask how it is possible for men rightly to pride themselves on attributes possessed in a higher degree by creatures so much lower? We must consider whether, in the absence of a religious justification, there is any ethical justification for the idea that the most noble traits are such as cannot be displayed without the infliction of pain and death. When we do this, we are obliged to admit that the religion of enmity in its unqualified form is as indefensible as the religion of amity in its unqualified form. Each proves itself to be one of those insane extremes out of which there comes a sane mean by union with its opposite. The two religions stand respectively for the claims of self and the claims of others. The one religion holds it glorious to resist aggression, and, while risking death in doing this, to inflict death upon others. The other religion teaches that the glory is in not resisting aggression, and in yielding to others while not asserting the claims of self. A civilized humanity will render the one glory just as impossible of achievement as the other. A diminishing egoism and an increasing altruism must make each of these opposite kinds of honor unattainable. For such an advance implies a cessation of those aggressions which make possible the nobility of resistance; while it implies a refusal to accept those sacrifices without which there cannot be the nobility of self-sacrifice. The two extremes must cancel; leaving a moral code and a standard of honor free from irrational excesses. Along with a latent self-assertion, there will go a readiness to yield to others, kept in check by the refusal of others to accept more than their due.

And now, having noted the perversions of thought and sentiment fostered by the religion of amity and the religion of enmity, under which we are educated in so chaotic a fashion, let us go on to note the ways in which these affect sociological conceptions. Certain important truths, apt to be shut out from the minds of the few who are unduly swayed by the religion of amity, may first be set down.

One of the facts difficult to reconcile with current theories of the Universe is, that high organizations, throughout the animal kingdom, habitually serve to aid destruction or to aid escape from destruction. If we hold to the ancient view, we must say that high organization has been deliberately devised for such purposes. If we accept the modern view, we must say that high organization has been evolved by the exercise of destructive activities during immeasurable periods of the past. Here we choose the last alternative. To the never-ceasing efforts to catch and eat, and the never-ceasing endeavors to avoid being caught and eaten, is to be ascribed the development of the various senses and the various motor organs directed by them. The bird of prey with the keenest vision has, other things equal, survived when members of its species that did not see so far died from want of food; and, by such survivals, keenness of vision has been made greater in course of generations. The fleetest members of an herbivorous herd, escaping when the slower fell victims to a carnivore, left posterity; among which, again, those with the most perfectly-adapted limbs survived: the carnivores themselves being at the same time similarly disciplined and their speed increased. So, too, with intelligence. Sagacity that detected a danger which stupidity did not perceive, lived and propagated; and the cunning which hit upon a new deception, and so secured prey not otherwise to be caught, left posterity where a smaller endowment of cunning failed. This mutual perfecting of pursuer and pursued, acting upon their entire organizations, has been going on throughout all time; and human beings have been subject to it just as much as other beings. Warfare among men, like warfare among animals, has had a large share in raising their organizations to a higher stage. Here are some of the various ways in which it has worked:

In the first place, it has had the effect of continually extirpating races which, for some reason or other, were least fitted to cope with the conditions of existence they were subject to. The killing-off of relatively-feeble tribes, or tribes relatively wanting in endurance, or courage, or sagacity, or power of coöperation, must have tended ever to maintain, and occasionally to increase, the amounts of life-preserving powers possessed by men.

Beyond this average advance caused by destruction of the least-developed races and the least-developed individuals, there has been an average advance caused by inheritance of those further developments due to functional activity. Remember the skill of the Indian in following a trail, and remember that under kindred stimuli many of his perceptions and feelings and bodily powers have been habitually taxed to the uttermost, and it becomes clear that the struggle for existence between neighboring tribes has had an important effect in cultivating faculties of various kinds. Just as, to take an illustration from among ourselves, the skill of the police cultivates cunning among burglars, which, again, leading to further precautions, generates further devices to evade them; so, by the unceasing antagonisms between human societies, small and large, there has been a mutual culture of an adapted intelligence, a mutual culture of certain traits of character not to be undervalued, and a mutual culture of bodily powers.

A large effect, too, has been produced upon the development of the arts. In responding to the imperative demands of war, industry made important advances and gained much of its skill. Indeed, it may be questioned whether, in the absence of that exercise of manipulative faculty which the making of weapons originally gave, there would ever have been produced the tools required for developed industry. If we go back to the Stone-Age, we see that implements of the chase and implements of war are those showing most labor and dexterity. If we take still-existing human races which were without metals when we found them, we see in their skilfully-wrought stone clubs, as well as in their large war-canoes, that the needs of defence and attack were the chief stimuli to the cultivation of arts afterward available for productive purposes. Passing over intermediate stages, we may note in comparatively-recent stages the same relation. Observe a coat-of-mail, or one of the more highly-finished suits of armor—compare it with articles of iron and steel of the same date; and there is evidence that these desires to kill enemies and escape being killed, more extreme than any other, have had great effects on those arts of working in metal to which most other arts owe their progress. The like relation is shown us in the uses made of gunpowder. At first a destructive agent, it has become an agent of immense service in quarrying, mining, railway-making, etc.

A no less important benefit, bequeathed by war, has been the formation of large societies. By force alone were small nomadic hordes welded into large tribes; by force alone were large tribes welded into small nations; by force alone have small nations been welded into large nations. While the fighting of societies usually maintains separateness, or by conquest produces only temporary unions, it produces, from time to time, permanent unions; and as fast as there are formed permanent unions of small into large, and then of large into still larger, industrial progress is furthered in three ways. Hostilities, instead of being perpetual, are broken by intervals of peace. When they occur, hostilities do not so profoundly derange the industrial activities. And there arises the possibility of carrying out the division of labor much more effectually. War, in short, in the slow course of things, brings about a social aggregation which furthers that industrial state at variance with war; and yet nothing but war could bring about this social aggregation. These two truths, that without war large aggregates of men cannot be formed, and that without large aggregates of men there cannot be a developed industrial state, are illustrated in all places and times. Among existing uncivilized and semi-civilized races, we everywhere find that union of small societies by a conquering society is a step in civilization. The records of peoples now extinct show us this with equal clearness. On looking back into our own history, and into the histories of neighboring nations, we similarly see that only by coercion were the smaller feudal governments so subordinated as to secure internal peace. And, even lately, the long-desired consolidation of Germany, if not directly effected by "blood and iron," as Bismarck said it must be, has been indirectly effected by them. The furtherance of industrial development by aggregation is no less manifest. If we compare a small society with a large one, we get clear proof that those processes of coöperation by which social life is made possible assume high forms only when the numbers of the coöperating citizens are great. Ask of what use a cloth-factory, supposing they could have one, would be to the members of a small tribe, and it becomes manifest that, producing as it would in a single day a year's supply of cloth, the vast cost of making it and keeping it in order could never be compensated by the advantage gained. Ask what would happen were a shop like Stewart's, in New York, supplying all textile products, set up in a village, and you see that the absence of a sufficiently-extensive distributing function would negative its continuance. Ask what sphere a bank would have had in the Old-English period, when nearly all people grew their own food and wove their own wool, and it becomes obvious that the various appliances for facilitating exchange can grow up only when a community becomes so large that the amount of exchange to be facilitated is great. Hence, unquestionably, that integration of societies effected by war has been a needful preliminary to industrial development, and consequently to developments of other kinds—Science, the Fine Arts, etc.

Industrial habits too, and habits of subordination to social requirements, are indirectly brought about by the same cause. The truth that the power of working continuously, wanting in the aboriginal man, could be established only by that persistent coercion to which conquered and enslaved tribes are subject, has become trite. An allied truth is, that only by a discipline of submission, first to an owner, then to a personal governor, presently to government less personal, then to the embodied law proceeding from government, could there eventually be reached submission to that code of moral law by which the civilized man is more and more restrained in his dealings with his fellows.

Such being some of the important truths usually ignored by men too exclusively influenced by the religion of amity, let us now glance at the no less important truths to which men are blinded by the religion of enmity.

Though, during barbarism and the earlier stages of civilization, war has the effect of exterminating the weaker societies, and of weeding out the weaker members of the stronger societies, and thus in both ways furthering the development of those valuable powers, bodily and mental, which war brings into play; yet, during the later stages of civilization, the second of these actions is reversed. So long as all adult males have to bear arms, the average result is that those of most strength and quickness survive, while the feebler and slower are slain; but when the industrial development has become such that only some of the adult males are draughted into the army, the tendency is to pick out and expose to slaughter the best-grown and healthiest; leaving behind the physically inferior to propagate the race. The fact that among ourselves, though the number of soldiers raised is not relatively large, many recruits are rejected by the examining surgeons, shows that the process inevitably works toward deterioration. Where, as in France, conscriptions have gone on generation after generation, taking away the finest men, the needful lowering of the standard proves how disastrous is the effect on those animal qualities of a race which form a necessary basis for all higher qualities. If the depletion is indirect also—if there is such an overdraw on the energies of the industrial population that a large share of heavy labor is thrown on the women, whose systems are taxed simultaneously by hard work and child-bearing, a further cause of physical degeneracy comes into play: France again supplying an example. War, therefore, after a certain stage of progress, instead of furthering bodily development and the development of certain mental powers, becomes a cause of retrogression.

In like manner, though war, by bringing about social consolidations, indirectly favors industrial progress and all its civilizing consequences, yet the direct effect of war on industrial progress is repressive. It is repressive as necessitating the abstraction of men and materials that would otherwise go to industrial growth; it is repressive as deranging the complex interdependencies among multitudinous, productive, and distributive agencies; it is repressive as draughting off much administrative and constructive ability, which would else have gone to improve the industrial arts and the industrial organization. And if we contrast the absolutely-military Spartans with the partially-military Athenians in their respective attitudes toward culture of every kind, or call to mind the contempt shown for the pursuit of knowledge in purely-military times like those of feudalism, we cannot fail to see that predominant warlike activity is at variance not only with industrial development, but also with the higher intellectual developments that aid it and are aided by it.

So, too, with the effects wrought on the moral nature. While war, by the discipline it gives soldiers, directly cultivates the habit of subordination, and does the like indirectly by establishing strong and permanent governments; and while in so far it cultivates attributes that are not only temporarily essential, but are steps toward attributes that are permanently essential; yet it does this at the cost of maintaining, and sometimes increasing, detrimental attributes—attributes intrinsically antisocial. The aggressions which selfishness prompts—aggressions which, in a society, have to be restrained by some power that is strong in proportion as the selfishness is intense, can diminish only as fast as selfishness is held in check by sympathy; and perpetual warlike activities repress sympathy: nay, they do worse—they cultivate aggressiveness to the extent of making it a pleasure to inflict injury. The citizen made callous by the killing and wounding of enemies, inevitably brings his callousness with him into society. Fellow-feeling, habitually trampled out in military conflicts, cannot at the same time be active in the relations of civil life. In proportion as the giving pain to others is made a habit during war, it will remain a habit during peace: inevitably producing, in the behavior of citizens to one another, antagonisms, crimes of violence, and multitudinous aggressions of minor kinds, tending toward a disorder that calls for a coercive government. Nothing like a high type of social life is possible without a type of human character in which the promptings of egoism are duly restrained by regard for others. The necessities of war imply absolute self-regard and absolute disregard of certain others. Inevitably, therefore, the civilizing discipline of social life is antagonized by the uncivilizing discipline of the life war involves. So that, beyond the direct mortality and miseries entailed by war, it entails other mortality and miseries by maintaining antisocial sentiments in citizens.

Taking the most general view of the matter, we may say that only when the sacred duty of blood-revenge, constituting the religion of the savage, becomes less sacred, does there arise a possibility of emergence from the deepest barbarism. Only as fast as the retaliation, which for a murder on one side inflicts a murder or murders on the other, becomes less imperative, is it possible for larger aggregates of men to hold together and civilization to commence. And so, too, out of lower stages of civilization higher ones can emerge, only as there diminishes this pursuit of international revenge and re-revenge, which the code we inherit from the savage insists upon. Such advantages, bodily and mental, as the race derives from the discipline of war, are outbalanced by the disadvantages, physical and moral, but especially moral, which result after a certain stage of progress is reached. Severe and bloody as the process is, the killing-off of inferior races and inferior individuals leaves a balance of benefit to mankind during phases of progress in which the moral development is low, and there are no quick sympathies to be continually seared by the infliction of pain and death. But as there arise higher types of societies, implying types of individual character fitted for closer coöperation, the destructive activities exercised by such higher societies have injurious reactive effects on the moral natures of their members, which outweigh the benefit resulting from extirpation of inferior races. After this stage has been reached, the purifying process, continuing still an important one, remains to be carried on by industrial war—by a competition of societies during which the best, physically, emotionally, and intellectually, spread most, and leave the least capable to disappear gradually, from failing to leave an adequately-numerous posterity.

Those educated in the religion of enmity—those who during boyhood, when the instincts of the savage are dominant, have revelled in the congenial ideas and sentiments which classic poems and histories yield so abundantly, and have become confirmed in the belief that war is virtuous and peace ignoble—are naturally blind to truths of this kind. Rather should we say, perhaps, that they have never turned their eyes in search of such truths. And their bias is so strong that nothing more than a nominal recognition of such truths is possible to them; if even this. What perverted conceptions of sociological phenomena this bias produces, may be seen in the following passage from Gibbon:

> "It was scarcely possible that the eyes of contemporaries should discover in the public felicity the causes of decay and corruption. *The long peace, and the uniform government of the Romans*, had introduced a slow and secret poison into the vitals of the empire."[1]

In which sentences there is involved the abstract proposition that in proportion as men are long held together in that mutual dependence

[1] "Decline and Fall," chapter ii.

which social coöperation implies, they will become less fit for mutual dependence and coöperation—the society will tend toward dissolution. While, in proportion as they are habituated to antagonism and to destructive activities, they will become better adapted to activities requiring union and agreement.

Thus the two opposite codes in which we are educated, and the sentiments enlisted on behalf of their respective precepts, inevitably produce misinterpretations of social phenomena. Instead of acting together, now this and now the other sways the beliefs; and, instead of consistent, balanced conclusions, there results a jumble of contradictory conclusions.

It is time, not only with a view to right thinking in social science, but with a view to right acting in daily life, that this acceptance in their unqualified forms, of two creeds which contradict one another completely, should come to an end. Is it not a folly to go on pretending to ourselves and others that we believe certain perpetually-repeated maxims of entire self-sacrifice, which we daily deny by our business activities, by the steps we take to protect our persons and property, by the approval we express of resistance against aggression? Is it not a dishonesty to repeat, in tones of reverence, maxims which we not only refuse to act out, but dimly see would be mischievous if acted out? Every one must admit that the relation between parent and child is one in which altruism is pushed as far as is practicable. Yet even here there needs a predominant egoism. The mother can suckle her infant only on condition that she has habitually gratified her appetite in due degree. And there is a point beyond which sacrifice of herself is fatal to her infant. The bread-winner, too, on whom both depend—is it not undeniable that wife and child can be altruistically treated by their protector, only on condition that he is duly egoistic in his transactions with his fellow-citizens? If the dictate, "Live for self," is wrong in one way, the opposite dictate, "Live for others," is wrong in another way. The rational dictate is—live for self and others. And, if we all do actually believe this, as our conduct conclusively proves, is it not better for us distinctly to say so, rather than continue enunciating principles which we do not and cannot practise; and thus bringing moral teaching itself into discredit?

On the other hand, it is time that a ferocious egoism, which remains unaffected by this irrational altruism, hypocritically professed but not believed, should be practically modified by a rational altruism. This sacred duty of blood-revenge, insisted on by the still-vigorous religion of enmity, needs qualifying actually and not verbally. Instead of senselessly reiterating in catechisms and church services the duty of doing good to those that hate us, while an undoubting belief in the duty of retaliation is implied by our parliamentary debates, the articles in our journals, and the conversations over our tables, it would be wiser and more manly to consider how far the first should go in mitigation of the last. Is it stupidity or is it moral cowardice which leads men to continue professing a creed that makes self-sacrifice a cardinal principle, while they urge the sacrificing of others, even to the death, when they trespass against us? Is it blindness, or is it an insane inconsistency, which makes them regard as most admirable the bearing of evil for the benefit of others, while they lavish admiration on those who, out of revenge, inflict great evils in return for small ones suffered? Surely our barbarian code of right needs revision, and our barbarian standard of honor should be somewhat changed. Let us deliberately recognize what good they represent and what mixture of bad there is with it. Courage is worthy of respect when displayed in the maintenance of legitimate claims and in the repelling of aggressions, bodily or other. Courage is worthy of yet higher respect when danger is faced in defence of claims common to self and others, as in resistance to invasion. Courage is worthy of the highest respect when risk to life or limb is dared in defence of others; and becomes grand when those others have no claims of relationship, and still more when they have no claims of race. But though a bravery which is altruistic in its motive is a trait we cannot too highly applaud, and though a bravery which is legitimately egoistic in its motive is praiseworthy, the bravery that is prompted by aggressive egoism is not praiseworthy. The admiration accorded to the "pluck" of one who fights in a base cause is a vicious admiration, essentially demoralizing to those who feel it. Like the physical powers, courage, which is a concomitant of these, is to be regarded as a servant of the higher emotions—very valuable, indispensable even, in its place; and to be honored when discharging its function in subordination to these higher emotions. But otherwise not more to be honored than the like attribute as seen in brutes.

Quite enough has been said to show that there must be a compromise between the opposite standards of conduct on which the religions of amity and enmity respectively insist, before there can be scientific conceptions of social phenomena. Even on passing affairs, such as the proceedings of philanthropic bodies and the dealings of nation with nation, there cannot be rational judgments without a balance between the self-asserting emotions and the emotions which put a limit to self-assertion, with an adjustment of the corresponding beliefs. Still less can there be rational judgments of past social evolution, or of social evolution in the future, if the opposing actions which these opposing creeds sanction are not both continuously recognized as essential. No mere impulsive recognition, now of the purely-egoistic doctrine and now of the purely-altruistic one, will suffice. The curve described by a planet cannot be understood by thinking at one moment of the centripetal force and at another moment of the tangential force; but the two must be kept before consciousness as acting simultaneously. And similarly, to understand social progress in the vast sweep of its course, there must be ever present to the mind the egoistic and the altruistic forces as coöperative factors equally indispensable, and neither of them to be ignored or reprobated.

The criticism likely to be passed on this chapter, that "The Educational Bias" is far too comprehensive a title for it, is quite justifiable. There are in truth few, if any, of the several kinds of bias, that are not largely, or in some measure, caused by education—using this word in an extended sense. As, however, all of them could not be dealt with in one chapter, it seemed best to select these two opposite forms of bias which are so directly traceable to teachings of opposite dogmas, and fosterings of opposite sentiments, during early life. Merely recognizing the fact that education has much to do with the other kinds of bias, we may now most conveniently deal with these, each under its specific title.

THE STRENGTH OF TIMBER.[1]

By JOHN ANDERSON, C. E., LL. D., F. R. S. E.

ALTHOUGH it is of less importance to investigate the strength of timber at the present time than it was formerly, in consequence of the diminished use of that material in permanent structures, and the more general employment of iron, still it will always be a very valuable material for certain purposes, and ought not to be neglected. Timber is variously used, even now, in permanent works, and is applied much more extensively in temporary structures—such as centerings and scaffolding. Hence its properties are well worthy of careful attention; and the student should be familiar, not only with the external appearance of the principal kinds of wood, but also with their relative strength, stiffness, toughness, and durability.

One of the most obvious inferences to be drawn from the experiments previously recorded is, that very wide variations exist in the strength and other elastic properties of different metals, and even of different specimens of the same metal. If we could investigate the properties of timber with the same care which has been bestowed on the metals, we should find that there is an even greater variation in the properties of different kinds of wood. This arises, in part, from the fact that timber is much affected by a number of external and internal conditions, during its growth and seasoning, and in its subsequent treatment, which gradually modify and change its properties.

[1] From "Strength of Materials and Structures." D. Appleton & Co.

It will only be necessary here to speak of the powers of resistance of a few among the many kinds of wood now employed in the mechanical arts. The greater number of the varieties of wood owe their commercial value to special characteristics, such as beauty of grain and capability of being polished—the description of which does not fall within the scope of the present article.

As a general rule, we may judge of the hardness of a wood by its specific gravity, if it is in its natural state. But the density may be increased by artificial compression, and this increase of density is generally accompanied by increase of strength. Some varieties of wood, as, for instance, *lignumvitæ*, are so dense that they sink in water, while some of the softer woods have not half the density of that fluid. The presence of gum or resin in any wood adds both to its strength and durability. Many woods will last a long time if kept constantly under water, but scarcely any wood is very durable when allowed to become wet and dry alternately.

The strength of a piece of timber depends upon the part of the tree from which it is taken. Up to a certain age, the heart of the tree is the best; after that period, it begins to fail gradually. The worst part of a tree is the sap-wood, which is next the bark. It is softer than the other parts of the wood, and is liable to premature decay. The deleterious component of the sap-wood is absorbed, if the tree is allowed to grow for a longer period, and in time the old sap-wood becomes proper timber-fibre similar to heart-wood. Hence, the goodness of a tree, for timber purposes, depends on the age at which the tree was cut down. When young, the heart-wood is the best; at maturity, with the exception of the sap-wood, the trunk is equally good throughout; and, when the tree is allowed to grow too long, the heart-wood is the first to show symptoms of weakness, and deteriorates gradually.

The best timber is secured by felling the tree at the age of maturity, which depends on its nature as well as on the soil and climate. The ash, beech, elm, and fir, are generally considered at their best when of 70 or 80 years' growth, and the oak is seldom at its best in less time than 100 years, but much depends on surrounding circumstances. As a rule, trees should not be cut before arriving at maturity, because there is then too much sap-wood, and the durability of the timber is much inferior to that of trees felled after they have arrived at their full development.

The strength of many woods is nearly doubled by the process of seasoning, hence it is very thriftless to use timber in a green state, as it is not only weak, but is exposed to continual change of bulk, form, and stability. After timber is cut, and before it is properly seasoned, the outside is found to crack and to split more than the inside of the mass, because it is more exposed to the desiccating effect of the surrounding atmosphere, but, as the outside dries, the air gradually finds its way to the interior. If timber is cut up by the saw when green, and allowed to season or dry in a gradual manner, it is found to be the most durable. In the arts, however, artificial drying is often resorted to, as in the case of gun-stocks. These are put into a desiccating chamber, where a current of air at 90° or 100° is passed over them, at such a rate as to change the whole volume of air in the chamber every three minutes, and it is found that a year of seasoning may thus be saved. The walnut-wood is as good, after this process, as if the seasoning had been accomplished by time and exposure, and works more smoothly under the cutting instruments of the stock-machinery.

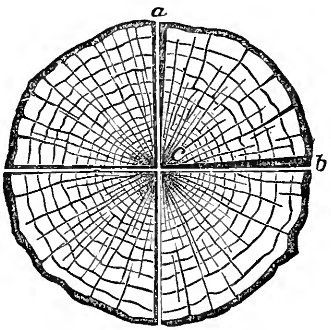
Wood will always warp after a fresh surface has been exposed, and will likewise change its form by the presence of any moisture, either from that contained in the atmosphere or from wetting the surface. The effect of moisture on dry wood is to cause the tubular fibres to swell; hence it is that, if a plank or board is wetted upon one side, the fibres there will be distended, and the plank, in consequence, must bend.

The natural law that governs the shrinking or contraction of timber is most important to practical men, but it is too often overlooked.

The amount of the shrinkage of timber in length, when seasoning, is so inconsiderable that it may in practice be disregarded. But the shrinkage in transverse directions is much greater, and presents some peculiarities which can only be explained by examining the structure of the wood, as resulting from its mode of growth. An examination of the end section of any exogenous tree, such as the beech or oak, will show the general arrangement of its structure. It consists of a mass of longitudinal fibrous tubes, arranged in irregular circles, which are bound together by means of radial plates or rays, which have been variously named: they are the "silver grain" of the carpenter, or the "medullary rays" of the botanist, and are in reality the same in their nature as the pith. The radial direction of these plates or rays, and the longitudinal disposition of the woody fibre, must be considered in order to understand the action of seasoning. For the lateral contraction or collapsing of the longitudinal fibrous or tubular part of the structure cannot take place without first tearing the medullary rays, hence the shrinking of the woody bundles finds relief by splitting the timber in radial lines from the centre parallel with the medullary rays, thereby enabling the tree to maintain its full diameter. If the entire mass of tubular fibre composing the tree were to contract bodily, then the medullary rays would, of necessity, have to be crushed in the radial direction to enable it to take place, and the timber would thus be as much injured in proportion as would be the case in crushing the wood in a longitudinal direction.

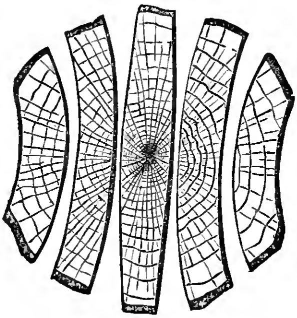
If an oak or beech tree is cut into four quarters, by passing the saw twice through the centre at right angles, before the splitting and contracting have commenced, the lines *a c* and *b c* in Fig. 1 would be of the same length, and at right angles to each other, or, in the technical language of the workshop, they would be square; but, after being stored in a dry place, say for a year, a great change will be found to have taken place, both in the form and in some of the dimensions. The lines *a c* and *b c* will still be of the same length as before, but from *a* to *b* the wood will have contracted very considerably, and the two lines *a c* and *b c* will not be at right angles to each other, the angle being diminished by the portion shown in black in Fig. 1. The medullary rays are thus brought closer by the collapsing of the vertical fibres.

FIG. 1.



But, supposing that six parallel saw-cuts are passed through the tree, so as to form it into seven planks, what will be the behavior of the several planks? Consider the centre plank first. After due seasoning and contracting, it will be found that the middle of the board still retains the original thickness, from the resistance of the medullary rays, while the thickness will be gradually reduced toward the edges for want of support, and the entire breadth of the plank will be the

FIG. 2.



same as it was at first for the foregoing reasons, and as shown in Fig. 2. Then, taking the planks at each edge of the centre, by the same law their change and behavior will be quite different: they will still retain their original thickness at the centre, but will be a little reduced on each edge throughout, but the side next to the heart of the tree will be pulled round or bent convex, while the outside will be the reverse, or hollow, and the plank will be considerably narrower throughout its entire length, more especially on the surface of the hollow side. Selecting the next two planks, they will be found to have lost none of their thickness at the centre, and very little of their thickness at the edges, but very much of their breadth as planks, and will be curved round on the heart-side and made hollow on the outside. Supposing some of these planks to be cut up into square prisms when in the green state, the shape that these prisms will assume after a period of seasoning will entirely depend on the part of the tree to which they belong, the greatest alteration would be perpendicular to the medul-

Fig. 3.

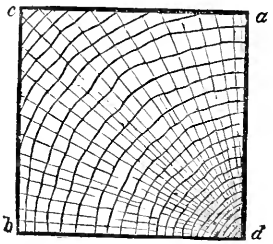
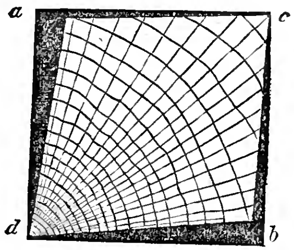


Fig. 4.



lary rays. Thus, if the square was originally near the outside, as seen in Fig. 3, then the effect will be as shown in Fig. 4, namely, contraction in the direction from *a* to *b*. After a year or two the square end of the prism will become rhomboidal, the distance between *c* and *d* being nearly the same as at first, but the other two edges brought closer together by the amount of their contraction. By understanding this natural law, it is comparatively easy to predict the future be-

Fig. 5.

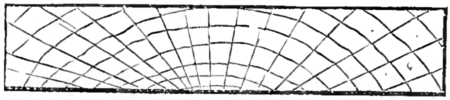
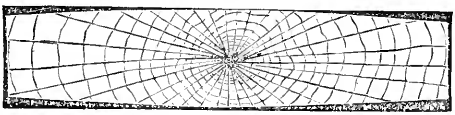


Fig. 6.



havior of a board or plank by carefully examining the end-wood, in order to ascertain the part of the log from which it has been cut, as the angle of the ring-growths and the medullary rays will show this, as in Figs. 5 and 6. If a plank has the appearance of the former, it must have been cut from the outside, and for many years it will gradually shrink in the breadth; while the next plank, shown in Fig. 6, must have been derived from near the centre or heart of the tree, and it will not shrink in the breadth but in thickness, with the full dimension in the middle, but tapering to the edges.

The foregoing remarks apply more especially to the stronger exogenous woods, such as beech, oak, and the stronger firs. The softer woods, such as yellow Canadian pine, are governed by the same law; but, in virtue of their softness, another law comes into force, which to some degree affects their behavior, as the contracting power of the tubular wood has sufficient strength to crush the softer medullary rays to some extent, and hence the primary law is so far modified. But even with the softer woods, such as are commonly used in the construction of houses, if the law is carefully observed, the greater part of the evils of shrinking would be obviated. Hence, also, it is that when a round block, as a mast, is formed out of a tree, it retains its roundness because it contracts uniformly or nearly so, whereas, if a round spar is formed out of a quartering of the same tree it will become an oval, or otherwise contorted toward that shape.

It would not be in accordance with the object to enumerate all the woods that are employed in the arts, therefore a few only are selected, or such as are employed for purposes where strength is the primary object, viz., ash, beech, elm, fir, hornbeam, mahogany, oak, and teak.

Ash is a coarse wood, but possessed of considerable strength, and is distinguished for its great toughness and elasticity, and is usually employed where severe shocks and wrenches have to be encountered, such as for agricultural implements, the felloes and spokes of wheels, and the shafts of carriages, for hammer-shafts, and for spring purposes generally wherever wood is employed for that purpose.

From its great flexibility it is seldom employed where rigidity is a desideratum. The combination of strength with flexibility is the characteristic of ash, and when the wood is from a young tree, or a tree not too old, it is an invaluable wood in many respects; but as the tree becomes older, the change to brittleness sets in and soon renders it less valuable. It is also remarkable for its endurance when kept dry, but when exposed to damp or to wet it rapidly decays. The numerical value of its properties varies considerably, but in general terms it may be stated that, as compared with oak, good ash has frequently a still greater tenacity and likewise a greater degree of toughness, but, from its flexibility, especially when young, it has considerably less stiffness, which unfits it for many purposes.

Beech has frequently considerable strength, and is chiefly distinguished for its uniformity, its smoothness of surface, and closeness of grain. It likewise possesses no little beauty, and takes a good polish, more especially when its silver grain is skilfully exposed. When well seasoned and not too old, it is frequently used for the cogs of mill-gear-ing, and is usually considered by millwrights as next to hornbeam, both in strength, toughness, and general suitability for that purpose. It requires, however, to be kept very dry, for in damp situations it quickly wears out, but, when beech is immersed in water constantly, its endurance is considerable. The strength of beech is nearly the same as that of oak; it is also tougher, but its stiffness is inferior to that of oak, even to the extent of 25 per cent.

Elm, although a cross-grained, rough wood, and mostly used for rough purposes, is yet held in great estimation for its toughness and non-liability to split by the driving of bolts. It is much used in the construction of blocks for pulley-tackle, for heavy naval gun-carriages, and for the naves of carriage-wheels. It is a wood which is little affected by constant immersion in water, but decays rapidly when alternately wet and dry, and consequently is not very durable for purposes involving exposure to a wet climate. Its chief defect in ordinary use is its great liability to warp, and twist, and get out of form; and, as regards strength, toughness, and rigidity, it is inferior to oak, as well as in almost every other respect.

The fir and pine woods are members of a large family, and are of great variety, and differ much in most of their properties. These classes of timber, in addition to being employed for building purposes, are likewise the chief materials that are used in great works, where the question of strength combined with cost becomes the most prominent consideration. The most durable varieties are the larch, the pitch-pine, and the firs, from Memel and Norway, and are valued mostly on account of the large quantity of resin, pitch, and turpentine, which they contain. The Canadian pine, variously termed white or yellow, is not a strong wood, but is much used by engineers for making patterns or models, on account of its smoothness of surface, its non-liability to warp, its comparative freedom from knots, and the facility with which it can be cut. The white or yellow pine is not nearly so strong or so stiff as oak, yet sometimes it is almost equal to it in its tenacity and toughness. In such a large family as that of the resinous firs and pines, there is almost an equal variation in their strength, toughness, and rigidity.

Hornbeam is a wood which is comparatively little used, except by engineers, for the teeth or cogs of wheels, and for mallets, for which purposes it is perhaps superior to all other woods, and this is mostly due to its great toughness and remarkably stringy coherence of fibre. Its cohesive strength and other properties depend much upon its age, as a plank, and still more on the age of the tree from which the plank was taken. When in the most favorable condition, it is fully equal to the average of oak (even when considered merely as a wood), but when cut from older trees, and when over-seasoned, it is frequently found worthless, and has soon to be renewed. When of proper age and quality, it has no equal for its own special purposes.

Mahogany is a beautiful, close-grained wood, but is used not so much on account of its strength, but more frequently because of its non-liability to shrink, warp, or twist, and from the peculiar property of taking a firm hold of glue. In the last respect it is superior to any other wood. Mahogany differs greatly in regard to its closeness, hardness, strength, and beauty. That from Honduras, called "bay-wood," is much inferior to that called "Spanish" mahogany, which comes from the West Indies; the former is much used in the construction of light textile machinery, but chiefly on account of its cheapness; and the latter is used for furniture or for other ornamental purposes. As regards strength, this wood is inferior to oak in all respects, and its great characteristic defect is unsuitability for exposure to the weather, or, indeed, for any purpose where it is made alternately wet and dry. When so subjected, it rapidly decays, and loses all its good qualities.

Oak, taken as a whole, is one of the strongest and most durable of woods, and is especially adapted for exposure to the weather of a damp climate, and is indeed suitable for almost every purpose where the properties of strength, stiffness, and toughness, combined with endurance, are required. Its value for ship-building is proverbial, and in its employment for the staves of casks, for treenails, for carriage-wheels, and for all such purposes requiring lightness and strength in combination, it is equally useful. From time immemorial it was esteemed the best timber for heavy roofs, and the condition in which some of these grand old roofs have reached our era fully attests the wisdom of the selection.

Oak is found of many degrees of quality, but probably none, taking every property into account, is superior to that which grows in England, and which is perhaps more durable than any other. Some of the foreign oaks are as good in some respects, but, as a whole, English is the best.

ON THE CAUSES OF CRIME.[1]

BY HON. HORATIO SEYMOUR.

THE name of this Association fails to give a full idea of its scope and aims. In terms they seem to be limited to that class of men who have brought themselves under the penalties of the law; but the moment we begin to study the character of criminals and the causes of crime we find that we are forced back to a scrutiny of our social system and of the weakness as well as the wickedness of our fellow-men. It is because the subjects of pauperism and crime thus lead to an analysis of human nature and to the consideration of social aspects

[1] Address before the National Prison Association at Baltimore.

that they have been made the matters of profound thought by able publicists and large-minded statesmen. At first thought it seems that the condition of a small body of men who have offended local laws should be left to the thoughtful control of local authorities, but it is soon found that the considerations involved are as broad as the spread of the human race. For these reasons leading men of different nations were drawn together at the late International Convention at London, and for these reasons this Association was formed. Crime knows no geographical limits, no boundaries of states. It is its nature to war with the welfare of the human family. It must be opposed by the united wisdom and virtue of all nationalities and of all forms of civilization. While local laws must frame penal codes, and local societies do the work of lifting up fallen men, still much is gained by a wide-spread sympathy and coöperation. There are many things which are beyond the reach of state action, in a moral point of view—things which do not come under the cognizance of laws, but which deeply affect the welfare of the whole country. At the first view our efforts seem to be limited to the justice which punishes crime, and to the charity which tries to reform the criminal, but we are soon led into a wider field of duty. We are apt to look upon the inmates of prisons as exceptional men, unlike the mass of our people. We feel that they are thorns in the side of the body politic which should be drawn out and put where they will do no more harm. We regard them as men who run counter to the currents of society, thus making disorder and mischief. These are errors. In truth they are men who run with the currents of society and who outrun them. They are men who in a great degree are moved and directed by the impulses around them. Their characters are formed by the civilization in which they move. They are in many respects the representative men of a country. It is a hard thing to draw an indictment against a criminal which is not in some respects an indictment of the community in which he has lived. An intelligent stranger who should visit the prisons of foreign countries, who should hear the histories of their inmates, would get a better idea of the inner workings of their civilization than could be gained by intercourse with a like number of their citizens moving in more conventional circles of society. As a rule, wrong-doing is the growth of influences pervading the social system, as pestilences are bred by malaria. Our study into this subject soon teaches us that prisons are moral hospitals where moral diseases are not only cared for, but science learns the moral laws of life—where it learns what endangers the general welfare of the community, what insidious, pestilential vapors permeate society, carrying moral disease and death into its homes. Prisoners are men like ourselves, and if we would learn the dangers which lurk in our pathways we must learn how they stumbled and fell. I do not doubt that some men are more prone to vice than others, but, after listening to thousands of prayers for pardon, I can hardly recall a case where I do not feel that I might have fallen as my fellow-men have done if I had been subject to the same demoralizing influences, and pressed by the same temptations. I repeat here what I have said on other occasions—that, after a long experience with men in all conditions of life, after having felt, as most men, the harsh injustice springing from the strife and passion of the world, I have learned to think more kindly of the hearts of men, and to think less of their heads. If we find that crimes are in a large degree the hot-bed growth of social influences; if the weakness of human nature is always open to their attacks; if they may at any time enter into our homes and strike at our family—then we must at least guard against them as we do the pestilence. To protect the public health and to learn the laws of life, we build and sustain with liberal hand hospitals where the sick and wounded can be cured. The moral hospital should be regarded with an equal interest. In each of them we should seek to cure the inmates. In each of them we should seek to find out the secret cause of disease. With regard to both we should in a large-minded way feel that the laws of moral and physical life are a thousand times more important to the multitudes of the world at large than they are to the few inmates that languish in their gloomy walls. The public hold in high honor the man of science who treads the walks of the hospital to find out the facts which will enable him to ward off sickness and death from others. This Association appeals to the public for the same sympathy and support for those who labor to lift up their unhappy brethren from moral degradation, and at the same time to do the greater work of tracing out the springs and sources of crime, and of warning the public of its share of guilt in sowing the seeds of immorality by its tastes, maxims, and usages. We love to think that the inmates of cells are unlike ourselves. We should like to disown our common humanity with the downcast and depraved. We are apt to thank God we are not like other men; but, with closer study and deeper thought, we find they are ourselves under different circumstances, and the circumstances that made them what they are abound in our civilization, and may at any time make others fall who do not dream of danger. It is a mistake when we hold that criminals are merely perverse men, who are at war with social influences. On the other hand, they are the outgrowth of these influences. Crimes always take the hues and aspect of the country in which they are committed. They show not only guilty men but a guilty people. The world holds those nations to be debased where crime abounds. It does not merely say that the laws are defective and the judges corrupt, but charges the guilt home to the whole society. This is just, for most of the crimes which disgrace us could not be done if there were not an indifference to their causes on the part of the community. As certain plagues which sweep men into their graves cannot rage without foul air, so many crimes cannot prevail without wide-spread moral malaria. It is the greed for gold, the love of luxury in the American people, which have caused the legislative frauds, the municipal corruptions, the violations of trust which excite alarm in our land. It is the admiration of wealth, no matter how gained, which incites and emboldens the desperate speculator in commercial centres to sport with the sacred interests of labor, to unsettle the business of honest industry, by playing tricks with the standards of value. Those who use the stocks of great corporations as machines for gambling schemes are more deliberately and artfully dishonest than the more humble swindler who throws his loaded dice. Many of the transactions of our capitalists are more hurtful to the welfare of our people than the acts of thieves and robbers. In the better days of American simplicity, honesty, and patriotism, these things could not have been done. No one would then dare to face a people indignant at such rapacious greed. Such influences have led to frauds, defalcations, breaches of trust. They have filled our prisons and overwhelmed many households with shame and sorrow. Yet the authors of such things are honored for their wealth, and we ask with eagerness how rich do they get, and not how do they get riches. To make the public feel that criminals are men of like passions with ourselves, and that crime is an infectious as well as a malignant disease, that its sources are not so much personal inclination as general demoralization, are the great first steps toward reform. When we feel the disease may enter our own houses and seize upon the mental and moral weakness of those we love, we are ready to study its causes and its workings. We shall then uphold and honor those men of humanity and true statesmanship who study out the cause of moral stains as we honor and support those men of science who search out in sick-rooms and hospitals the cause, and cure the complaint, which kills the body. He who masters the diagnosis of crime gains a key to the mysteries of our nature and to the secret sources of demoralization which opens to him a knowledge of the great principles of public and private reform —the true methods of a good administration of the laws. Pauperism and crime have been the subjects of earnest thought by the best and wisest men of the world, not only on account of their direct interest, but also on account of their relationship to all other matters of good government. Neither of them can be driven out of existence. They will always be problems to vex statesmanship, but they must always be battled with. In the social edifice they are like fires ever kindling in its different parts, which are to be kept under by watchfulness and care. If neglected, they burst out into the flames of anarchy and revolution, and sweep away forms of government. These subjects must be studied directly, and in their moral aspects. There is a pervading idea in our country, that the spread of knowledge will check crime. No one values learning more than I do; but it is no specific for immorality and vice. Without moral and religious training, it frequently becomes an aid to crime. Science, mechanical skill, a knowledge of business-affairs—even the refinements and accomplishments of life—are used by offenders against law. Knowledge fights on both sides in the battle between right and wrong. At this age it lays siege to banks. It forces open vaults stronger than old castles. It forges and counterfeits. The most dangerous criminal is the educated, intellectual violator of the law, for he has all the resources of art at his command—the forces of mechanics, the subtlety of chemistry, the knowledge of men's ways and passions. Learning by itself only changes the aspect of immorality. Virtue is frequently found with the simple and uneducated, and vice with the educated. Surrounded by glittering objects within their reach, our servant-girls resist more temptations than any other class in society. We must look beyond the accidents of knowledge or ignorance if we wish to learn the springs of action. To check vice, there must be high moral standards in the public mind. The American mind must move upon a higher plane. To reform convicts, their hopes must be aroused and their better instincts worked upon. I never yet found a man so untamable that there was not something of good upon which to build a hope. I never yet found a man so good that he need not fear a fall. Through the warp and woof of the worst man's character there run some threads of gold. In the best there are base materials. It is this web of entwined good and evil in men's character which marks the problems and perplexities of the Legislature and judge, while there is no honest dealing with this subject unless the American people are charged with their share of guilt; and, while Christian charity leads us to take the kindest view we can of every man, it does not follow that crime should be dealt with in a feeble way. *Let the laws be swift, stern, and certain in their action.* What they say let them do, for CERTAINTY *more than severity carries a dread of punishment.* Let the way of bringing offenders to justice be direct, clear, and untrammelled. The technicalities of pleading, proof, and proceedings, in many of our States, are painfully absurd. To the minds of most men a criminal trial is a mysterious jumble. The public have no confidence that the worst criminal will be punished. The worst criminal cherishes at all times a hope of escape. In every part of our country there is a vague idea that certain men of legal skill can extricate offenders without regard to the merits of their case. This is a fruitful cause of crime. There is not in the minds of the American people a clear, distinct conception of our penal laws, their actions, and their results. Not less hurtful to justice are those fluctuations of the public mind, which shakes off spasmodically its customary indifference and fiercely demands a conviction of those who happen at such times to be charged with crime, and thus make popular clamor take the place of judicial calmness and impartiality. No one feels that there is in this country a clear, strong, even flow of administration of criminal law. The mood of the popular mind has too much to do with judicial proceedings. The evils connected with the administration of justice in our land are due in a good degree to the swift changes in the material condition of our country. An increase of our numbers of more than 1,000,000 each year, of more than 2,500 each day, of more than 100 each hour, explains many of the causes of our overburdened system of penal laws. Framed for a different state of society, our perplexities are increased by the fact that more than one-quarter of this daily addition to our population is made up of those who come from other countries strangers to our customs and laws, and in many instances ignorant of our language. History gives no account of such a vast increase of the numbers of any country by constant peaceful action. Conquest rarely makes as many prisoners of war as we make captives to the peaceful advantages of our continent. They bring us wealth and power. They also bring us many problems to solve. British laws deal with British subjects. French courts decide upon the guilt or innocence of Frenchmen. Germany keeps by its usages and customs the ideas of right and wrong in the minds of the Teutonic race. But we in America have to deal with and act upon all nationalities, all phases of civilization. While these facts palliate the defects of our penal laws and their administration, they certainly make more clear and urgent the duty that we keep pace with the swift changes going on around us. More than this, it enables us to take the lead in the great work of reform as we deal with more plastic materials than are found in the fixed conditions of older nations. Here, too, we have a broader field filled with men of varied phases and aspects of different civilization, in which we can study the wants and the weaknesses, the virtues and the vices, of the human race. For a series of years nearly 300,000 immigrants are annually landed at the harbor of New York. Disorder and crime are always active along the line of march of great armies. I believe there is no instance in history of a movement of the human race so vast and long continued. I am glad to state a fact which in some degree palliates the disgrace which attaches to the administration of justice and the conduct of public affairs in that great city, but I should fall short of telling the truth if I did not also say that *the discredit of that great city mainly springs from the sad fact that its men of wealth as a body lack that genuine self-respect which leads to a faithful, high-minded performance of the duties each citizen owes to the public.* Is there any other basis upon which we can found this great work of patriotism and philanthropy than the one contemplated by this Association? It may at first view seem to be limited to a small class, but it opens up into a broad field of unpartisan, unsectarian labor. The objects we have in view, although they make our prisons their starting-point, are so wide in their bearing that they brought together at the London International Association, in the interests of our common humanity, men of the best minds of most countries of Europe and America. These, in spite of the differences of religion, language, and form of civilization, could act in accord in devising measures to lift up the fallen and to spread the principles of morality and justice among the peoples of the world. It is found that true statesmanship, like true religion, begins with visiting the prisoners and helping the poor. It is certain that in our own country Edward Livingston, the public man who ranks high in European regard for intellectual ability, gained his position by his great work on the penal laws of Louisiana. When it was the fashion in the scientific world to hold that men and animals were dwarfed on this continent, this work was brought forward by our friends in Europe as a proof that statesmanship was full-grown here. It is a remarkable fact that an able foreign writer selected the Louisiana code and the proclamation of General Jackson against the doctrine of secession as the two ablest productions of the American mind, not knowing that they both came from the same pen. An exposition of Mr. Livingston's system has lately been published in France by M. Charles Lucas, a member of the Institute, and formerly president of the Council of Inspectors of the Penal Institutions of that country. M. Lucas is a distinguished writer and leader in the work of criminal reform. He belongs to that body of large-minded, philanthropic men, who seek to benefit humanity by wise systems of legislation. A certain breadth and reach of mind seem to mark those men who have entered upon the study of penal laws and the reformation of criminals. While there is much to condemn in our system of laws and in their administration, there is much to admire in the practical workings of many of our prisons. In some respects we are in advance of other people. Much has been done in many of our States to improve the condition of our criminals, and much more to rescue the young from vice and destruction. I should be glad to speak of the instances of ability and self-devotion shown by men who have charge of public or private charities established for the reformation of offenders. They would lend a weight to my argument which my reasoning cannot give, but I must leave these things to be brought out by the discussions of this congress. I only seek to show the ends at which it aims; I only seek to make for it the sympathy and support of the public in its efforts to combine and organize the forces of those who, in different parts of our country, are working in this field of philanthropic and patriotic labor. Crime has its origin in the passions which live in every breast, and the weakness which marks every character in its nature. It concerns each of us, as clearly as the common liability to fall prematurely before disease and death. No man can know human nature, no man can be a great teacher to his fellow-men, no man can frame laws wisely and well, who has not studied character in convict-life. There he can best see the lights and shadows of our natures, see in the strongest contrasts what is good and what is bad. The prisons, to which all vice tends, are the points from which the reform can be best urged which seeks to find out where vice begins. Starting from the sad ends of crime and running back along the tracks, it is seen that in a large degree they are engendered by public tastes, habits, and demoralizations. It is in our prisons we can best learn the corrupting influences about us which lead the weak as well as the wicked astray, ay, and sometimes make the strong man fall into disgrace and misery. In these moral hospitals the thoughtful man, the philanthropist, and the statesman, will look for the causes of social danger and demoralization. When we begin at the prison and work up, we find opening before us all the sources of crime, all the problems of social order and disorder, all the great questions with which statesmanship, in dealing with the interests and welfare of a people, must cope when it seeks to lift up high standards of virtue and patriotism. In the most highly-civilized countries the subjects of pauperism and crime secure the most attention and thought. They turn men's minds from selfish to unselfish fields of labor. Those who enter those fields will find in them marks of toil and care by the best human intellects. The grandest minds have worked at their intricate problems. The ambition of the first Napoleon sought to gain immortality in his code of laws as well as in victories on the fields of battle. Much has been done in many of our States to improve prison discipline. Something has been done toward reforming prisoners, but the largest view of the subject, which looks to the moral health of society, and the baleful influences at work in its organization, have not received the attention they deserve. When prisons are visited by men of mind, when prisoners are looked upon with kindly eyes by those who can study their characters and learn from them the virtues, vice, and wickedness which mark our race; when, tracing back the courses of their lives, they shall find the secret sources of their errors and their crimes—then we shall have not only our laws justly enforced and reformed, wrong-doers punished, but, more and better than these, we shall gain a public virtue and intelligence which will secure the safety and happiness of our homes and the glory and stability of the republic. Then wealth gained by unworthy means will no longer be respected. No one can recall the events of the past few years, particularly those of the great commercial centres, without feeling there is an ebb-tide in American morals. Not a little of the glitter of our social and business life is a shining putrescence. Fungus men have shot up into financial prominence to whom a pervading deadening moral malaria is the very breath of life. They could not exist without this any more than certain poisonous plants can flourish without decaying vegetation. While I have tried to present in clear terms the claims of this Association upon the public sympathy and support, it must be understood that we claim for it only the merit of being a useful auxiliary to moral and religious teachings. If those who take part in its work should fall short of its broader and higher objects of a national character, they will at least get this great gain: they will learn to think more humbly of themselves, more kindly of their fellow-men, and to see more clearly the beauties of Christian charity.

THE RECENT PROGRESS OF NATURAL SCIENCE.

I.

ON the occasion of the celebration at Breslau of the twenty-fifth anniversary of Prof. Goeppert's presidency of the Silesian Society for National Culture, Prof. Ferdinand Cohn delivered an address, characterized by eloquence of the highest kind, on the above subject. As the wanderer, he said, who is climbing toward a high mountain-peak, feels from time to time the desire to stand still a little, and look back on the way over which he has passed, to enjoy the wider outlook which he gains from his higher stand-point, so, he thinks, there are moments in the uninterrupted progress of science, when we long in some measure to strike a balance, and see how much acquired property the present puts aside as useless, how much it uses only for temporary purposes, and how many enduring acquisitions have been made.

Dr. Cohn refers, no doubt with justice and some pardonable pride, to the foremost place held by Germany, during the last quarter of a century, in the march of science. At the same time he awards due praise to other European states, and above all to England, which, during that time and more particularly at present, he thinks, abounds in men of the highest eminence, whose scientific achievements stand prominently out on account of their astonishing energy, clearness, depth, and independence of thought. Still, we cannot but admit that Dr. Cohn is right in asserting that Germany is free from the dilettanteism which abounds in this country, and that as a rule science in Germany is both far more wide-spread and far more thorough than it is among ourselves, and that the opportunities furnished there to all classes for scientific study at the ordinary educational establishments have until recently left us almost nowhere. But, happily, signs of the beginning of the end of this state of things among us are becoming rife.

After briefly referring to the intellectual awakening of Germany along with the rest of Europe at the time of the Reformation, and showing how this start forward was, especially in the case of Germany, in a great measure frustrated by the Thirty Years' War, Dr. Cohn pays a high and justly-merited tribute to France, and especially to Paris, on account of the supreme place she took during the first thirty or forty years of the present century in nearly all the sciences. The glory of France in this direction has, however, he thinks, departed, and Germany is becoming daily more and more the intellectual centre of the world. Had Dr. Cohn written his lecture now, he might have somewhat modified his language; for, within the last few months, the signs have been many, that in the direction of science the French are determined to try to hold their own with the foremost in Europe. Their professors are prosecuting an amount of research which puts our own to shame, while they are at the same time forming a school of investigators. We do not grudge to Germany all the praise she well deserves, and the influence which the results of German research exercise on other nations is likely to urge them to such vigorous and determined efforts, that, sooner or later, science and every other progressive influence shall be "great gainers." Meantime, however, Germany is doubtless in the ascendant.

In the year 1845 appeared the first volume, and in 1846 the second, of Humboldt's "Cosmos." As comprising a view of the whole created universe depicted with the most wonderful sympathy, the book is as it were a canon forming a key to every thing that was known of Nature at the time. No man was then more suited for such work than was in the highest degree A. von Humboldt. A "Divina Commedia" of science, the "Cosmos" embraced the whole universe in its two spheres, heaven and earth. Under the leadership of the great searcher of Nature, as Dante once by the hand of Virgil, we climb from the depths of the universe, with its farthest nebulæ and double stars, down through the star depths to which belongs our solar system, to the air- and sea-enveloped earth, where form, temperature, and magnetic condition, are unveiled to us; then to the wealth of organic life, which, stimulated by the light, unfolds itself on its surface. It is an overwhelming picture of Nature, of surpassing beauty of outline, abounding in grand perspective, with the most careful execution of the smallest detail.

But we cannot conceal from ourselves that the "Cosmos," published twenty-five years ago, is in many of its parts now antiquated, not merely because it is wanting in many facts which have since been discovered, but most particularly because Humboldt was ignorant of some highly-important questions which have since taken their place in the foreground of scientific discussion, while our scheme of the universe during the last ten years has been considerably modified by the introduction of new and influential ideas. Any one, who to-day would attempt to recast the "Cosmos," must proceed like the Italian architect who took the pillars and blocks of the broken temples of antiquity, added new ones, and rebuilt the whole after a new plan.

There are three discoveries which, during the last quarter of a century, have entirely changed the position of natural science: the mechanical equivalent of heat, spectrum analysis, and the Darwinian theories.

Since, in the year 1842, an unknown physician in a Swabian country-town, Dr. Mayer, of Heilbronn, pointed out that a hammer 424 kilogrammes in weight, which falls from the height of a metre on an anvil, raises the heat of the latter by one degree centigrade, and that by this process of bringing a falling motion to a stand-still it is converted into a fixed quantity of heat—since then has science gained a new conception of the conditions of matter and of the powers of Nature. This new doctrine appears in the mechanical theory of heat announced by Joule, Krönig, Maxwell, and Clausius, in the doctrine of the conservation of energy of Helmholtz and Thomson, and by means of the brilliant writings of Tyndall it has become the common property of the educated world. Electricity and magnetism, heat and light, muscular energy and chemical attraction, motion, and mechanical work —all forces in the universe are only different forms of one and the same power, which has dwelt from the first in matter in invariable quantity, neither increased nor diminished; not the least trifle of it can be annihilated or created. Only the phenomenal forms of power are changeable; light can be converted into a chemical equivalent, this again into heat, heat into motion, and indeed a fixed quantity of one force always and only into an equivalent quantity of another. In like manner also the quantity of matter has remained unchanged from the beginning; not the least particle or molecule can be annihilated or created out of nothing, and only in the transformation of perishable bodies are the molecules formed into ever-new combinations. What we distinguish as natural forces are only movements of molecules, for the least particles of matter out of which bodies are composed are not inseparably united to each other, but are loosely held together and in continuous whirling and undulatory motion; according to the swiftness and width of undulation of the molecule will this motion of our nerves be regarded, now as sound, now as heat, then as light or as color. Moreover, the chemical union of the elements of matter, the attractive power of gravitation in all the bodies of the universe, are but varied forms of this universal motive force. The unity and permanency of substance with its two attributes, matter and force, and their innumerable modifications, which go to form the bodies of the universe, were in the first instance enunciated as a philosophical maxim by the great thinker Spinoza. Now it is established as a philosophic fact by means of exact measure and weight.

Again, on the inner organization of the system of the universe has unexampled light been thrown by the wonderful researches which were begun in 1859 by two men, united by the closest bonds of a friendship which bore rich fruit for science. After the light of the sun had, in the third decade of this century, been brought into the service of art by Nièpce and Daguerre, Bunsen and Kirchhoff compelled it also to render service to chemistry and astronomy. Like those magicians of the legend who, through the power of their knowledge, compelled the spirits of the elements to disclose their most recondite secrets, the genius of these men compelled the rays of light imprisoned in the spectrum apparatus to make revelation of things in the world of stars which the curiosity of men had deemed forever inaccessible. Already had Kirchhoff ascertained what terrestrial elements were present in the sun's atmosphere, and what were not; quite recently has it been discovered that there is even present in the sun a substance (*helium*) which hitherto has been unknown on the earth. Moreover, also, the inner structure of the sun, the distribution of its incandescent, liquid, and gaseous parts, its luminous and colored envelop, the nature of its spots and protuberances—all this is no longer a play-ground for fantastic imaginings, but the subject of exact research. Since the great eclipse of 1868, Lockyer and Janssen, Zöllner, Huggins, and Father Secchi, have observed, day after day, storms, whirlwinds, flame-sheaves, outbursts of burning hydrogen to the height of 20,000 miles: thus has been developed an entirely new science—the meteorology of the sun. Moreover, on other obscure regions of the heavens, on the physical and chemical conditions, even on the laws of the movements of the fixed and double stars, on nebulæ and milky ways, on planets and comets, on zodiacal and northern lights, has spectrum analysis thrown its enlightening rays. No less by rigorous mathematical method, through which astronomy, even at an earlier period, had been brought to a certain amount of perfection, has she in the most recent time enjoyed an unexpected triumph, by solving, through the researches of Schiaparelli, the riddle of the comets, in being able to recognize the identity of their nature with that of the swarms of shooting-stars whose remarkable brilliancy long ago made them universally known.

II.

During the last quarter of a century, the history of the formation of our earth has assumed a new aspect. When the "Cosmos" appeared, the opinion prevailed that our earth, once a globe of liquid fire, became covered with a crust of congealed scoriæ, on which, by-and-by, the first animal- and plant-life made its appearance. After an almost infinite length of time, during which the Silurian, Devonian, Carboniferous, and Permian strata were deposited, a terrible catastrophe, affecting simultaneously the whole earth, so completely destroyed the first palæozoic life, that not a single species survived the universal devastation. Upon the lifeless expanse, it was supposed, appeared then the Secondary Fauna and Flora, entirely unconnected with and different from the extinguished one, until, after frequent repetitions of the same process at longer or shorter intervals, man made his appearance, and along with him all existing plants and animals: with him begins the Historical Period, whose duration has not exceeded 6,000 years. The causes of these world-wide revolutions geology sought in the violent reaction of the molten interior against the once extremely slender crust.

In opposition to these views, the opinion peculiarly associated with the name of Lyell has made way, that no violent revolutions, returning at intervals, destroyed the external structure of the earth and all the life it sustained, but that all changes even in the earliest times affected only the earth's surface, and that these could only be the results of the same powers of Nature which are actively at work on the earth at the present time; and that, moreover, the gradual but ever active powers of water, of air, and of chemical change, have perhaps had a greater share in accomplishing these transformations than the fierce heat of subterranean masses of lava. The explorers of the buried remains of plants and animals show it to be impossible that all life in those geological formations could have been destroyed simultaneously, for many species are common at several stages; in particular, many existing animals and plants reach far back into the primitive world. Man himself could be shown to have been contemporary with many extinct species of plants and animals, and therefore his age on the earth must be extended back to an indefinite period. Man was witness to that inundation which buried the plains of the old and the new world under the waves of the sea of ice. Even in the immediately preceding period, when the sub-tropical elephant, rhinoceros, and hippopotamus, disported themselves in the lignite woods of Middle Europe, have traces of mankind been found. Only in the most recent times has a foundation been laid for the prehistoric records of mankind, by means of which we may be able to obtain a knowledge of the state of civilization, weapons, implements, and dwellings, of that primitive race.

No book of recent times, Dr. Cohn thinks, has influenced to such an extent the aspects of modern natural science, as Charles Darwin's work "On the Origin of Species," the first edition of which appeared in 1859. For, even to so late a period, was the immutability of species believed in; so long was it accepted as indubitable that all the characteristics which belong to any species of plants and animals were transmitted unaltered through all generations, and were under no circumstances changeable; so long did the appearance of new fauna and flora remain one of the impenetrable mysteries of science. He who would not believe that new species of animals and plants, from the yeast-fungus to the mammalia, had been crystallized parentless out of transformed materials, was shut up to the belief that in primeval time an omnipotent act of creation, or, as it may be otherwise expressed, a power of Nature, at present utterly unknown, interfered with the regular progress of the world's development; yea, according to the researches of D'Orbigny and Elie de Beaumont, twenty-seven different acts of creation must have followed each other previous to the appearance of man—but, after that, no more. It was Darwin who lifted natural science out of this dilemma, by advancing the doctrine that the animals and plants of the late geological eras no more appeared all at once upon the scene, than those of the preceding epochs simultaneously and suddenly disappeared; on the contrary, these are the direct descendants of former species, which gradually in the course of an exceedingly long period, through adaptation to altered conditions of life, through the struggle for existence, through natural and sexual selection, have been changed into the new species. Prof. Cohn does not doubt but that Darwin and his school may have over-estimated the reach of the explanations given by him to account for the transmutation of species, and especially the importance of natural and sexual selection, but the fundamental fact has been established, and will remain so for all future time. This fact is, that the collective life of the earth, from the beginning even until now, and from the fungus-cell up to man, represents a single series which has never once been broken, whose members through direct propagation have proceeded out of each other, and in the course of a vast period have been developed into manifold and, on the whole, perfect forms.

The sciences which are concerned with life have during late years been cultivated on all sides; even in earlier years Cuvier and Jussieu had done as much for zoology and botany as the state of discovery in their time permitted, but since 1858 the boundaries of both kingdoms have been widely extended by the labors of Carpenter, Huxley, and Pourtalès.

After referring to the researches of Goethe in the last century, and those of Bauer and of Johannes Müller in the present, in reference to the physiology of plants and animals, Prof. Cohn says it was only in our own time, and first in 1843 in Schleiden's "Grundzügen der Wissenschaftlichen Botanik," that the new principle was followed out; the principle, namely, that all vegetable phenomena and all the various forms of plants proceed from the life and the development of their cells. After Schwann discovered that animal bodies also were built up from an analogous cell, mainly by Virchow was then developed from this principle the modern cellular physiology and pathology which trace the condition both of healthy and diseased men and animals back to the life-function of their cells. But, as the lecturer says, to attempt to follow out the advances made by science in these directions during the last twenty-five years would require a large volume, and cannot be done in the space of a lecture or an article.

Even the cell itself has been changed. Until Schleiden's time it was a little bleb filled with fluid; we now regard it as a soft glutinous body constructed out of the albuminous protoplasm first distinguished by Mohl in 1845, and which is covered with a cellular integument, as the oyster is with its cell. After waxing eloquent over the cell as an entity, an "ego" by itself, and its relations to the outer world, Prof. Cohn says that science now teaches us that there is only one life and one cell, the cell of plants and of animals being essentially the same. The most highly-developed animal differs from the simplest plant only in the number and greater development of the matter composing the cells, but, above all, to the more complete elaboration (*Arbeitstheilung*), and the stricter subordination of the separate cells to the collective life of the organism. Between the two extremes of the living world, the yeast-fungus and man, there is the same difference as there is between a group of individual men who do not know how to organize their strength, and a strictly-disciplined, well-ordered army suitably formed and well armed, and which, by the strict subordination of the many wills to the central authority, is always equal to the highest achievements.

It is true that these scientific researches into biology have left as yet the most important questions unsolved. It is not yet possible to regard all life-processes as simple modifications of the other forces of Nature and to ascertain their mechanical equivalents; we cannot yet convert absolute heat or light into life; and, although chemistry is daily doing more and more to bridge over the gaping chasm which once separated the organic and inorganic systems, it has not yet succeeded in finding out the precise matter which exclusively supports the life-process, on which alone the cells subsist. Thus, then, the beginning of life is still wrapped in obscurity.

After referring in this connection to the transmission of epidemics among plants, animals, and man, and to the microscopical labors of Leeuwenhoek, Ehrenberg, Gagniard-Latour, Schwann, and Kützing, Prof. Cohn goes on to say that the investigators of the present time, to whom Pasteur has given a powerful impulse, have been the first to establish beyond doubt that without *Bacteria* no putrefaction, and without yeast-fungi no fermentation takes place; that this decomposition is accomplished only through the sustenance and living activity of those microscopic cells.

Many a mystery of life will doubtless be unfolded to us if our opticians during the next twenty-five years should manage to raise the power of the microscope in the same proportion as in the previous quarter of a century, in which it has been at least quadrupled. The best microscope of Schiek and Plössl in 1846 did not magnify more than 500 diameters; the "immersion-lens xv." of Hartnack over 2,000 diameters. Still Dr. Cohn does not venture to hope that during the next twenty-five years all the questions of science which are at present being agitated will be solved. As one veil after another is lifted, we find ourselves behind a still thicker one, which conceals from our longing eyes the mysterious goddess of whom we are in search.

Dr. Cohn, in concluding his eloquent address, attempts to point out the characteristics which distinguish the present from the past generation. In the former epoch, students confined their researches to single and carefully-marked-off divisions of Nature, without any regard to the neighboring and closely-allied regions, which must necessarily lead to the one-sided view that these divisions belong to Nature herself. In the present generation, on the other hand, the several physical sciences have entered into the closest organic union. Physics and chemistry, along with mathematical astronomy and geology, have been blended into a new science—the history of the development of worlds; palæontology, systematic botany, and zoology, have been joined into a united science of organisms; the physiology of plants and of animals have become coalesced in universal biology; the boundary between the organic and inorganic aspects of Nature is being ever more and more obliterated, and out of the several natural sciences a single uniform, universal natural science is being constructed.

But the deeper natural science penetrates from outward phenomena to universal laws, the more she lays aside her former fear to test the latest fundamental questions of being and becoming (*Sein und Werden*), of space and time, of matter and force, of life and spirit, by the scale of the inductive method, and the more confidently she lifts her views concerning the universe out of the cloudy atmosphere of hypothesis into the clear ether of theory grounded on fact, so much the more will the gap be narrowed which since Kant has separated science from philosophy. Schiller's advice to philosophers and men of science—

> "Feindschaft sei zwischen euch; noch ist das Bündniss zu frühe;
> Nur wenn in Kampf ihr euch trennt, dann wird die Wahrheit enthült,"

has been followed for more than half a century, to the gain of the natural sciences, but often to the injury of philosophy, which would knock away the firm ground from under our feet. But since Herbart and Schopenhauer, and especially through Hartmann's labors, have the two chief drifts of the work of the human mind been approaching; and if natural science has a mission to mould the future of our race, she must court the purifying influence of philosophical criticism; and this mission, in Dr. Cohn's estimation, the science of the future cannot reject. Its importance rests not merely in the much interesting and useful information which can be made available to trade and industry, for daily economy and universal civilization; she must build a sure foundation for our collective view of the universe, for our knowledge of ultimate and highest things. It must be no longer the case that even our most educated classes, in consequence of insufficient education, have neither interest nor intelligence for the pursuit and acquisition of scientific knowledge. Moreover, science will be no more able to shun battle with other systems of the universe which have been hallowed by the traditions of a thousand years, than were Socrates and Aristotle, Copernicus and Galileo. Victory will lie on the side of truth.

But if anxious souls should fear that, with the advance of a scientific knowledge of the universe among the people, would come a breaking up of political and social order, let them be assured by the teaching of history. When we perceive the flash of an electric spark, we certainly do not take it for a bolt darted by the revengeful Jupiter; and, as the vault of heaven is resolved into air and light, so also must the Olympus be shattered which was built thereon. But the ideas of the true, the beautiful, and the good, remain unshaken; they have been all the more firmly established, for they have been deduced from the order of the universe and from the mind of man himself. And that the pursuit of natural science does not lead to materialism, and in no way injures the ideal mind, is vouched for by the case of Alexander von Humboldt himself, who, even in extreme old age, kept up his love for research and power of work as well as his lively susceptibility for and energetic share in all the noble pursuits of mankind.

Dr. Cohn concludes his lecture, so brimful of true eloquence founded on sober fact, with a high compliment to the many worthy qualities of the president of the Silesian Society, Dr. Goeppert. Such a man as he is said to be, the lecturer truly says, may hope, like Goethe, Humboldt, and other previous philosophers, to maintain, to the utmost limit of existence, life, heart, and spirit, full of the freshness of youth, and, moreover, in later generations be honored as a true guardian of the highest good of grateful mankind.—*Nature.*

EPILEPTIC ORIGIN OF ISLAMISM.

DR. J. C. HOWDEN, medical superintendent of the Montrose Royal Lunatic Asylum, recently read an able paper before the Edinburgh Medico-Psychological Association on the mental condition of epileptics in relation to the religious sentiment. He states that these patients manifest the strangest mental contradictions. Irritability, suspicion, impulsive violence, egotism, and strong homicidal propensities, are among the most commonly-observed characteristics in the insane epileptic; but these traits are very frequently combined with strong devotional feeling, manifested in simple piety or in decided religious delusions. Dr. Howden has the following remarks on the peculiar mental characteristics of epileptics:

"The mysterious nature of the disease—the consciousness of infirmity and helplessness—develops a craving for sympathy in the epileptic which we rarely see in other lunatics. In the wards and airing-courts of our asylums, epileptics may be distinguished from their fellow-patients by the fact that they are generally found associating in little groups of twos or threes. They sympathize with each other, lean on each other for help in the time of trouble, and, however much they exhibit violence and viciousness to others, they rarely attack each other. Along with this desire for sympathy, the epileptic is mercifully endowed with strong hope. He is always getting over his trouble, he thinks the turns are less severe, and will tell you, perhaps the day before a fatal seizure, that he thinks he will have no more fits. We all know how much hope has helped the physician in his efforts to combat this disease with a whole battery of drugs, each of which in its turn seems for a time to promise success, only too surely to fail in the end. This craving for sympathy finds a deep response in the highest development of hope—religion; and the sufferings of this life are assuaged by the assurance of sympathy and aid from Heaven, and of a blessed future where suffering and sorrow are no more.

"Again, when religious emotion develops itself in delusions, another element of character comes into play. Vanity and egotism give shape and form to his dreams and fancies. When cut off by sleep or epileptic trance from communication with the outer world through the senses, the ever-waking mind operates on the stores which memory has hoarded, and works up those wonderful visions in which the most exaggerated egotism finds gratification in interviews with the Almighty, direct communications with the Saviour, or revelations as to the salvation of the human race."

Several remarkable instances are related in which devout feeling, offering the strongest evidences of genuineness, coexisted with the most dangerous forms of homicidal violence. A young man, aged twenty-seven, subject to irregular epileptic fits, read his Bible attentively, and showed a strongly devotional frame of mind. While in the asylum, he wrote a very earnest letter to the clergyman of the village church, asking to be permitted to partake of the sacrament, and was allowed to do so; "yet a few weeks afterward he nearly killed a fellow-patient—a poor, demented creature—because he called him a Fenian, and his conduct continues to this day a singular jumble of piety and vice.

"When actual religious delusions are present in epileptics, these are generally founded on visions occurring during a state of trance, but sometimes, as in the following case, the delusion continues after the memory of the vision on which it was founded has faded. The case is curious, not only from the nature of the delusions, but from the fact that the subject of them was a boy only thirteen years old, an epileptic from infancy. On admission to the asylum he spoke with an earnestness, and, granting his premises, an intelligence beyond his years. He told me he was Adam, the first man, born again into the world. When questioned as to his previous life in the Garden of Eden, he replied that he had been so long dead that he could not be expected to recall particulars, but added that it was perfectly true that he had eaten the forbidden fruit, and when asked why he had done so, he replied: 'It's all very well to blame me; but you would just have done the same thing if you had been in my place.' He pointed to a picture of a woman on the wall, which he said was the portrait of Eve. He says he has been in heaven, and describes what he saw there. He takes fits every two or three weeks, and on recovering from them he is dull and stupid; then he becomes possessed of some extravagant delusions, always of a religious nature. Sometimes he returns to his old delusion that he is Adam, sometimes he is God, at other times Christ, and not unfrequently the devil. When questioned as to the ground of his belief, he generally says that it has been revealed to him, and that he feels that it is true, pointing with his finger to his epigastrium."

After describing a variety of cases of trances, visions, and religious delusions, occurring in the epileptic, Dr. Howden remarks that these and like cases naturally suggest the inquiry as to how far epilepsy has had to do with the origin of certain religious creeds, and how far the visions of the many so-called religious impostors may have had an epileptic origin.

"There is evidence that many religious fanatics were epileptics or cataleptics. Hecker, describing the dancing mania of the fourteenth century, says: 'While dancing, they neither saw nor heard, being insensible to external impressions through the senses, but were haunted by visions, their fancies conjuring up spirits, whose names they shrieked out. . . . Others, during the paroxysm, saw the heavens open, and the Saviour enthroned with the Virgin Mary, according as the religious notions of the age were strangely and variously reflected in their imaginations. Where the disease was completely developed, the attack commenced with epileptic convulsions. Those affected fell to the ground senseless, panting and laboring for breath. They foamed at the mouth, and, suddenly springing up, began their dance amid strange contortions.'

"Ann Lee, the mother of the Shakers, is described as 'a wild creature from birth, a prey to hysteria and convulsions, violent in her conduct, ambitious of notice, and devoured by the lust of power.' While in the prison at Manchester a light shone upon her, and the Lord Jesus stood before her in the cell, and became one with her in form and spirit. A writer says: 'A combination of bodily disease—perhaps catalepsy—and religious excitement appears to have produced in her the most distressing consequences. During the spasms and convulsions into which she occasionally was thrown, her person was dreadfully distorted, and she would clinch her hands until the blood oozed through the pores of her skin. She continued so long in these fits that her flesh and strength wasted away, and she required to be fed, and was nursed like an infant.'"

There is strong evidence that Mohammed was an epileptic, and that, though a man of undoubted power and strong religious feeling, he founded his pretensions as a medium of revelation on visions which appeared to him during epileptic trances. Washington Irving, in his "Life of Mohammed," says:

"Dr. Gustav Weil, in a note to 'Mahommed der Prophet,' discusses the question of Mohammed's being subject to attacks of epilepsy, which has generally been represented as a slander of his enemies and of Christian writers. It appears, however, to have been asserted by some of the oldest Moslem biographers, and given on the authority of persons about him. He would be seized, they said, with violent trembling, followed by a kind of swoon, or rather convulsion, during which perspiration would stream from his forehead in the coldest weather; he would lie with his eyes closed, foaming at the mouth, and bellowing like a young camel. Ayesha, one of his wives, and Zeid, one of his disciples, are among the persons cited as testifying to that effect. They considered him at such times as under the influence of a revelation. He had such attacks, however, in Mecca, before the Koran was revealed to him. Cadijah feared that he was possessed by evil spirits, and would have called in the aid of a conjurer to exorcise them, but he forbade her. He did not like that any one should see him during these paroxysms. His visions, however, were not always preceded by such attacks. Hareth Ibn Haschem, it is said, once asked him in what manner the revelations were made. 'Often,' replied he, 'the angel appears to me in a human form and speaks to me. Sometimes I hear sounds like the tinkling of a bell, but see nothing.' (A ringing in the ears is a symptom of epilepsy.) 'When the invisible angel has departed, I am possessed of what he has revealed.' Some of the revelations he professed to receive direct from God, others in dreams; for the dreams of prophets, he used to say, are revelations."

Bayle says ("Dictionnaire Historique et Critique," article "Mohammed") that he was subject to the *mal caduc* (epilepsy), and that he tried to make his wife Cadijah believe that "he only fell into convulsions because he could not sustain the glory of the appearance of the angel" Gabriel, who came to announce many things from God concerning religion.

The following passage is quoted by Moreau (de Tours) from "Gisbert Voctins:"

"Non video cur hoc negandum sit (epilepsiæ et maniacis deliriis aut enthusiasmis diabolicis Mahommedi ad fuisse energema) si vitam et actiones ejus intueamur."—"I do not see how it can be denied (that the fanaticism of Mohammed arose from the maniacal delirium or diabolic enthusiasm of epilepsy), if we look carefully into his life and actions."[1] The inhabitants of Mecca considered him to be a madman and possessed, and his wife thought he was a fanatic deceived by the artifices of a demon.

"By his ecstatic visions" (says Moreau), "had he not become the dupe of his visions, whence sprung the first idea of his divine mission, and then had not these visions become the principal, if not the sole basis of his apostolic works, as well as the source of his audacity, and of his prophetic power over the ignorant and superstitious spirit of his countrymen?"[2]

It seems incredible that a religion which sways the minds of 200,000,000 of the human race at the present day should have no better foundation than the visions and dreams of an epileptic.

[1] "Life of Mohammed," by Washington Irving, p. 30.

[2] "Psychologie Morbide," par le Dr. J. Moreau (de Tours), p. 552.

Religious systems must not, however, be judged of by the ordinary laws of reason; they must be estimated rather by their influence for good or evil on men's lives and on society.

The imagination may, when unfettered, during a state of trance, work upon what was during consciousness a constant theme of reflection, and elaborate therefrom ideas and theories pregnant with many moral truths, and, though vanity has, no doubt, influenced the actions of most of the so-called religious impostors, it has taken the direction of attempts to benefit their fellow-men, and to satisfy that craving which seems instinctive in the human mind to lean for aid and sympathy on something stronger and better than itself, to connect the present life with an eternal state of existence, and to attain a high standard of moral perfection.

Imperfect though the doctrines of such men as Swedenborg and Mohammed may be, they attempted to satisfy, and to a certain extent have succeeded in satisfying, those yearnings in many human beings, whom they have made, if not better, at least more contented with life than if left to the unbridled guidance of their own passions and impulses.

A millennium of reason may be in store for the human race, but the day is yet far distant; and we cannot afford at present to sneer at the credulity of our fellow-men, when in the latter half of the nineteenth century we hear of a learned bishop consecrating a cave where Bernadotte Soubarons, a girl of fourteen, saw the Virgin Mary, and read of thousands of pilgrims flocking to this sacred grotto in the year 1872 to worship with the most earnest convictions.

Need we wonder that the ignorant Arabs, 1,300 years ago, living, as far as a knowledge of Nature's laws was concerned, in a state of heathen darkness, should have been attracted to the Moslem faith, which, while it held out bright hopes for a future life, consorted well with their inclinations in the present.

The mere act of believing is, to most men, a source of happiness, and the happiness appears sometimes to be in the inverse ratio to the credibility of the thing believed in, as Moreau (de Tours) says: "Ils croient, mais pour croire, en tout état de cause, ils faut d'abord qu'ils ne comprennent pas."—*Abstract from the Journal of Mental Science.*

ASPHALT PAVEMENTS.

WITHIN the past few years several streets in the city of New York have been overlaid with a compound called by its inventors "asphalt," but better characterized by the public as "poultice pavement." When first laid down, this material appeared to fulfil all the requirements of a serviceable pavement, being smooth, hard, and apparently durable. Actual experience, however, showed the material to be so friable that in a short time the ordinary travel on the streets reduced it to a fine, black powder, which, in dry weather, was thrown up in murky clouds by every passing vehicle and every gust of wind, finding entry into the adjacent houses through the minutest crevices, and in wet weather was kneaded into a nasty, viscous mud. Soon the streets thus paved were impassable, and the commissioners were forced to order the removal of what was left of the "poultice" pavement.

This experience was not well calculated to conciliate public opinion in favor of asphalt as a material for paving; and, though travellers returning home from Paris were loud in praise of the asphalted roadways of that capital, contrasting the roar of our granite-paved, filthy thoroughfares, with the smooth, noiseless, cleanly streets of the French capital, they were listened to with incredulity. Their "odious comparisons," instead of causing us to envy the Parisians for their happy solution of the great question of pavements, had only the effect of exciting compassion for the poor outside barbarians who put their trust in asphalt. For, had we not tried asphalt here, and found it wanting?

Yet it was not the asphalt pavement at all which proved a failure in these experiments. The material used was a spurious compound; a mixture of sand and gas-house refuse, which had this only in common with asphalt, that the two substances went by the same name. Here the adage, "Give a dog a bad name," was reversed. The genuine asphalt pavement was thus involved in the ill-fortune of its base counterfeit; only for a little while, it is to be hoped. So soon as we discover within convenient distance from our centres of population native deposits of asphalt, we shall avail ourselves of the improvements introduced into the art of road-making in France, and the "coming man" can go about his affairs without having his ears stunned by the clatter and roar of vehicles; the horse of the future perform his service without constantly risking life and limb; and the carriage of the future roll along without being jolted to pieces. In France the asphalt pavement is as much a success as the railway, and, as we are still seekers, still experimenters in this matter, it is perhaps well that we learn the processes followed by French engineers.

Dr. L. Meyn, of Halle, has published a pamphlet on "The Asphalts," which sums up all the information that is accessible regarding this material. In the present paper we propose to give, mostly in his own words, the history of asphalt as a material for paving foot-paths and roadways.

Natural asphalt, or asphalt-stone, is a porous, calcareous rock, saturated with bitumen, or natural tar, and capable of being worked into a tough, hard mastic. It is not unlike mortar in general appearance, and its color is usually chocolate, giving a fracture of lighter color. Its grain is fine, and each molecule of limestone is coated with the bitumen. The proportion of the latter in the mass varies from 7 to 15 per cent. At a temperature of between 338° and 356° Fahr., asphalt-stone falls to powder, and may then be dissolved in hot melted bitumen.

This substance does not occur very abundantly in Nature, the only deposits of any importance, so far as yet known, being found in the Val de Travers and at Seyssel, in Switzerland; Seefeld, in the Tyrol; Lobsan, in Alsace; Hölle, in Holstein; and Limmer, in Hanover. The deposit at Hölle is by far the most extensive in Europe; but, though here the particles of the limestone are thoroughly permeated by the bitumen, the material is not considered by the Paris Asphalt Company to be suitable for pavements, because it contains an excess of pure petroleum. Yet Dr. Meyn thinks that by exposure to air the greater part of this surplus may be dissipated, and the remainder oxidized.

Ancient authors state that Babylon was partly built with asphalt, and that an asphalt cement was used for the walls of Nineveh. A Greek physician, Eirinus, endeavored to bring this substance into use as a building material in 1712. He was the first to discover a method of reducing the asphalt of the Val de Travers to the liquid state, and obtained the monopoly from the King of Prussia of all the asphalt beds he might discover in the principality of Neufchâtel. He published in 1721 a "Dissertation on Asphalt," in which he gives as follows the process of making asphalt cement: "The preparation of this cement is very easy. The stone must be slightly warmed till it can be coarsely powdered. A small quantity of pitch is added, to make it thinner and more soluble, and then the whole is melted over a slow charcoal-fire." This cement was to be used instead of mortar, and also to protect wood and stone-work against decay. There is still to be seen at Couvet, a little village in the Val de Travers, a flight of stone steps, dating from the time of Eirinus; the lower steps are coated with asphalt, and are almost entirely unimpaired, while the upper ones, which were not so protected, are worn into holes. But the material did not continue long in use for building purposes, for in 1802, after the discovery of asphalt-stone at Seyssel, near Geneva, we find the preparation of a mastic, from bituminous limestone and tar, heralded as a new invention.

In 1832, the Seyssel quarries fell into new hands, and from that period we date the progress made in the matter of asphalt pavements. The new proprietor of the quarries, Count Sassenay, devoted himself exclusively to producing a continuous and homogeneous material, and carefully instructed his workmen in the best manner of laying this pavement. The celebrated foot-path of the Pont Royal, the fine pavement of the Place de la Concorde, Paris, as well as many pavements at Lyons, belong to that period. Sassenay's process is still employed in preparing asphalt for paving foot-paths, and the mode of laying down the pavement is as follows: The foundation must be even, for any inequality of its surface will cause the pavement to wear out more rapidly in some parts than in others. The mastic is broken into pieces, and melted in caldrons with bitumen at a temperature between 150° and 170° Cent. Then from 60 to 70 per cent. of sand is added, and the mixture is ready for application to the surface to be covered.

But still a good pavement for roadways was a desideratum. First the experiment was tried of laying down a bed of broken freestone, and pouring over this melted asphalt mastic. This method, however, proved unsuccessful, for, when cold, the mastic was too brittle, and if one of the corners of the stones was struck and broken by carriage-wheels, a hole was made, which gradually widened, and was difficult to mend. In Lyons, a layer of asphalt mastic, two inches in thickness, was spread over four inches of concrete. This was found to be an excellent pavement, but a fatal objection to it was its costliness.

It was at last observed that the roads and paths leading to the quarries of the Val de Travers were always in good condition, firm, solid, and elastic. Here was an asphalt pavement, formed of the small pieces of the mineral which fell from the carts, and which were pressed down and flattened by the wheels. The first highway asphalted on this principle was that between Bordeaux and Rouen. The road was first macadamized, and then covered to the depth of an inch and a half with asphalt, broken up in small pieces. As the plan appeared to be a complete success at first, several other roads were asphalted in the same way. Soon, however, the crushed granite of the macadam began to cut its way through the asphalt, and broke its continuity, thus allowing it to be permeated with dirt and water. Finally the problem was solved by a Swiss engineer, A. Merian, of Basle, who proposed to lay down powdered asphalt in a warmed state on the street, and, by applying strong pressure, to form at once an impermeable, elastic surface. The French engineers readily adopted the suggestion, and the first trial of the new method was made in the Rue Bergère. The engineers cried "Eureka!" and well they might, for experience in Paris shows that—1. The asphalt costs, in the first instance, one-third less than stone pavement; and 2. That the annual cost of maintenance is three-quarters less than that of a macadamized road.

The process of preparing the asphalt pavement is thus described by M. Léon Malo: The asphalt-stone is brought direct from the quarries, and broken up into small pieces, about the size of those used for macadamized roads; it is then heated over a stove in a drum-shaped iron vessel with feet, till it crumbles into powder. In order that the powder may not lose its heat, the whole apparatus is conveyed on to the street where it is to be applied. Then a foundation of *béton* is laid, about four inches deep, which may, however, be thicker or thinner, according to the nature of the soil. On a macadamized road the concrete may be omitted; but on loose soil it should be laid as thick as six inches. The arch of the roadway should only be just sufficient to drain off the rain-water. The powdered asphalt is then spread over the surface, to a depth of 16 to 20 inches (according to the amount of traffic), and stamped down. Then a heavy roller is drawn over it.

With regard to the danger of horses slipping and falling on the smooth surface of the asphalt pavement, the following facts are of interest:

At Lyons, which has long had mastic roads, a number of cavalry-horses fell on a street of compressed asphalt. This accident arose from the circumstance that the asphalt had been laid on an old macadamized road, and had therefore that considerable arch which is unnecessary and dangerous for the asphalt road. The cavalry riding in a long line, those horses near the side of the road slipped on the steep incline.

At Marseilles, where the asphalt roads from the harbor to the town were made with a very gentle curve, there has been no increase in the number of accidents, though the traffic is enormous. A very slight arch of the road is quite sufficient to allow the rain to run off from such a smooth surface.

It is also not advisable to lay the asphalt on any street with a gradient greater than 1 in 60, though in London some streets having a gradient of 1 in 57, and even to 1 in 46, have been covered with asphalt without any apparent danger. It is of course extremely difficult to get any accurate information about the number of accidents on the streets, general vague impressions being worthless; but in Paris the number of horses which were observed to fall in the Rue Neuve des Capucines, during two months, was as follows: In the former, which was paved with sandstone, in blocks, from Fontainebleau, one horse in 1,308 fell; on the latter, which was covered with asphalt, one in 1,409, so that the balance was in favor of the asphalt.

In snow or frost asphalt is not so slippery as granite, being in itself warmer, and also more easily warmed by the slightest rays of the sun; hence, the ice is more slow in forming, and quicker in melting, than on granite.

It has been proved that the greatest number of accidents to horses happen when the asphalt is not cleaned, for the surface is never muddy or greasy, except with foreign matter, and this ought to be constantly washed off with water, which is plentifully laid on in Paris, and to some degree in London. At any points where this cannot be done, a slight sprinkling of coarse sand will prevent the horses slipping. This is only a temporary remedy, but valuable in case of emergency. It is one of the great advantages of asphalt, however, that it is so easily and cheaply cleaned.

In case of a conflagration, the asphalt pavement will not help to spread it. In London heaps of wood were set fire to on asphalt pavements, but, when the embers were raked away, there were only a few weak flames seen issuing from the asphalt, and they went out of their own accord in a few moments.

In conclusion, we give the results of experience with these pavements in London, and these are: 1. The first cost of the asphalt road is the same as that of a granite pavement. 2. The annual cost of maintenance is a trifle less. 3. Where a granite pavement is worn out in from seven to ten years, an asphalt pavement is still in perfect condition. 4. Asphalt, when taken up, may be used again and again.

REGARDING MATTERS IN INDIA.

By CAPTAIN LYON.

A LECTURE BEFORE THE LONDON SOCIETY OF ARTS.

IN describing the various views, the lecturer said: I beg to ask your assistance this evening in what I am going to do. I want you to use your imagination, and fancy yourselves on board ship, and —so that it may be pleasant and agreeable—in one of these new Bessemer ships, where you have no sea-sickness to endure. We will go down the Mediterranean, through the Suez Canal, down the Red Sea—where the heat is frightful, and the thermometer 120° on deck and any number below, in fact perfectly suffocating—to Aden. We will not stay there, but press on to Ceylon, where we shall arrive in ten days, and where the beauty of tropical vegetation is seen for the first time—lovely beyond description. Thence we go on to Madras; but before we arrive I will show you the god Ganesa. There he is, in all his glory. He is the god most worshipped of all the Hindoo gods —a beauty, you see. His history is as follows: For certain reasons it was considered necessary that Siva should marry, and as he was an old bachelor he did not like it. However, the marriage took place between him and Parvatee, who unfortunately gave birth to a son. Parvatee had a brother, called Vishnu, who was always upbraiding her, and Ganesa, who was a most lovely child, always took his mother's part. At last, Vishnu one day began upbraiding her again, and Ganesa threatened to thrash him, and the result was that they had a fight, and Ganesa got a tremendous thrashing instead, and Vishnu, with one blow of his cimeter, cut off his head. Parvatee took a fit of the sulks at this; but in the end Siva was asked to restore Ganesa to life. Siva at last consented to do so; but on looking for him they could only find his body, but no head. Here was a difficulty. The gods were consulted as to what was to be done, and the result was that a god was sent to bring the head of the first animal he saw and put it on Ganesa's body; and this animal, unfortunately, was an old elephant, with one tooth. They took his head and stuck it on to Ganesa's body, and you see the result. Parvatee did not like this, and in return, to pacify her, Brahma said that Ganesa should be most worshipped of all the gods. Before a Hindoo builds a temple, or a house, or goes a journey, he prays to Ganesa. And so I say: "O Ganesa—glorious and honorable Ganesa—grant me success this evening. May I please all this people! All reverence to you, Ganesa."

I will now go back to our steamer, and we must fancy ourselves coming into Madras. There is the steamer just as she appears soon after daylight off the roads. Madras has no harbor whatever, and so every captain arrives as early as possible, to get away before night; as soon after daylight as he can he casts anchor in the roads, and if you come on deck in the morning you will see round the vessel the boats in which you will be expected to land, one of which you are now looking at. I leave you to imagine the effect when an English lady sees for the first time twenty or thirty of these fellows in the morning. The boat is called a catamaran, and it is the only chance you have of landing if the surf is high. You are lashed to this thing, and they bring you to shore. The sea washes right over you, but, as the water is warm, except that you do not like the ducking, it does not much hurt you. These fellows are off the boat, and in the water, and on to the boat again in a moment. Although they say the sea abounds in sharks, they are never eaten, and they actually say the sharks will not touch a black man.

Well, the first thing you do, having landed, is to go to an hotel, and find yourself a carriage. There are three kinds you can choose from. There is the old palanquin, put upon wheels, called the palanquin coach, which is what Europeans generally use. The horse looks sorry, but he can go; every horse has his *ghora-walla* to attend him, and a woman too. You buy the ghora-walla and the woman when you buy the horse. It is the man's business to clean and feed the horse, and the woman's to cut grass for him. The next carriage is called a *shigrampoo*. You pay 1*s.* 6*d.* an hour for this, and have to pay beforehand, and whether the pony goes or not it is all the same. The Hindoo has no idea of time; he prefers that the pony should not go, and so Europeans seldom use this. The next is a bullock bandy—no springs. The bullocks come from Mysore, and are admirable goers. The native standing by the side is the owner, and the other is the fellow that drives. The natives are all vain, and want to be photographed, and are sure to stand wherever they see a camera. Now we start on our way to the hotel, having chosen one of the conveyances. We shall not have gone far before we see something of this sort at the corner of nearly every street—an almost naked barber, engaged in the act of shaving, all for one penny. They say they are most wonderful fellows at it. They actually shave people while they are asleep. I found them very indifferent hands. If they are not engaged in that, these very fellows are shaving the natives' heads. It is wonderful to relate that, although there is the most intense heat, the natives invariably shave their hair off. They say it cools them. You never hear of a sunstroke.

We will now turn into the main street of Madras. The large building to the left is a sort of emporium, where every thing is sold. The building on the right is the Bank of Madras. Passing through this, at the end we come to the bazaar, and we will just pass through a corner of it and see one or two of the shops, such as everybody is obliged to use if he is not prepared to go to one of the few Europeans in the place. There you see the cap used by the natives as a substitute for a hat—it is nothing but a piece of linen folded in a peculiar shape. You see the two men who are making these caps are wearing similar ones. Another shop is that of a native tailor. The natives themselves never wear much that requires any shaping, and consequently there is little for them to do in the way of cutting out. But they are wonderfully good hands, nevertheless.

Having passed these, we soon get to the hotel, hoping to find peace and rest. But when the Peninsular and Oriental steamers come in everybody knows it, and hundreds of the natives are on the lookout to get money. They see what hotel you go to, and then begins the cry for *bakshish*—nothing but bakshish. But first of all let us look at the *picota*, the machine that is used for drawing water. There it is, and the natives run along the top of the long pole to press it down, and then they turn round and run backward and foreward, keeping the machine at work all day; and in the rice-season it is very disagreeable, and even perfect purgatory, to live near where one of these machines is, and hear the two bits of wood rubbing together, and going on "cah, cah" all night and all day. It drives you almost mad. Woe betide the unhappy fellow who gets a bed near one of these picotas.

Arrived at the hotel, you find a lot of fellows asking for bakshish, and playing drums. You give them some money, only too glad to be rid of them. They are succeeded by fellows who play tricks with some stuff dipped in turpentine, through which a man jumps backward and forward. When they are gone, they are succeeded by a conjurer who shows you the way to get rid of your wife if you have got one; or, if you have not, the way you can if you get one and don't like her. He ties the woman up tightly in a net first, and, when he has done that, he puts a basket on the ground. He then takes the top off, and proceeds to put her into the basket. There is the unhappy wife in the basket. The little boy plays the tom-tom, beating it all the time, the fellow standing looking on. As soon as the woman is packed up, he covers up the basket, and, seizing a sword, he plunges it in. The woman shrieks and yells frightfully, the blood pours out in torrents, the ladies who are looking on faint, and the gentlemen curse and swear, and pull him away. When they tear open the basket, they find it empty, and the woman comes out of the house where you are staying and asks for bakshish. This fellow is succeeded by two other jugglers, who spread a cloth before you over the sand, and in some mysterious way cause a fine large branch of the mango-tree to appear, and grow up under the cloth. It is a curious fact that in Egyptian history we read of the same trick with the lotus-tree as this with the mango-tree.

Now we come to the snake-charmers, the most wonderful race of men in the whole of India. They take up a cobra, the most deadly of all reptiles, and still hardly ever are bitten. There is the photograph of these snake-charmers before you. The snakes are never still. The poison-bag is in the roof of the mouth; and, by certain means, this bag is pressed, and the poison ejected. But, when you remember that two hours is about the limit one lives after the bite of a cobra, you cannot help wondering at the carelessness of these fellows. And though nowadays they say that by ejecting certain alkali, ammonia, or something of the kind, into the blood, the bite can be cured and the poison destroyed, yet still, in the wilds of India, who would be able to do this in the short space of time allowed to live after having been bitten? There is one little animal alone that enjoys exemption from the fearful bite of the deadly cobra. It is a favorite amusement to some people to watch the struggle. They will turn a large cobra loose in the room, and then immediately place a *mongoose* before it. The mongoose instantly attacks the cobra, and a desperate fight ensues; the cobra bites the mongoose over and over again, but the poison seems not to have the slightest effect on it, and the battle will certainly result in the death of the cobra. If the mongoose dies, it is from sheer loss of blood and exhaustion, and not from the effects of the poison, as thousands can testify. Dr. Short has held for many minutes the mouth of a cobra fixed on to a mongoose, but it has got up and run away, without any hurt. What peculiar antidote he possesses science has not yet been able to discover.

Having now taken a cursory view of Madras and its people, and the jugglers, such as they are, we pass on to consider their religion and their temples.

First, I must tell you that the word temple does not exist in India. It is merely a word imported by us. The word they use is *devila*, and means the house of God. A temple does not consist of one, but four component parts. What we generally call a pagoda is nothing but the gopurum, answering to the Egyptian pylon over the door. The four parts of each temple are the *gopurum*, or door; the *mundapum;* the *teppa kolum*, or tank; the *vimanum*, or sanctuary.

Now, I propose to show you these, and give you some idea of what they are. We will take the train at night from Madras, and at twelve next day we find ourselves at Trichinopoly, close to which is one of the largest and finest temples in all India. The view is taken from the gate-way at the south entrance. The pyramids are called the gopura, and mark the entrance into each separate court. The houses are inhabited by 8,000 Bramins, who are not all necessarily priests; but, like the tribe of Levi among the Jews, from whom the priests were taken, so among the Hindoos the priests are taken from among the Bramins. The others hold their shops in the temple. There are 21 of these gopura; the large gopurum to the right is 300 feet high. The next view gives the gopurum more in detail, and shows it exactly as it is. The lower part is of stone, the upper part of brick, and this is covered with figures, representing different scenes in their holy history. Sometimes these gopura are very much more ornamented than others; but they are always for the same purpose, that is, to cover the entrance into the different parts of the temple.

We now come to a mundapum. A mundapum may be composed of simply eight stones. Take four stones and put them upright in the ground, about eight feet high; put the other four along the top, and you have got a mundapum, and such exist in thousands all over India; and, whether elaborate as this is, or perfectly plain, whether square, or round, the result is the same, and you have a mundapum. In this case each pillar is one single block of granite, out of which those figures 15 feet high have been carved; it is covered with a flat stone roof. It constitutes one of the finest mundapa in India.

We next proceed to look at a teppa kolum, or tank, as you see here. The god not only is treated in every way like a human being, but he must have his excursion in the water, and his ride in the car—21 times he goes round that centre pavilion you see in the middle. On the left and on the right you see mundapa, and the small gopurum covers the entrance into the sanctuary.

I may as well tell you that the sanctuary is nothing but an oblong building, perfectly plain, dark as pitch, not the smallest glimmer of light being admitted. No European is ever allowed to enter it, except a prince of royal blood, and he must enter it alone; and, if any other European, or heathen, or low-caste man, dares to put his foot inside the sacred portals, the temple must be abandoned, or the man must die. Such is the rule of the Hindoos.

I will just show you, in passing, the interior of a mundapum—that is, a very plain one—one of those we just saw the outside of. That curious thing in the middle, called a flag-staff, was used formerly to mark the distance a man was allowed to approach toward the sanctuary. He was not allowed to pass nearer than that. But gradually it has fallen into disuse, and now he may walk within three or four yards of the sanctuary-door. It is so dark, though, that nothing can be seen.

Passing from Trichinopoly we here leave the railway, and have to choose the way we will travel. There are three ways before us. We can go on horseback, and, starting an hour before sunrise, and galloping all the time till the sun rises, accomplish 12 or 14 miles at the outside. The next way, which is more comfortable by far, is by the palanquin, carried by men on their shoulders, and you go along very easily. But if you are heavy it is a great misfortune, for more bearers are required to carry it, and consequently more money to pay them. But this is now almost obsolete, except in the native states, and so you are obliged to fall back upon the bullock-coach, which I will show you.

That is the vehicle in which you have to travel all over the south of India, except on the few spots where there may be railroads. This one is occupied by natives; turn them out and get in, and be sure to sleep with one eye open, or you will not travel very far. If you close your eyes the man will immediately stop, and the bullocks will lie down and go to sleep too, and the man will get under the carriage, and you will be lucky if you get over two miles instead of twenty. I have known a native go three times round his own village, and come back to his own door, and when you awoke, thinking you were twenty miles on the road, and routed him out from his own house, and asked him where it was, he would tell you it was a village eight or nine miles off, but you saw it was the same man and the same bullocks, which you ought to have changed long before getting that distance.

Nominally, there are plenty of roads in India, and good ones, too. The government pay enormous sums to keep them in repair. The contractors are natives, and they keep them in good order for five or six miles out of the town where the Europeans are likely to drive, because if they saw bad roads they would make a row; but nothing is more execrable than they are farther on; there are holes big enough and deep enough to bury a man in; you will often be 24 hours doing 12 miles.

However, we go on to Madura, the Rome of India. It is one of the largest and most noted places, and has one of the richest temples. The first building we are going to see is a mundapum. Opposite the entrance to all these mundapa are what are called the guardians of the gods, of which you see one here. There he stands, carved out of a single block of granite 15 feet high, beckoning with one hand, and with the other warning you not to come unless you are properly prepared, with his foot on the head of a cobra—whether typical of the triumph of the Hindoo religion over the worship of the serpent, is a question I dare not go into, for it is enough to mention that one subject among *savants* and you set them all arguing. However, passing in beyond this, we see one of the most beautiful buildings in the whole of India. It is a mundapum, and was built by the last King of Madura before we took it. It cost one million of money, and took 22 years to build. The story is, that the reason of his doing so was that he asked the god to come and pay him a visit. The god said he had no objection, but he had not a house fit to receive him in. So the king at once set to work and built what you see, and, though he is long since dead and gone, the god is brought ten days every year to pay a visit to this mundapum. It is 333 feet long and 84 feet wide, and is considered by all to be one of the finest in India. It is built of pure gray granite. Every pillar in it to the right and left is whitewashed. The natives always whitewash them to a certain height. On each side are representations of the king and his successors. You see him on the right under his canopy, and beside him his two wives. The story goes that Trimul Nayak married a daughter of the Rajah of Tanjore. The day after he brought her home he took her to see this magnificent building, which was just completed. After walking through it, as she did not say a word, he asked her why she had not spoken, and what she thought of it. She answered that her father had a better stable for his horses. In a fury he drew his dagger and stabbed her in the side, and it is said that, when the pillar was cut, and they sculptured the figure of the wife, the hole appeared in the side; and, although they changed the pillar three times, every morning after, they found the hole still there, as a warning to passionate husbands to keep their tempers. One of the pillars outside this temple, being very much exposed to the weather, is consequently much damaged. It represents Vishnu giving his sister in marriage to Siva, and every year there is a cermony of marriage performed. But, while the ceremony is going on, a Bramin invariably sneezes, and as that is an omen of bad auspices, the marriage is postponed, and, as this has been going on year after year, it probably will to all eternity. That sneezing puts a stop to it.

The outside of this celebrated mundapum is similar to that we saw before at Trichinopoly, the two side-pillars being carved differently, the one on the right being Ravana, the celebrated giant, who was condemned to bear a mountain on his back in punishment for his sins. Exactly opposite is situated the celebrated Temple of Madura, the richest in India, with an income of £4,000 a year, and an enormous number of priests. The difference between this and the other at Trichinopoly is that this is all covered over, while that is uncovered. That one is very poor, while this is enormously rich. I ought to have said a few words here respecting Hindoo worship. There is not a single Hindoo temple dedicated to the worship of the one God, and they have no representation of Him. He is something too awful for that. They never address Him except through a priest, or one of his personifications, Brahma, Vishnu, and Siva. These are the three principal deities. Brahma is Creation, Vishnu is Preservation, and Siva Destruction. And, although it is said that there are 330,000,000 gods in India, yet the simple truth is, all these are only names given to one or other of these in any particular place where the god is worshipped. He is always named for some act or other which he is supposed to have performed at or near the place of worship. One or other of these three is the god, and there are 330,000,000 names of these gods. That is the whole secret of the Hindoo religion.

Passing into this celebrated temple, we come to the golden lotus-tank, one of the most celebrated tanks in India. It is supposed that in this temple originally there was no tank, and so Siva was obliged to make a passage under the sea to allow the water of the Ganges to come a thousand miles and supply this tank with water. Alongside this tank there was a bench, and there was a sect of holy men who had a right to sit upon it. This bench had the peculiar faculty of elongating itself at pleasure, or becoming shorter, as the case might be, and therefore, when anybody applied to be admitted a member of this holy sect, he was ordered to sit on the bench. If the bench elongated, he was to be received as a member; if the bench became shorter, he went head over heels into the water, and could not become a member; and, as the water was in a very foul state, he did not have a very pleasant bath.

Now we come to the Palace of Madura. It formerly covered a square mile of ground, and was a most splendid building. Every pillar you see is 50 feet high. There is very little of it left now, and what little there is, is used as a court of justice every day in the season. The next view will give you a better idea of this wonderful place. It is taken from the inside, looking outward, and gives a side-face view of the square, three sides of which still stand. The interior of one of the colonnades also gives a very good idea of the grandeur of the place.

We now strike across the sea-shore, and on going a little to the north we cross a small arm of the sea, and come to Ramisseram, which has the most celebrated temple in the south, if not in the whole of India. Its corridors are considered the finest in the south—the door at the end marks the entrance to the sanctuary—they are 300 feet long; each pillar is one block of solid gray granite. Unfortunately, from its being whitewashed, much of the beauty is hidden. If at any future day it should be cleaned, it will, of course, be in a better state of preservation thereby.

This gives an idea of the strange way the Hindoos sculpture the pillars in their temples. The figure is nothing but that of a juggler, and yet he is carved out of one of the pillars in one of the most sacred temples in India. The side-aisle of the Temple of Ramisseram is 700 feet long; the window at the end is five feet high, and gives some idea of its length. When we consider that the pillars are of granite, and the enormous time it must have taken to build such a temple, and carve such a wonderful corridor, I think you will agree with me that it is a work which the world can hardly excel. Four thousand feet is the aggregate length of the corridors. The temple is situated at the edge of the sea, and receives the pilgrim after his long and toilsome march of 3,000 miles from the north. Only those who know what Indian travel is can conceive what he must have gone through; when he leaves the Ganges he is laden with bottles, one of which he is bound to leave at every temple till he arrives here, and leaves the last, and here he hopes for rest. But he has no rest yet, for the Bramins take him to the sea, and the actions they make him go through at daylight are very absurd. Then, between here and Ceylon, is a long sand-bank, seven miles long, which formerly was a portion of the land, and through this the pilgrim is condemned to wade to a temple built on a rock. At last the Bramins have done with him, and he finds rest and repose here. He wanders through the splendid corridor late in the evening—in the dark night—and knows he has earned the right to remain. He feels that he has insured to himself beatitude hereafter, and, he hopes, prosperity in this world.

Before finishing, I must ask you to understand what Indian caste is. It is compared to our society, but in reality is very different from it. A high-caste man, no matter what his position, though he may be a beggar and perform the most extraordinary offices, still always has the right of *entrée* into the houses of the richest natives, and is welcomed wherever he goes, and always received well. On the other hand, a low-caste man, though with millions of money, is never allowed to enter a temple. Among the higher caste are the fakirs. There is one, such as I saw him. He confessed to me that water had never touched his body, his nails had never been cut, he had never been shaved, and his hair was bound up with rags, and was a solid mass of dirt and filth, and yet this man was received with open arms in the magnificent palaces of the rich natives, where he was always welcome Such as I saw him I show him to you.

TO FREDERICK A. P. BARNARD.[1]

THE years are many since, in youth and hope,
Under the Charter Oak, our horoscope
We drew thick-studded with all-favoring stars.
Now, with gray beards, and faces seamed with scars
From life's hard battle, meeting once again,
We smile, half sadly, over dreams so vain;
Knowing, at last, that it is not in man
Who walketh to direct his steps, or plan
His permanent house of life. Alike we loved
The Muses' haunts, and all our fancies moved
To measures of old song. How, since that day,
Our feet have parted from the path that lay
So fair before us! Rich, from life-long search
Of truth, within thy academic porch
Thou sittest now, lord of a realm of fact,
Thy servitors the sciences exact;
Still listening, with thy hand on Nature's keys,
To hear the Samian's spheral harmonies
And rhythm of law. I, called from dream and song,
Thank God! so early to a strife so long
That, ere it closed, the black, abundant hair
Of boyhood rested silver-sown and spare
On manhood's temples, now at sunset chime
Tread with fond feet the path of morning-time.
And if perchance too late I linger where
The flowers have ceased to blow, and trees are bare,
Thou, wiser in thy choice, wilt scarcely blame
The friend who shields his folly with thy name.

AMESBURY, MASS., *Tenth Month*, 1870.

[1] Whittier's beautiful dedication of "Miriam" deserves a wider circulation than it has received.

EDITOR'S TABLE.

COERCION IN EDUCATION.

THE question of collegiate reform has again broken out in public discussion. Dr. McCosh has written a letter to the *Evening Post*, protesting against certain contemplated changes in the management of the students in Harvard University. It is proposed to abolish the compulsory recitations, to allow the students greater freedom, but to hold them rigorously to the final examinations — a proceeding which Dr. McCosh thinks is not only in itself mistaken, but, by its adoption in so influential an institution as Harvard, would exert an injurious influence on other colleges of the country. The immediate question is that of college discipline. While there is a great stir in behalf of general compulsory education, Harvard proposes to relax its coercive practices. President Elliot, in his report to the Board of Overseers, suggests that the time has come for allowing more liberty to students, and, as their average age of admission to his institution is now above eighteen years, he thinks that the school-boy tactics might be dispensed with, and the students be treated more as responsible men, preparing for the work of life. Dr. McCosh holds, on the contrary, that the college is a place for discipline, which is to be acquired by the enforcement of external rules and the close supervision of the students by tutors, and the method of enforced recitations.

President Elliot assumes that the policy of European universities is more free than that of American colleges, and in this respect is worthy of our imitation. Dr. McCosh denies this. He says: "In all the good colleges of Great Britain and Ireland, the tendency of late years has been toward a weekly or daily supervision of studies. In Oxford and Cambridge, which have produced such ripe scholarship and high culture, the teaching is conducted, not by loose lectures of professors, but by numerous erudite tutors, who may not have more than half a dozen pupils present at a time, possibly not more than one, but who rigidly insist that the pupils be present and do their work." In regard to the German system, Dr. McCosh states that the *Gymnasien* and *Realschule*—the preparatory schools—take charge of the pupils from the age of ten or twelve to eighteen, and carry their scholarship as far as the freshmen or sophomore classes in our American colleges. And he says that at these institutions "attendance is rigidly required, and the instruction is of a thoroughly drill-character. Every one ought to know that the foundation of German scholarship is laid, not in the universities, but in the Gymnasien. In the universities of Germany there is much to commend. Berlin, with its two hundred teachers, can furnish high instruction in every department of human learning. It is the very place for an American youth to go to, when, having taken his degree at home, he wishes to perfect himself in some special department of scholarship. At all the universities a few studious youth work with great assiduity and success. But a very large portion are not studious, and take a deeper interest in beer-drinking, *Burschen* songs, and sword-duels, than in careful reading."

The question here raised is not to be settled by European precedents, because—first, as we see, the doctors disagree as to the facts; and, second, because it is a radical question affecting our whole educational system, and can only be settled by an appeal to first principles. The difficulty encountered is by no means confined to the higher institutions; it is coextensive with all modes of public education, and is just as palpable and refractory in the middle and lower schools as in the colleges. The trouble arises from the massing together of students of unequal moral and intellectual capacities. Between those of superior and inferior grade, there is an undoubted antagonism of interests and requirements. The management that is best suited for the one class, under existing views of education, is not best for the other, and we see in every school the evils that arise from uniformity of system. For the development of the highest character, self-restraint and self-direction, with free and responsible action, are indispensable; and, in every school, there are those who are capable of this self-education, and who suffer from a meddlesome and offensive coercion. On the other hand, there is the great majority who seem to require external direction and police supervision, and of whom, perhaps, little can be made under any system. Which shall be sacrificed?

That there is a tendency to escape from the low agency of external rules and regulations, and to give greater scope to the principle of individual self-government, is unquestionable. President Elliot's remark, that "the time has come for allowing more liberty to students," is but the recognition of a great change in regard to the best method of controlling human beings in all branches of social regulation. With the gradual disappearance of slavery within the sphere of civilization; with the decline of political tyranny and interference with the individual; with the relaxation of the severities of family government, and the management of apprentices; with the passing away of religious coercion in matters of belief, and with the substitution of the principles and practice of non-restraint for the old methods of violence, even in lunatic asylums, there has been a corresponding change in the school-room; its barbarisms of discipline have ceased, and the question is now one mainly of the degree of supervision. Many evil consequences undoubtedly flow from this profound transition, but it must be accepted as an on-working of humanity, and a phase of the action of Nature. To assume that the forces in play have now reached their final equilibrium, we think is irrational, and to arrest the movement at its present stage we hold to be impossible.

It is now virtually conceded that the highest results of scholarship in the universities are not attained by the coercive drill-system. Speaking of the German institutions, Dr. McCosh says that "at all the universities a few studious youth work with great assiduity and success; but a very large portion are not studious, and take a deeper interest in beer-drinking, songs, and sword-duels, than in careful reading." Such is the outcome of that thorough-going preliminary drill which characterizes the lower or preparatory schools of Germany. The passage of students from these to the universities is regarded as an escape from drudgery, which produces a vicious reaction when the sphere of freedom is reached. At all events, this thorough drill-system is a failure with the great mass of students. It is the same in England. Dr. McCosh speaks of "the ripe scholarship and high culture" which marked the educational policy of Oxford and Cambridge, but this description is applicable to but a very small proportion of the students. Notwithstanding the vigorous coercion of discipline in the great public schools which prepare for the universities, and notwithstanding the supervision that Dr. McCosh alleges in the universities themselves, the number of whom ripe scholarship and high culture can be affirmed is scandalously few. Whatever truth there may be in Sydney

Smith's remark that the universities are in the habit of taking credit for all the mind they do not succeed in extinguishing, it is pretty certain that the small number of graduates who give character to the school are those who would succeed under any system. So far, indeed, as the great body of the students are concerned, there is small ground for boasting of the success of the English system. When we consider the wealth and resources of the English universities and great public schools, when we remember their ancient prestige, the talent at their command, and their high place in public confidence, in the light of the results produced, we can cordially agree with Prof. Blackie, of Edinburgh, in his letter to Dr. Hodgson, when he pronounces the whole system "a superstition, a blunder, and a failure."

School-discipline can never be divorced from the nature of school-occupation. If the studies are repulsive, if they do not take hold of the feelings, or if they produce indifference or antagonism, force is the teacher's only alternative, to keep the school in order, and carry on its work. The essential implication of coercion in influencing conduct is a penal policy. A compulsory system is one that punishes for a breach of rules. In civil society, where the object is simple protection, government has nothing to do but to attach penalties to the violation of law. But it is widely different in education, the object of which is to incite the student to put forth his energies; for, in the end, all true education is self-education. But a punitive system appeals to the lowest motive, the fear of the infliction of some form of pain, and it can never stimulate to the best or highest action. In the past history of education, flogging has been its almost constant accompaniment, and this has been coincident with schemes of study that have failed to enlist the sympathies of pupils, and to quicken their nobler emotions. Take the one element of language, the study of which constitutes the staple of school-drudgery, and which is habitually pursued as arbitrary and irrational task-work, and what can we expect but that students will require to be *driven* through the irksome routine of daily toil. Prof. Halfourd Vaughn indulged in no exaggeration, when, called before a committee of the British Parliament to testify as to the working of the English system, he said: "There is no study that could prove more successful, in producing, often thorough idleness and vacancy of mind, parrot-like repetition and sing-song knowledge, to the abeyance and destruction of the intellectual powers, as well as to the loss and paralysis of the outward senses, than our traditional study and idolatry of language." Two hundred years ago, Milton criticised the education of his time from exactly this point of view. He denounced it unsparingly, and went so far as to declare that a better system was not only possible, but might do more even for dunces than the prevailing method could do for brighter minds, and he put the statement in the following quaint and pungent form: "I doubt not that ye shall have more ado to drive our dullest and laziest youth, our stocks and stubs, from the infinite desire of such a happy nurture, than we have now to haul and drag our hopefullest and choicest wits to that asinine feast of sow-thistles and brambles, which is commonly set before them as the food of their tenderest and most docible age."

THE FAREWELL BANQUET TO PROFESSOR TYNDALL.

Prof. Tyndall having closed his labors in this country, has sailed for home. His work has made a deep impression upon the public mind, as was testified by the farewell dinner given in his honor in this city, before leaving. The affair was, in several respects, remarkable. No such brilliant gathering of scientific, literary, and professional gentlemen has ever before assembled on a festive occasion in this metropolis. As his lecture-rooms, in the various cities he has visited, have been crowded by the most intelligent and cultivated people, so the dining-hall at Delmonico's was filled with two hundred guests, many from abroad, and representing the colleges and scientific institutions of the country, together with a large body of the most eminent gentlemen of our city. The spirit of the occasion was one of harmonious enthusiasm for the distinguished professor in whose honor it was made, and of lively interest in the subjects and ideas he represents. The speaking was excellent, and, although graver and more didactic than is customary at such times, was yet by no means unexciting, and met with the most cordial responses. Of course Delmonico, prince of caterers, lost no reputation in the elegant and sumptuous repast which he furnished, but the social and intellectual treat was the great feature of the evening. Prof. Tyndall made a happy address, in which he explained the motive of his coming to this country, the laborious character of the work which his lectures involved, and the reasons which compelled him to decline the numerous urgent invitations that have poured in upon him from all directions, to lecture in the cities of the interior and the West. We have no space now to refer to the several admirable speeches that were made, upon subjects variously connected with the interests of science. They were too valuable to be left in the incomplete shape in which the reporters gave them to the newspapers, and they will be shortly published as an appendix to the little volume of his lectures which Prof. Tyndall has carefully prepared, and which will be given to the public in a few days.

LITERARY NOTICES.

The Earth a Great Magnet. A Lecture delivered before the Yale Scientific Club. By Alfred Marshall Mayer, Ph. D., Professor of Physics in the Stevens Technological Institute. Chatfield & Co., New Haven.

The author of this lecture is well known to the scientific world, both in this country and Europe, as an original investigator in the field of physics. He has made numerous researches in various physical branches, the results of which have been published in the scientific journals, domestic and foreign. He is now prosecuting various inquiries at the Stevens Institute of Technology, in Hoboken, where they have the finest collection of physical apparatus that can be found in any institution in this country, if not in the world. Having won his spurs as an original experimenter, and established his place among those who extend and create scientific knowledge, he now turns his attention to the work of diffusing it among the people. It is common to say that original investigators are not good expositors; and this is often true, but it is also true that they are frequently the very best of teachers. We have recently had a conspicuous example of this in Prof. Tyndall, and we now have another in Prof. Mayer. The lecture before us is a model, in its logical form, its copious and beautiful experiments, and its lively and graphic language. As an exposition of the elements of terrestrial magnetism in a compressed and readable form, it is perfect. Trübner, of London, has caught it up and issued it; and the *London and Edinburgh Philosophical Magazine*, the first scientific authority, has reviewed it in so just and discriminating a way that we cannot do better than to quote a portion of its statement: "This is the report of a lecture delivered before the Yale Scientific Club on February 14, 1872, in which the lecturer proposed to present to his audience '*one prominent truth* in simple and striking experiments.' The truth which is kept steadily before the mind throughout the lecture is, that the earth is a great magnet; and this truth is developed step by step by experiments of the most conclusive kind, each having been rendered distinctly visible to the audience by means of the *vertical* lantern, so that the processes of demagnetizing, with all the interesting motions of the needles, were seen projected on a luminous screen, eighteen feet in diameter.

"The lecture itself is a masterly production, and exhibits the result of much close reading as well as experimental research. Quotations are given from earlier writers on magnetism, illustrative of the sound knowledge which they possessed; and, as each experiment illustrative of the lecture is described, as well as the apparatus employed in manipulation, the reader is conducted from a consideration of the most ordinary magnetic phenomena presented by bar and electro-magnets to that of the same phenomena evolved from terrestrial magnetism. A paragraph selected from the closing portion of the lecture will fully substantiate this statement: 'Now we have finished our experiments; and what have they shown? I have temporarily magnetized a bar of soft iron, by pointing it toward a pole of our large magnet. I did the same with the bar and the earth. I permanently magnetized an iron bar by directing its length toward the pole of the magnet, and vibrating it with a blow of a hammer. I did the same with a bar, struck when pointed toward the earth's magnetic pole. I have shown you the action of a small magnetic disk on iron filings placed above and around it. You saw the earth produced the same action on the beams of the aurora. I showed you the action of this disk on a freely-suspended magnetic needle, and pointed out to you the earth's similar action on a dipping-needle carried over its surface. I have evolved a current of electricity from a magnet, by cutting with a closed conductor across those lines in which a magnetic needle, freely suspended, places its length. I did the same with the earth by cutting across those lines which are marked out by the pointing of the dipping-needle. Therefore, what am I authorized to infer? When the effects are the same, the causes must be the same; for, according to all the principles of philosophy, and conformably to that universal experience which we call common-sense, like causes produce like effects.'"

Family Thermometry. A Manual of Thermometry for Mothers, Nurses, Hospitallers, etc., and all who have charge of the Sick and of the Young. By Edward Seguin, M. D. Pp. 72. Putnam & Sons.

This is a valuable monograph upon an important subject, and is an interesting indication both of the progress in medical science, and of the need and possibility of diffusing its benefits among the people. More and more as physiology and pathology advance, are we discerning the fundamental nature of the thermal processes in the living economy. That the animal body is, first of all, a furnace to which the digestive system furnishes fuel, and the respiratory system the agent of combustion, is not a mere curious chemical fact, but it is a central and vital physiological law, which is involved with the whole subject of health and disease, of life and death. It may not be proper to say that heat is life, but it is an essential condition of it, and is unquestionably the raw material of it—if not life, it is yet transformable into life. But the organism generates its heat and loses it by fixed physical laws, while the whole scheme of its activities depends upon the maintenance of the vital temperature at a given point, the *norme* of health, which is 98° Fahr. in the Caucasian race. Any deviation from this point is an indication of disturbance and disease. The rise of temperature above the standard involves one class of disturbances; its fall below, another class. The physician alone can deal with the special complications which arise when the temperature ascends or sinks abnormally, but it is in the power of those not physicians to observe the indications, and thus to determine not only when the medical man should be called, but to furnish him with positive and valuable data for his treatment. The use of the thermometer has become indispensable in intelligent medical practice, but Dr. Seguin has shown that it is equally indispensable to mothers in the intelligent management of their children. The only difficulty is to get them to use it, and to give a little attention to the method of registering the results observed. The ordinary thermometer is badly graduated with reference to this use, and so Dr. Seguin has devised a physiological thermometer marked in so simple a way that it may be employed by anybody with facility. The health-point, or *norme*, is marked zero; O = H, or health. From this point, in fever, the index runs up, and, in depression, it runs down, proportionally to the danger in both directions, the points of significance being indicated upon the scale. Careful directions are given for using the instrument, and simple charts are prepared for recording the observations. These charts, and the systematic records they contain, are indispensable as forming a history of the case, for it is not only the deviations of temperature, but the train of variations and intermittent changes, that it is desirable to know. Dr. Seguin says: "The supreme importance of the first observation of the first abnormal temperature, at the first moment of a sickness, cannot be overrated. If it rarely shows, by name, what the intruding illness will be, at least it can often, by exclusion, tell what it will not be. For instance, a high first temperature, as of 3 to 4° above the point of health, cannot herald typhoid fever, but can measles or scarlatina. Moreover, the first observation serves as a mile-post to start the reckoning of the future stages, of increase or effervescence, of full force or diminution, of convalescence or relapse." Dr. Seguin observes: "The A B C of motherhood is the name I would give to that part of nursing which mainly consists in spying the subtle and bold invasion of disease, and of measuring from the first its deadly strides into the vitals of the innocent. The mother who can do that is the sentry. When she detects the moment of the invasion of the cradle, and measures the strength of the enemy on the stem of her thermometer, and can transfer and read its warnings on her chart, she is prepared for the struggle with death itself." Yet there is a difficulty here which Dr. Seguin has not been slow to perceive, and which he states without reserve or circumlocution. He says: "But where shall we find a mother who has been taught her duty in that matter of life and death? No use to mince it; it is a shame and a scandal that, in the curriculum of education devised for our sisters and wives, there is room for algebra, trigonometry, etc., and none for the fine art of nursing; that they are taught to look through microscopes and telescopes, but not in the faces of the little ones to read therein health or sickness; that they can tell the latitude of Peking, the height of Chimborazo; know at what point potassium fuses, or mercury solidifies, but that not one ever heard at what point of elevation of the latter metal in a thermometer life escapes from their dearest."

The Forces of Nature. A Popular Introduction to the Study of Physical Phenomena. By Amédée Guillemin. Translated from the French by Mrs. Norman Lockyer, and edited, with Additions and Notes, by J. Norman Lockyer, F. R. S. Macmillan & Co.

The novel and interesting feature of this book is its profuse and sumptuous illustrations. Its author has won some reputation as a popular writer on science, and the work has evidently lost nothing in translation and editing; yet its text alone would give it little claim to attention. The pictorial part of the work is not only copious and varied, but is finely executed, and renders the volume both attractive and instructive. It has no value as a text-book, and not much as an authority for reference; but it may be read with pleasure, and many of the illustrations cannot fail to be helpful to the student. The work is unique as a popular scientific luxury.

Epidemic Cerebro-Spinal Meningitis. With an Appendix. By Meredith Clymer, M. D. Philadelphia: Lindsay & Blakiston. 1872.

In this little work, which is mainly a reprint of the author's additions to Dr. Aitken's "Science and Practice of Medicine," we have, in compact form, a large amount of valuable information concerning one of the most dreaded, because most deadly, of man's diseases. As first published in 1866, and revised two years later, Dr. Clymer's monograph contained a sketch of the geographical and clinical history, the pathology and treatment of cerebro-spinal meningitis, as also, under the head of "Etiology," a brief account of the conditions attending outbreaks of the disease, and a very full list of authors upon the general subject. This new edition contains all the matter of the first two, and has, besides, a most valuable appendix, which deserves to be in the hands of every family that is capable of studying intelligently its own welfare. This portion of the work was prepared on the heels of the terrible epidemic of cerebro-spinal meningitis in New York during the first six months of last year, when, out of 790 persons attacked, 607 died. Availing himself of the records of the Health Department, and of the observations of Dr. Russell, Registrar of Vital Statistics, the author has been able, in this appendix, to throw much light upon the vexed question of the causes of the disorder. Thorough investigation proved these to be filth, overcrowding, defective sewage-pipes, and the like. It would appear that the disease is not propagated by contagion or infection, and consequently its origin must be ascribed to unwholesome conditions in the household or neighborhood where it manifests itself. If the public would be awake to the dangers they may themselves be creating, they would do well to procure this book, and give the appendix, at least, a careful perusal.

The following discriminating notice of "Physics and Politics," from the pen of Prof. John Fiske, appeared in the February *Atlantic*. It gives so clear an insight into the quality of that remarkable little volume, that our readers will thank us for reproducing it:

"If the International Scientific Series proceeds as it has begun, it will more than fulfil the promise given to the reading public in its prospectus. The first volume, by Prof. Tyndall, was a model of lucid and attractive scientific exposition; and now we have a second, by Mr. Walter Bagehot, which is not only very lucid and charming, but also original and suggestive in the highest degree. Nowhere, perhaps, since the publication of Sir Henry Maine's 'Ancient Law,' have we seen so many fruitful thoughts suggested in the course of a couple of hundred pages.

"The principal aim of Mr. Bagehot's book is to point out some of the conditions essential to progress in civilization, and to show how it is that so small a portion of the human race has attained to permanent progressiveness. It has been customary to contrast man with inferior animals as alone capable of improving his condition from age to age; the implication being that, while none of the inferior animals show any capacity for progress, on the other hand all men, without distinction save as to degree, possess such capacity. And some metaphysical writers have gone so far as to describe progressiveness as a tendency inherent in humanity. The gulf between man and other animals, wide enough in any event, has in this way been unduly exaggerated. In reality it need not take a very long survey of human societies, past and present, to assure us that beyond a certain point stagnation has been the rule, and progress the exception. Over a large part of the earth's surface the slow progress painfully achieved during thousands of prehistoric ages has stopped short with the savage state, as exemplified by those African, Polynesian, and American tribes which can neither work out a civilization for themselves, nor appropriate the civilization of higher races with whom they are brought into contact. Half the human race, having surmounted savagery, have been arrested in an immobile type of civilization, as in ancient Egypt, modern China, and in the East generally. It is only in the Aryan race, with the Jews and Magyars, that we can find evidences of a persistent tendency to progress; and that there is no inherent race-tendency at work in this is shown by the fact that some of the Aryans, as the Hindoo, and Persians, are among the most unprogressive of men. The progress of the European Aryans, like the evolution of higher forms of life, has been due only to a concurrence of favorable circumstances.

"It is one of the puzzles of sociology that the very state of things which is preëminently useful in bringing men out of savagery, is also likely to be preëminently in the way of their attaining to a persistently progressive civilization. 'No one,' says Mr. Bagehot, 'will ever comprehend the arrested civilizations unless he sees the strict dilemma of early society. Either men had no law at all, and lived in confused tribes, hardly hanging together, or they had to obtain a fixed law by processes of incredible difficulty. Those who surmounted that difficulty soon destroyed all those that lay in their way who did not. And then they themselves were caught in their own yoke. The customary discipline, which could only be imposed on any early men by terrible sanctions, continued with those sanctions, and killed out of the whole society the propensities to variation, which are the principle of progress.'

"A word to the wise will suffice to show that Mr. Bagehot has here struck nearer to the explanation of the arrested civilizations than any previous writer. Among numerous tribal groups of primitive men, those will prevail in the struggle for existence in which the lawless tendencies of individuals are most thoroughly subordinated by the yoke of tyrannical custom—the only yoke which uncivilized men can be made to wear. These communities will grow at the expense of less law-abiding tribes, until the result is a strong nation ruled by immovable custom, as in the case of Egypt, or China, or India. The problem now is how to get beyond this stage, and to relax the despotism of custom without entailing a retrogression toward primeval lawlessness. This problem has never been successfully solved except where a race, rendered organically law-abiding through some discipline of the foregoing kind, has been thrown into emulative conflict with other races similarly disciplined. And this condition has been completely fulfilled only in the case of the migrating Aryans who settled Europe.

"This is but one of Mr. Bagehot's many bright thoughts. We have barely room to hint at another. It was formerly assumed that, instead of mankind having arisen out of primeval savagery, modern savages have fallen from a primeval civilization, having lost the arts, the morals, and the intelligence which they originally possessed; and in our time some such thesis as this has been overtly maintained by the Duke of Argyll. Mr. Bagehot shows that in every way such a falling off is incompatible with the principle of natural selection. Take, for example, the ability to anticipate future contingencies—to abstain to-day that we may enjoy to-morrow. This is the most fundamental of the differences between civilization and savagery. Now, obviously, the ability to postpone present to future enjoyment is, in a mere material, economic, or military aspect, such an important acquisition to any race or group of men, that when once acquired it could never be lost. The race possessing this capacity could by no possibility yield ground to the races lacking it. Or take the ready belief in omens by which the life of the savage is so terribly hampered. Could a single tribe in old Australia have surmounted the necessity of searching for omens before undertaking any serious business, it would inevitably have subjugated all the other tribes on the continent. So, because the men who possess the attributes of civilization must necessarily prevail over the men who lack these attributes (and this is always true in the long-run, though now and then a great multitude of barbarians may temporarily overthrow a handful of civilized men), because this is so, it follows that there cannot have been, in prehistoric times, a general loss of the attributes of civilization.

"To do justice to Mr. Bagehot's fertile book would require a long article. With the best of intentions, we are conscious of having given but a sorry account of it in these brief paragraphs. But we hope we have said enough to recommend it to the attention of the thoughtful reader. We are glad to see that the young science of sociology has received such an early and satisfactory treatment in Dr. Youmans's series of popular books.

BOOKS RECEIVED.

The Ten Laws of Health. By J. R. Black, M. D. Philadelphia: Lippincott, 1872.

The American Chemist. A Monthly Journal of Theoretical, Analytical, and Technical Chemistry. Edited by Charles F. Chandler, Ph. D., F. C. S. Vols. I. and II.

Annals of the Dudley Observatory. Albany, 1871.

The Le Boulengé Chronograph. By Brevet-Captain O. E. Michaelis. New York: Van Nostrand, 1872.

Theoretical Navigation and Nautical Astronomy. By Lewis Clark, Lieutenant-Commander U. S. N. New York: Van Nostrand, 1872.

Primeval Man. An Examination of some Recent Speculations. By the Duke of Argyll. New York: De Witt C. Lent & Co., 1872.

A Century of Medicine and Chemistry. A Lecture Introductory to the Course of Lectures to the Medical Class at Yale College. By Prof. B. Silliman, M. D. New Haven, 1871.

A School *sui generis*. An Essay read before the New York State Teachers' Association at Syracuse. By C. H. Anthony, A. M. Albany: Weed, Parsons & Co., 1872.

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MISCELLANY.

Antiquity of Civilization.—M. Oppert read an essay at the Brussels Congress, to show, from the astronomical observations of the Egyptians and Assyrians, that 11,542 years before our era man existed on the earth at such a stage of civilization as to be able to take note of astronomical phenomena, and to calculate with considerable accuracy the length of the year. The Egyptians, says he, calculated by cycles of 1,460 years—zodiacal cycles, as they were called. Their year consisted of 365 days, which caused them to lose one day in every four solar years, and, consequently, they would attain their original starting-point again only after 1,460 years (365 × 4). Therefore the zodiacal cycle ending in the year 139 of our era commenced in the year 1322 B. C. On the other hand, the Assyrian cycle was 1,805 years, or 22,325 lunations. An Assyrian cycle began 712 B. C. The Chaldeans state that between the deluge and their first historic dynasty there was a period of 39,180 years. Now, what means this number? It stands for 12 Egyptian zodiacal cycles *plus* 12 Assyrian lunar cycles.

$$\left.\begin{array}{l} 12 \times 1{,}460 = 17{,}520 \\ 12 \times 1{,}805 = 21{,}660 \end{array}\right\} = 39{,}180$$

These two modes of calculating time are in agreement with each other, and were known simultaneously to one people, the Chaldeans. Let us now build up the series of both cycles, starting from our era, and the result will be as follows:

Zodiacal Cycle.	Lunar Cycle.
1,460	1,805
1,322	712
2,782	2,517
4,242	4,322
5,702	6,127
7,162	7,932
8,622	9,737
10,082	11,542
11,542	

At the year 11542 B. C. the two cycles came together, and consequently they had on that year their common origin in one and the same astronomical observation.

A Plant-Battery.—Under the heading "Arceuthobium shedding its Seed," L. A. M., in the Bulletin of the Torrey Botanical Club, gives the following account of what deserves to be called a vegetable *mitrailleuse:* "I visited the swamp in Warrensburg, the first week in October. I found its female plants of Arceuthobium nearly all gone. Every effort that I made to cut twigs from the matted clumps, where the colonies of these strange parasites grow, brought them down in showers. Fearing that I should fail to get plants with full seed-vessels, I picked a single plant with vessels much swollen. While holding it gently between my thumb and finger, to observe it more closely, I felt the tiniest recoil of the capsule, and the seed struck me a smart blow in the face. I gathered another, and another, and each pretty little bomb went off with a force that must have carried it several feet away. The seed flies out of the base of the capsule, instead of the top; but its position on the plant makes that the top, as, when ripe, the vessels hang with the true summit turned downward. I found the seeds and empty seed-vessels lodged all about on the branches. The plants which have ripened seed fall off nearly all together: those which have not blossomed, or have failed to be fertilized, probably remain for another year. When the seeds are being sown, there must be quite a brisk bombardment going on for several days. Isolated colonies of Arceuthobium in forests may have been planted by seed adhering to the feet of birds."

Government Telegraphy.—The first number of the London *Telegraphic Journal*, in a leading article on Government telegraphy.

has some very pointed criticisms on the working of the new system in England. The end sought by the Government in assuming control of the telegraph interests of the country was, by cheapening the rates and extending the lines, to bring the advantages of the system within the reach of a larger number of people, expecting thereby, just as in the case of the post-office, to derive sufficient income for the maintenance of the lines by the increased patronage that cheap rates would secure. As was anticipated, a large increase of business has resulted; but this very increase promises to defeat the chief advantage which the telegraph is designed to afford, viz., speed of communication. "Speed," says the *Journal*, "is the very essential of the telegram; it is its *raison d'être;* therefore, there is no good in reducing the charge for this convenience, if the convenience itself vanishes. It becomes, in fact, much more expensive. We now pay a shilling for a telegram, when a penny stamp, or even a half-penny card, would have sufficed. In former days a telegram was an outlay, certainly, but we paid much for a speed that we obtained. Many would still pay as much for the same advantage, but find they pay a reduction for a ghost of it." The writer does not despair of a remedy for this state of things, but says that the reticence of the authorities concerning the details of their management prevents the suggestion of any means of relief. The case adds one more to the already long list of examples where the Government plays the part of an obstructive.

Silica as a Basis of Paint.—There was lately discovered in North Wales a deposit of almost pure silica, several feet in depth, which on analysis shows the following constitution: silex, 79 parts; water, 13; oxide of iron, 3; alumina, 4; magnesium, 1. In the manufacture of crystal glass and porcelain this discovery is of considerable interest, but it is perhaps still more valuable as furnishing an excellent fire-proof and water-proof paint. When taken from the bed the silica is freely washed in water, and on being dried it becomes brilliantly white, and is then an impalpable powder. In preparing it as a base for paint, the water is dried out. It mixes readily with pigments and oils, is worked with the greatest ease, and resists the action of acids and of heat. When perfectly dry, the paint is extremely hard and polished on the surface. Applied on the inside or outside of houses, it excludes damp.

White Spots on Photograph Proofs.—Ever since the invention of photography on paper, says the *Moniteur Scientifique*, photographers have been trying to discover the cause of those white points which so frequently appear on their proofs, destroying their value as works of art, and rendering them unsalable. It is commonly supposed that these spots are owing to a defect in the paper—the presence in it of hypochlorite of soda, used by the paper-maker for bleaching purposes. But, as the manufacturers claim that chemical analysis fails to detect in their goods the faintest trace of the hypochlorite, M. Ernest Baudrimont set himself to discover where the fault lay. He first made a thorough analysis of the paper and the size used in taking photographs, but without finding there the cause of the spots. One thing, however, he did discover, which helped him to find the true solution of the problem, and this was that the spots always occurred on the face of the picture, but never on the back. He next artificially produced some spots on a perfect proof, by the employment of the hypochlorite of soda, the hyposulphite of soda, and the cyanide of potassium. After drying the pictures, he applied to the spots a solution of nitrate of silver. It was found that the white spots produced by the hypochlorite and by the cyanide remained totally unchanged, whereas those produced by the hyposulphite very rapidly changed, first to a yellow, then to a brownish tint. M. Baudrimont next touched with the silver solution spots appearing spontaneously on some pictures, and the result was, that at first a yellow point, which soon turned to brown, appeared in the centre of the spots, finally extending over their entire surface. Hence, the author concludes that the white spots occurring in photograph proofs are entirely owing to the hyposulphite of soda, used to *fix* the positive impression. If the proof is not thoroughly washed after the application of the hyposulphite, or if it is dried between sheets of blotting-paper, which are impregnated with the hyposulphite, from having served the same purpose before, the white points will inevitably make their appearance.

Ancient Ferns.—At a late meeting of the Torrey Botanical Club of this city, Dr. J. Newberry exhibited a fossil fern which he had obtained from the Miocene formation in the western part of the continent. It was an *Onoclea*, and was not distinguishable from the recent Linnæan species, *Onoclea sensibilis*. This certainly carries back the lineage of our common sensitive fern to a very ancient period.

At the same meeting of the club, there was also exhibited a fine specimen of that singular plant which grows parasitic on the roots of the pine-tree, and is hence called, in the Eastern States, *pine-drops*. The plant is rare at the East, and seldom attains the height of two feet. The specimen exhibited was four feet high.

Our Native Birds acquiring New Habits.—In a late number of the *American Naturalist*, Prof. Samuel Lockwood gives an interesting account of that beautiful bird known as the golden robin, or Baltimore oriole, in connection with one of our carpenter-bees. He states that last June large numbers of these humble-bees were found under the horse-chestnut trees, then in full bloom, in the campus of Rutgers College. The strange fact was, that every one of these insects was decapitated, and the heads were lying around with the bodies; further, it appears that every one of the headless bees was a stingless male. The professor worked out the case with much patient perseverance, and found to his surprise that this wholesale slaughter was the work of four orioles. Another fact which astonished him was, that the bodies of all these insects were empty, the viscera having been drawn out at the ring-like opening where the head had been neatly snipped by the birds. The process was to catch the bees while hovering at the ball-like opening of the flowers. After severing the head, they extracted the viscera for the sake of the honey-sac. Several very interesting considerations are brought out in the course of the article—such as the acquired taste; the birds had found out that honey was nice. Was it not singular, too, that they had learned that it could be got in such a manner? And there was also the curious fact that the bird confined its marauding to the white-headed bees, the stingless males—thus carrying on his terrible work with impunity, and almost wantonness, as it contented itself with simply the honey-bearing sac.

Prof. Lockwood also notes a curious change of habit in the kingbird. Speaking of the wonderfully plucky manner of this courageous little bird in attacking crows and other large birds, as securing the general admiration, he says that for himself that admiration has gone down to zero, as he has noticed that the bird has not any true knightly qualities, but can do some very mean things. The professor then instances a case in which a pair of robins had built a nest in a tree so near by that the process could be watched from the house. A pair of kingbirds kept all the time near, and watched progress with genuine royal indolence, and, when all was finished, with kingly impudence took possession. The rightful owners made but a feeble effort to resist this invasion. The kingbirds retained possession until their young were raised.

More than a year ago, Prof. Lockwood likewise called attention to the fact that the great butcher-bird, or Northern shrike, contrary to all precedent, had begun to visit in winter the cities where the European sparrows have become naturalized. The bird in summer collects grasshoppers, small lizards, etc., and impales them on the spines of the locust or other trees, eating them at its leisure. He notices the case in which a shrike in its winter visit gibbeted a sparrow in the city by putting its neck in the crotch of a small branch of a larch, and then, having knocked in the top of its head, the bird extracted its victim's brains.

Paper as a Building-Material.—An English company prepare a water-proof material out of paper-pulp, or any fibrous substance, by saturating it with ammoniated copper solution—a digest of copper scraps in concentrated ammonia. This treatment dissolves the fibres and renders the paper impervious to water. A number of sheets of paper are moistened on the surface, placed on each other, and thoroughly pressed. They thus are made to adhere firmly together, and are then fashioned into the various forms required. The product may replace corrugated iron for roofing, or it may be made into columns and flutings for internal decoration. It is said to be a very durable material even when exposed to air and rain.

Bowlder-like Masses of Clay in the Long Island Drift.—An extensive excavation in the side of Harbor Hill, near Brooklyn, Long Island, has revealed the presence of detached bowlder-like masses of clay embedded in the drift. Mr. Elias Lewis, of Brookyn, who has examined these objects, writes that they lie unbroken like bowlders of granite, and have the same rounded outline. One mass, consisting of a tough, fine-grained bluish-gray clay, was eight feet in vertical diameter, and seven feet through from side to side. Mr. Lewis is of the opinion that these masses were transported by ice and deposited in a frozen state, but adds that it is difficult to understand how they should have retained their form beneath moving water during the long time necessary for the accumulation of the layers of gravel and sand which surround them; nor is it clear how stratification of deposits could occur in water deep enough to float icebergs.

Will some one familiar with glacial deposits inform the readers of The Monthly whether similar masses of clay or earth of any kind are common in the recognized glacial drift?

Fuzi-Yama and Hakusan.—These, the two highest and most famous mountains of Japan, have lately had a new determination of their respective heights. A British officer made the ascent of Fuzi-Yama, on the 9th of September, and found, by approved and carefully-conducted methods, the height to be 13,080.32 feet, which is less than its accepted altitude, namely 14,177 feet. This same officer ascended Hakusan, being the first foreigner that has done so. His measurement makes this mountain higher than the accepted figures, which Stieler sets down at 8,178 feet. The new measurement gives 9,200 feet. Both these mountains are held sacred by the Japanese, Fuzi-Yama perhaps being specially so, as its singular name would imply, which means the "No-two-mountain;" that is, the none-such, the peerless, the inimitable. They are both volcanic mountains, with vast craters. Hakusan is snow-capped the whole year, while it may be called a snow-mountain for two-thirds of the year. It is sometimes called "Siro-Yama," White Mountain, and is truly the Mont Blanc of Japan. Both mountains are yearly visited by many thousand pilgrims. This last explorer describes Fuzi-Yama as an ash-heap, with a cone of lava and clinker. The only vegetation at top were lichens. "The crater, by approximate measurement, was found to be $2\frac{1}{2}$ miles in circumference, and its depth about 440 feet." As the mountain is a cone, and stands by itself, it is regarded as the most beautiful mountain in the world. It would be rare to find a Japanese landscape in which the artist has not by some ingenuity introduced the peerless Fuzi-Yama.

Combustion under Pressure. — It is shown from the observations of James B. Eads, C. E., as given in the *Journal of the Franklin Institute*, that combustion goes on at the same rate in compressed as in free air. There is, however, this difference between the phenomena of combustion under the two conditions, that a flame is more readily extinguished in free than in compressed air. This is demonstrated by Mr. Eads's experiments with the flame of a candle under varying pressures. Thus, at the depth of $108\frac{1}{2}$ feet in a shaft, the flame having been blown out thirteen times in rapid succession, it reappeared at the wick each time, except the last. At a somewhat greater depth, and under 52 lbs. pressure to the square inch, the flame was in the same way extinguished fifty-two times, with the same result. Mr. Eads's explanation is, that the abnormal pressure brings the oxygen of the air into close contact with the incandescent body, and so tends to keep up combustion; but the process is not more rapid than under ordinary circumstances, for the reason that the increased density of the air retards the movement of the gases resulting from combustion and surrounding the flame.

A Spider's Engineering.—A writer in *Hardwicke's Science-Gossip* saw a spider's web stretched across a small mill-stream, and attached on either side to stems of grass and other herbage. The stream was about three feet in width, and the web resembled a cart-wheel in general outline, having a diameter of at least six feet. The writer asks how "an animal that neither flies, leaps, nor swims," could accomplish such an engineering feat. But is it true that the spider does not swim or leap? In fact, the animal can run on the surface of water, can leap from place to place, and can *float* after the manner of Mr. Home the *medium*. It can even dive in water. But, further, it can swing like a pendulum, suspending itself like a thread from some elevated point. The writer in *Hardwicke* does not tell whether there was any object near the web on either margin of the stream of sufficient height to allow of the animal's so swinging from one side to the other.

Geology of the Great Plain of Morocco.—The *Journal of the Geographical Society* (British) has a paper by George Man, F. G. S., on the geology of Morocco, of which we give the substance. The plain of Morocco rises 1,700 feet above the sea-level, and is covered with a tufaceous crust, from a few inches to three feet thick, which is burnt for lime near the city of Morocco. The underlying rock is of similar composition but not so hard, and is called by Mr. Man a "cream-colored limestone and gray marl of cretaceous or tertiary age." Midway between Mogador and Morocco are flat-topped hills 200 or 300 feet high, covered with tabular masses of chalcedony. This suggests an enormous erosion of the plain. The author contradicts Rolfe and others who assert that snow remains upon Mount Atlas during the entire year, and says that in the first week of May snow was to be found only in deep gullies and in drifts. The mass of the Atlas range is mainly composed of porphyrites and porphyritic tufas, overlaid by cretaceous rocks, with basalts rising in erupted dikes and masses evidently post-cretaceous. Metamorphic rocks appear in rugged hills near Morocco, and white limestone on the high Atlas. Glacial moraines may be seen on this range nearly 8,000 feet above the sea, forming gigantic ridges and mounds of porphyritic blocks, in some places damming up the ravines; and at the foot of Atlas are enormous mounds of bowlders. These mounds oftentimes rise 2,000 feet above the level of the plain, and according to Mr. Man were produced by glaciers. Of marine drift no trace is visible.

Cross between the Zebu and European Cattle.—The organ of the Royal Prussian Agricultural Department contains a notice of some experiments on the cross between the zebu, or Indian ox (*Bos Indicus*), and European cattle, by W. Nathusius-Konigsborn. The doubts that have existed in regard to the fecundity of this cross led to the experiments which, the writer thinks, must forever set the question at rest. The male zebu made use of was a yearling calf from the Zoological Gardens, of the peculiar bluish-white color characteristic of the zebu race. Four heifers of Holland stock were got with calf by this animal, and produced two heifers and two bull-calves, all of which were successfully raised. Though the dams were variously colored, all the calves had white stars in their foreheads. When they arrived at suitable age, they were bred with each other and with other cattle, and both sexes proved in every respect capable of propagating their race. The amount of milk given by the half-bloods was about 500 quarts per annum. This was so much below the ordinary average as to prevent all hope of their being a desirable breed. In addition, the oxen, from which much was expected in speed and endurance, proved so incorrigibly obstinate as to defy all efforts to train them for the yoke, lying down on the smallest provocation, and in one case, where it was necessary to lead one of them a short distance, the animal died the next day, it was supposed from the effects of anger and excitement. They acted much more like half-tamed wild-beasts than like domestic cattle. The only redeeming feature was the quality of their flesh, which, in those that were sent to the butcher, proved to be excellent.

Solidifying Petroleum.—The *Journal de l'Eclairage au Gaz* describes as follows a process invented by Jordery and Paschkoff for the solidification of petroleum, thus making it more easily and more safely transportable: "First make a decoction of the root or leaves of the *Saponaria officinaria*, quillay, or any other substance possessed of saponific properties. Then an amount of this decoction or extract, equal to one-twentieth of the petroleum to be solidified, is placed in a vat, and the petroleum suffered to flow in upon it slowly, the whole being constantly stirred in the mean time. This process may be followed with oils in general, and with volatile oils it will prevent loss from leakage and obviate many of the dangers now attending their transportation."

Curious Phenomenon in Vegetable Physiology.—It has long been known to botanists that, occasionally, after the felling of pine and fir trees, their stumps would continue to increase in diameter, i. e., form new woody layers for several years. Dutrochet mentions some cases of extraordinary longevity in the stock of *Pinus picea* after the trunk had been felled. He says that, in the year 1836, a stock of *Pinus picea*, felled in 1821, was still alive, and had formed 14 thin new layers of wood—that is, one each year; and another, felled in 1743, was still in full vegetation, having formed 92 thin layers of wood, or one each year. This singular phenomenon was long a puzzle to botanists and vegetable physiologists. Over thirty years ago Goeppert, an accomplished botanist of Breslau, undertook an investigation of the subject. The result is published at large in the "Annales des Sciences Naturelles" for 1843. It appears that in all the cases examined by Goeppert there was a union of the roots of the fallen trees with the roots of living trees growing in the immediate vicinity, and his explanation of the phenomenon was that the stumps maintained their growth by drawing their supplies of sap from the trees with which they were thus connected. The union of roots in these cases was sometimes woody, and sometimes only by the bark of the roots. So far as observed, this anastomosis, or natural grafting, is confined to coniferous trees, and to only a few species of them, chiefly the silver-fir, the spruce, and occasionally the Scotch fir. In the London *Gardeners' Chronicle* of August 31st is an account of an instance of this kind of anastomosis of the roots of a larch, and a figure is given of the specimen, in which the stump and its root-connections are exhibited. The cut stump shows rotten wood in the centre, with the new wood at the circumference surging over the edges of the wound.

Although the discovery of this root-union explains some of the questions involved in this curious phenomenon, it does not explain them all; for instance, why does not the sap, which is thus robbed from the roots of the nurse-tree, pass up in the usual channels and overflow at the top of the stump, as is the case when a grape-vine or deciduous tree is cut during the active ascent of the sap? As the growth of new wood in exogenous trees takes place from the cambium, and the cambium is supposed to be the sap which has been elaborated in the leaves, what is the source of the cambium in these stumps?

It would seem as if there was here a complete contradiction of the ingenious theory of some of the French botanists that wood growth begins in the leaves or leaf-buds, and descends continuously thence to the roots, so that, in fact, wood may be considered the united mass of roots which emanate from the leaves of the plant.

The theory of De Candolle is, that the woody and cortical layers originate *laterally* in the cambium furnished by preëxisting layers, and nourished by the descending sap. To use the words of De Candolle, "The whole question may be reduced to this: either there descend from the top of a tree the rudiments of fibres which are nourished and developed by the juices springing *laterally* from the body of the wood and bark, or new layers are developed by preëxisting layers which are nourished by the descending juices formed in the leaves." The latter part of this statement, though somewhat vague and unsatisfactory, probably involves the true theory of the formation of wood. The *preëxisting layers* mentioned in De Candolle's statement include the medullary rays which reach the circumference. These medullary rays are composed of cellular tissue derived from the pith, and, like it, are capable of indefinite extension by cell-multiplication.

The primary state of all the tissues of the plant is the condition of simple cells, each of which is, in a certain sense, an independent body, having its own life-work and history in the complicated mass of which the tree is composed. All extension of the tree in any direction is made through the medium of cell-growth and cell-modifications, and, wherever there is cellular tissue in a state of vitality, there may be cell-multiplication whenever material for growth, i. e., sap in different stages, is brought into contact with such tissue.

In the case of the pine-stumps alluded to, the medullary rays of the recent wood retain their vitality, and, when the sap rises, it is transmitted through these rays and through the interspaces of the woody matter to the surface beneath the bark, these being appropriated to the organization of new cells whose walls are thickened by continuous secondary deposits, as in the normal formation of woody tissue. Of course, the amount of this woody formation will be limited, from the deficient supply of sap and want of concentration which it would obtain by passing through the leaves.

Puncturing the Pericardium.—The pericardium, or membranous sac surrounding the heart, sometimes becomes so filled with liquid that the movements of that organ are impeded. This is called dropsy of the heart. The surplus fluid may be relieved by the introduction of a trocar into the sac, but the operation is regarded as extra hazardous. Dr. Chairou, of the Paris Academy of Medicine, has tried a new method of treating the disorder in question. A young soldier just recovered from a pleurisy was found presenting all the symptoms of dropsy of the heart. The physician made a puncture into the pericardium with a capillary needle, and sucked out a considerable quantity of thick sero-sanguineous liquid, which soon became coagulated. The following morning the patient was pacing the corridors of the hospital in the very best of spirits.

Slag as a Building-Material.—"What shall be done with the slag?" is always a very urgent question for the proprietors of iron-works. Many are the plans which have been proposed for the utilization of this waste material, but, if we are to judge of their value by the amount of slag utilized, it must be confessed that they do not help to answer the iron-manufacturers' question. And yet many of the processes for the conversion of slag into a material for building would seem to promise very fair results. Mr. S. Egleston lately read a paper before the American Institute of Mining Engineers, in which he gives a history of these processes, stating at the same time, in a few words, the salient peculiarities of each. After recounting the failures which attended the first efforts, the writer sets forth the process followed in Königshütte, Silesia. There the slag is run from the furnace into a hemispherical basin on wheels, the bottom being strewed with sand or fine coke-dust to the depth of an inch. It is then drawn to the place where it is moulded into bricks. The slag and sand having been mixed together till most of the gases have escaped, the whole is pressed into a mould, and punctured frequently to let out the gas. A close-fitting cover then compresses it. The red-hot brick is next taken to the kiln, covered with powdered coal, and left to anneal. Four men make 500 bricks in five hours. In Silesia these bricks cost 25 per cent. less than ordinary bricks. The lead-slag of the furnaces in the Hartz Gebirge gives bricks of inferior quality, being very brittle. A Belgian engineer, M. Sepulchre, was the first to successfully transform slag into a stone which could be generally used. He caused the slag-channels to terminate in an excavation, the sides of which had an inclination of 30°. This steep inclination causes the section of the pits to increase very rapidly, allowing the solid crust on the surface of the liquid slag to rise with it without being attached. The mass takes from five to ten days to cool. The product is a stone which, rather soft at first, grows hard on exposure to air. Slag suitable for such treatment should contain from 38 to 44 per cent. of silica. Experiment shows that stone of this kind made from the slag coming from white iron can bear a pressure of 242 kilogrammes (500 pounds) to the square centimetre (one-third of an inch) without fissure. If from gray iron, it will not crush at a pressure of 405 kilogrammes. It is, therefore, stronger than the best marble.

Antiquity of Man in America.—The discoveries that are constantly being made in this country are proving that man existed on this continent as far back in geological time as on the European Continent; and it even seems that America, really the Old World geologically, will soon prove to be the birthplace of the earliest race of man. One of the late and important discoveries is that by Mr. E. L. Berthoud, which is given in full, with a map, in the "Proceedings of the Philadelphia Academy of Sciences for 1872," p. 46. Mr. Berthoud there reports the discovery of ancient fireplaces, rude stone monuments, and implements of stone in great number and variety, in several places along Crow Creek, in Colorado, and also on several other rivers in the vicinity. These fireplaces indicate several ancient sites of an unknown race differing entirely from the mound-builders and the present Indians, while the shells and other fossils found with the remains make it quite certain that the deposit in which the ancient sites are found is as old as the Pliocene, and perhaps as the Miocene. As the fossil shells found with the relics of man are of estuary forms, and, as the sites of the ancient towns are on extended points of land and at the base of the ridges or bluffs, Mr. Berthoud thinks the evidence is strongly in favor of the locations having been near some ancient fresh-water lake, whose vestiges the present topography of the region favors.—*American Naturalist.*

Effects of Coal-Gas on Plants.—Some of our readers will remember that, in Philadelphia, a few years ago, a florist, Mr. Thomas Robertson, had his plants destroyed by gas escaping from the street mains. He applied to the city for damages, but judge and jury decided that coal-gas would not injure plants. Since that time reports have been given of experiments by some learned Frenchman, who also decided that no injury resulted, and now it is said experiments have recently been made in Berlin to ascertain the effect of coal-gas upon the roots of trees exposed to its influence. Three trees were selected, two limes and a maple, and, after seventy days, the gas was cut off, to see whether the trees which had become blasted would recover. One of the lime-trees again put forth foliage, but exhibited evidences of ill health, while the remaining two trees were killed. That part of the earth which was compacted around the roots appeared to transmit most rapidly the poison of the gas. We suppose there is no one who has had any unbiassed experience in the matter but knows that coal-gas will destroy plants in the manner stated. Those who have had no experience had better take care to guard against it.—*Gardener's Monthly.*

Cromlechs in Algeria.—The Cromlechs (*dolmens*) of Algeria was the subject of an address made by General Faidherbe at the Brussels International Congress. He considers these structures to be simply sepulchral monuments, and, after examining five or six thousand of them, maintains that the dolmens of Africa and of Europe were all constructed by the same race during their emigration from the shores of the Baltic to the southern coast of the Mediterranean. The author does not, however, attempt to explain the existence of these monuments in other countries—Hindostan, for instance, and America. In Africa, he says, cromlechs are called tombs of the idolaters—the *idolaters* being neither Romans, nor Christians, nor Phœnicians, but some antique race. He regards the Berbers as the descendants of the primitive dolmen-builders. Certain Egyptian monuments tell of invasions of Lower Egypt 1,500 years before our era by blond tribes from the West. The bones found in the cromlechs are those of a large and dolichocephalous race. General Faidherbe gives the average stature (including the women) at 1.65 or 1.74 metre, while the average stature of French carabineers is only 1.65 metre. He did not find a single brachycephalous skull. The profiles indicated great intelligence. The Egyptian documents already referred to call the invaders Tamahu, which must have come from the invaders' own language, as it is not Egyptian. The Tuaregs of the present day may be regarded as the best representatives of the Tamahus. They are of lofty stature, have blue eyes, and cling to the custom of bearing long swords, to be wielded by both hands. In Soudan, on the banks of the Niger, dwells a negro tribe ruled by a royal family (Masas), who are of rather fair complexion, and claim descent from white men. *Masas* is perhaps the same as *Mashash*, which occurs in the Egyptian documents applied to the Tamahus. The Masas wear the hair in the same fashion as the Tamahus, and General Faidherbe is inclined to think that they, too, are the descendants of the dolmen-builders.

Deep-Sea Photometer.—A deep-sea photometer, or instrument for measuring the chemical power of the solar ray at great depths in water, was shown at the late London Exhibition by Mr. C. W. Siemens. A roll of sensitive paper, hermetically closed in a glass tube, is placed in a thick disk attached to the bottom of an iron frame to be dropped by a wire into the sea. In the frame is an electro-magnet. The tube is held in a dark recess till the magnet is formed, and then it springs into the light, but is withdrawn again when the electric current ceases. The actinic force of the rays is, of course, determined from the amount of darkening produced on the paper in a given time.

Cheap Hydrogen Gas.—The statement comes from Paris that a Mr. Giffard has devised a process for the rapid production of hydrogen from water, which promises to make its use as an illuminator more economical than that of ordinary coal-gas. It is claimed that by this method hydrogen may be generated on a large scale, 18,000 cubic feet per hour, at a cost of from fifteen to thirty cents per thousand cubic feet, so that by combustion with solid refractory substances, such as magnesium, platinum, lime, marble, etc., it may advantageously compete with coal-gas for illuminating purposes.

Building-Stone and Fire.—Dr. Adolph Ott, in the *Engineering and Mining Journal*, treats of the resistance offered to fire by the various kinds of stone employed in building. According to this author, the presence of magnesia in limestone (magnesian limestone, dolomite) hastens the decomposition of the mass under the action of heat, the magnesia parting with its carbonic acid at the comparatively low temperature of 600° Fahr. Common limestone will stand a higher temperature without decomposition. As our Westchester and also Vermont marble is a magnesian limestone, this fact is of very considerable interest for this city. It appears that, in Chicago, as also probably in Boston, the sandstones made the most obstinate resistance to the heat. This is explained by the fact that the chief ingredient in stones of that class is quartz, a substance remarkable for its infusibility. As for granite, gneiss, mica-slate, and other rocks of the primary formation, which are commonly esteemed indestructible, Dr. Ott shows that they can make but very feeble resistance to heat. The water enclosed in such rocks accounts for their bursting and exploding when heated. Portland cement-stone is said to show extraordinary resistent power, almost equalling sandstone in this respect. Of brick walls the author is disposed to think well, provided they be honestly built of hard material throughout, and of the requisite degree of thickness.

NOTES.

Notwithstanding the high price of meat and the great scarcity of potatoes in England, there are this winter, says the *Saturday Review*, 40,000 less paupers in London than three years ago. This is owing to an organized system of transferring labor to portions of the country where it is most needed, and thus relieving the overstocked points where pauperism is always most rapidly developed. The *Review* calls for an extension of the system, and urges those who are wasting their funds in ill directed charities, which oftentimes actually increase the number of paupers, to give this one, which aims to make the lower classes self-sustaining, a fair amount of consideration.

Mr. T. C. Webb, of Philadelphia, has made experiments with a plate electrical machine, in an insulated room, that seem to show the fallacy of the ordinary theory of the discharge of a charged conductor. A room eight by nine feet, and about eight feet high, was constructed, and suspended upon gutta percha, and its perfect insulation shown by a Thomson galvanometer. The plate-machine acted in all respects the same as in an uninsulated room; sparks were given off, and the conductor completely discharged when touched to the sides of the building. The experiments given in the *Philadelphia Magazine* seem to show conclusively that the common theory of the electrical machine is erroneous.—*American Manufacturer.*

Writing on the subject of malaria, Dr. Rey urges upon the inhabitants of malarious districts the adoption of every safeguard against becoming chilled. He considers the chill, often felt in warm climates at sunset, as very pernicious, and agrees with all authorities in pronouncing cold, with damp, to be exceedingly dangerous. Residents in lowland or damp situations should, therefore, take special precautions to keep the circulation in such a condition that the extremities are not cold, and the surface generally is comfortably warm. By maintaining this condition of body, other diseases besides the so-called malarial would also be warded off.

The *American Journal of Science and Art* has a letter from a correspondent in Mississippi who states that beavers are on the increase in that State, as also in Alabama. When the writer first settled in Hinds County, Mississippi, thirty-five years ago, he could scarce find one beaver-dam in the vicinity of his residence; but, in 1850, every considerable stream in the county had its dams, which caused serious injury to the low lands. A few years ago a trapper caught over seventy beavers in less than one month's time within the limits of the county. The animals are still multiplying, and the writer has no doubt that this is true, not alone of his particular locality, but of all Central Mississippi and Alabama.

A correspondent of the London *Times*, writing on the potato-disease, says its prevention depends upon attention to three things: 1. The choice of seed. 2. The removal of mycelium and resting spores from the seed chosen, to be accomplished by drying in the sunlight, and by dipping the seed-potatoes in a solution of lime with a little carbolic acid; and 3. The preservation of seed in a temperature which will prevent the growth of mycelium. It will not grow in a temperature below 48° Fahr.

The immense fields of sea-wrack which are found in the neighborhood of the Gulf Stream are estimated to cover a superficial area equal to that of France. M. Leps, of the French Navy, thinks that this sea-weed could be utilized for agricultural and industrial purposes, and suggests that it might be brought home in compressed bundles, or burned on the spot, and its soda and iodine thus secured.—*American Journal of Science and Art.*

A curious cause is assigned, by M. Collas, for the blue color of the sky. In opposition to M. Lallemand, who attributes the color to a fluorescent phenomenon—a reduction of refrangibility in the actinic rays beyond the violet end of the spectrum—M. Collas maintains that the color is due to the presence of hydrated silica in a very finely-divided state, carried into the atmosphere with the aqueous vapor. The blue color of the Lake of Geneva is referred to a similar cause.—*Athenæum.*

The Australian meat preserving companies have commenced the exportation of bone-dust to England. By strong pressure, the crushed bones are moulded into *briquets* 6 inches square and 3 thick, weighing about 6 pounds. A ton weight of this compressed bone-dust occupies 26 cubic feet.

A very simple remedy for echo in large public halls, churches, and the like, is suggested by a writer in the *Railway Times*, viz., the stretching of thin wires. These break the waves of sound, and prevent reverberation.

The London *Times* reports that Mr. Aden, in-door engineer in the Edinburgh Telegraph-Office, has invented a system by which, with existing instruments, it has been found practicable to send messages from both ends of a single wire simultaneously. The invention has been tested between Edinburgh and Glasgow, and it has been found that one wire is capable of doing double work.

The manufacture of spirits from mosses and lichens is becoming an important branch of industry in Northern Russia. The alcohol is said to be of good quality. The development of this industry will have an important bearing on the question of food-supply in the Russian Empire; the more spirits made from Iceland moss, the more cereal grains will there be left to subsist the people.

When the working-collier is provided with a safety-lamp, ingenuity must be further taxed to provide the means of guarding against his mad recklessness. The man will open the lamp, if it is at all possible, to get better light for his work, to light his pipe, or merely from foolhardiness. Lamps have, therefore, been contrived which go out on being opened. Another plan is to lock the lamp with a plug of lead, on which a device is punched, and which cannot be opened without breaking the plug. The latest contrivance is a lamp which is closed with a steel spring, and which cannot be opened except by the action of a very powerful magnet, such as the colliers would not be likely to possess.

It is proposed in France to supersede gold and silver coinage by platinum. The use of this metal for coins is nothing new, for the Russian Empire had a platinum coinage over a quarter of a century ago. As early as 1799, experiments were made at the Paris Mint, and some beautiful specimens of platinum medals were produced.

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ON THE IMPORTANCE OF THE CULTIVATION OF SCIENCE.[1]

By JOSEPH HENRY, LL. D.,

SECRETARY OF THE SMITHSONIAN INSTITUTION.

GENTLEMEN: I beg leave to tender you my sincere thanks for the honor you have conferred upon me by inviting me to preside at the farewell banquet to Professor Tyndall. I need scarcely say that it would give me great pleasure to be with you on that interesting occasion, although I would prefer not to occupy the place your partiality would assign to me, since I fear I should not be able, from want of experience, to do justice to so conspicuous a position.

I regret, however, to have to inform you that my official duties in Washington, at this season of the year, are such as to render it improper for me to be absent for even a single day; and, although I deeply sympathize with you in the objects of the banquet, I am obliged very reluctantly to forego the pleasure and profit of accepting your kind invitation.

The objects of this banquet, as I understand them, are, first, to do honor to our illustrious visitor, who has generously devoted so much time and labor to gratify his friends and the public in this country with a course of lectures; and, second, to advocate the claims of abstract science to higher appreciation and more liberal support. In regard to these topics I ask permission to indulge in a few remarks which may not be deemed inappropriate to the occasion. Dr. Tyndall is eminently worthy of all the attention he has received from the people and press of this country, and all the expressions of kindness and regard we can now bestow upon him. As Professor of Physics in the Royal Institution of Great Britain, he is the worthy successor of a

[1] Letter to the Committee of Arrangements of the Farewell Banquet to Professor Tyndall, at Delmonico's, New York, February 4, 1873.

series of the most remarkable men of the present century. He is not only a distinguished laborer in the line of original research, but also one of the best living expounders of scientific principles. His books are everywhere read in this country with avidity, and have done more to give precise and definite knowledge of the principles of the sciences of which they treat than any other series of works ever published. Indeed, it is only a master in science who is capable of preparing elementary scientific works. With a modesty—or, perhaps, self-respect—which constitutes a distinguishing trait of the man of true science, Professor Tyndall omitted to mention the fact that many of the phenomena which he presented in his lectures were his own discoveries. In the proposition which he has announced of giving the proceeds of his lectures to advance the cause of abstract science in this country, he has evinced another characteristic of the higher type of the scientist—namely, a paramount regard for his mission and a generous sympathy with humanity, as expressed in an aphorism of the founder of the Smithsonian Institution, that "the man of science is of no country; the world is his country, and mankind his countrymen."

In an age and country which boasts of its intelligence it might seem superfluous to say a word in regard to the importance of the cultivation of science, or, in other words, of a knowledge of the laws of the phenomena of the universe of which we form a part, yet it is lamentably the case that few comparatively, especially among statesmen and politicians, and even among those devoted to literature and the fine arts, properly appreciate the influence of abstract science on the present condition of the civilization of the world. Living in the present, enjoying its innumerable comforts and facilities of life, they do not realize the conditions of the past, or, if they imperfectly realize them, the changes are attributed to fortuitous circumstances really exercising a subordinate influence, or to apparent proximate causes such as the immediate practical application of science to art.

It is only of late years that the investigations of the tendencies and changes of the human family have been systematically studied under the general denomination of anthropology, and its subdivisions of ethnology and archæology. From these studies we may infer that man is a being capable of indefinite moral and intellectual development; not that he is a progressive being from the result of a law of necessary development, but, as it were, providentially so under the influence of certain essential conditions, among which are, first, freedom of intercourse of different peoples, and the ready interchange of thought; second, a prevailing religion which shall enjoin purity, love, justice, and truth; and, third, an ever-increasing knowledge of the laws, or principles, of the changes of the phenomena of Nature which constitute abstract science. That man is not necessarily a progressive being is shown by the fact that large portions of the inhabitants of the world are still in a condition of barbarism, from which they show no indications of emerging, and cannot probably do so except by influences from without.

Whatever opinion may be adopted as to the origin of man, it cannot be denied that we have descended from a race of ancestors but little elevated above the brute—from naked savages, the denizens of caves, feeding upon wild fruits, devouring shell-fish, or struggling for mere existence with the larger quadrupeds of the times, gradually emerging from this state by the invention of weapons of flint and bone, through long geological periods, into a pastoral condition; thence, again, into a higher state of mental development, which culminated in the civilization of Greece and Rome, in which the true in sentiment, and the beautiful in art, were developed in an astonishing degree. This progress was mainly due to the migratory character of the races which contributed to the condition we have mentioned. Tribes which remain entirely isolated may utilize the suggestions and facilities of life which are afforded them by their localities, and when these are exhausted become permanently stationary, but tribes impelled by want of subsistence, or the desire of conquest to migrate to other localities, as is stated to have been the case with the Aryan race in their migration from the East to the West, gather up the separate civilizations as they advance, and hence, by accretion or intercourse with others, rise to a higher plane. But this mode of advance is limited, and could make no further progress than that exhibited in the brilliant though unsymmetrical civilization of Greece and of Rome. This civilization, though it challenges our admiration and marks an important era in the history of the human race, was deficient in two of the essential elements of further progress, namely—first, in the prevailing influence of the higher and holier morality of Christianity; and, secondly, in that scientific knowledge of the laws of Nature which enables man to control its operations and to employ its energies to effect his purposes in ameliorating the condition of the earth. Without these elements of progress the Romans could not advance beyond a limited degree, and finally fell a prey to their barbarian conquerors.

Being confined in my remarks on this occasion to the discussion of the influence of physical science, I can only advert to the ameliorating effect produced by Christianity in its restraining influence on the semi-barbarism which followed the fall of the Roman Empire, and its aid in preserving the learning of the past through the darkness of the middle ages, and must leave to our theological brethren the full discussion of this part of our theme.

It is a fundamental principle of political economy that the physical state of man can only be ameliorated by means of labor, or, in other words, by the transformation of matter from a crude to an artificial condition. But this cannot be effected, except by expending what is called *power* or energy. In ancient times, almost the exclusive source of this energy was muscular force, derived from compulsory human labor; and all the monuments and objects that have been left to us, as marks of ancient civilization, are the results of organized systems of slavery. The rock-sculptures of Elephanta, the Pyramids of Egypt, and the temples of Greece, were all the result of the labor of slaves, directed by the minds of freemen. It is said that a hundred thousand slaves were employed at one time in the construction of the Pyramids of Egypt; one hundred and twenty thousand were engaged in hewing the obelisks of Thebes, and an equal number in digging the ancient canal which joined the Nile and the Red Sea. These slaves were treated as beasts of burden, or as mere machines, of which Athens, in her palmy days, had four hundred thousand, with but *twenty thousand* freemen.

Now, we owe the abolition of this condition of humanity, in the higher civilized nations of the world at the present day, to the study of the laws of the operations of Nature. By a knowledge of these laws the energies of the elements of Nature are substituted for human labor, and by this substitution mankind is not only relieved from brute-labor, but also given control of energies which enable him to produce effects which could only result from the muscular power of beings of a superior order. It may be shown by a simple calculation that about fifteen tons of anthracite coal burned in the furnace of one of our best steam-engines exerts an energy equal to that of an able-bodied slave, working ten hours a day for thirty years of his active life. It is this substitution of the energies of Nature for the power of human muscle that, as we have said, has abolished slavery and elevated humanity to a higher plane than was ever dreamed of by the wisest sages of ancient times. To illustrate this, a few examples will suffice. As one of these, we may refer to the progress of the arts of locomotion, and the means which science has afforded for the instantaneous interchange of thought between men in the most distant parts of the earth; as another, to the production of clothing fabrics, in which a single individual, directing the energies of an engine of one-man power, is capable of doing three thousand times the work of an ordinary weaver. As a third example, we may point to the art of printing by means of the steam-press, in which a single man will make more copies in a given time of a composition, than a million of ancient transcribers could do. Science is every day creating new arts, and modifying and improving the processes of old ones. We are skeptical as regards the value of *lost arts*. It is true there are arts which have fallen into disuse, and others which depend upon the skill and patience of the individual, but none which rests on any lost secret of Nature which science cannot restore.

The results we have mentioned are frequently attributed by superficial observation to immediate practical invention of persons having little or no knowledge of abstract science. But, in regard to this, it must be recollected that our whole civilization is pervaded by a knowledge of facts primarily derived from scientific investigation. Such inventions as those we have alluded to are not produced in a barbarous country, or even in those of a comparative high civilization without science.

If we desire an illustration of the condition of civilization based upon empirical art, upon facts accidentally discovered, or invention without science, we have merely to turn to China and Japan. These countries have long since utilized all the facts and empirical processes the result of accident or simple invention, and have, consequently, remained stationary for thousands of years, and must remain so continually, unless they borrow a knowledge of science from abroad.

It is not, however, merely the material wants of man that are gratified by the results of science; it administers also to his highest intellectual development. Placed in a universe of constant change, on an isolated globe, surrounded by distant celestial objects on all sides, subjected to influences of various kinds, it is a sublime occupation to measure the earth and weigh the planets, to predict their changes, and even to discover the materials of which they are composed; to investigate the causes of the tempest and volcano, to bring the lightning from the clouds, to submit it to experiment by which it shall reveal its character, and to estimate the size and weight of those invisible atoms which constitute the *universe of things.* It is the pursuit, above all, which impresses us with the capacity of man for intellectual and moral progress, and awakens the human intellect to aspirations for a higher condition of humanity, and gives a pleasurable consciousness to those who successfully pursue it, of contributing, in however small a degree it may be, to such a desirable consummation. The effect of such pursuits on the mind of the individual himself cannot be otherwise than salutary. While it exalts the understanding, it exercises the imagination, and awakens and constantly cherishes a love of truth for its own sake. The man imbued with the proper spirit of science does not seek for immediate pecuniary reward from the practical applications of his discoveries, but derives sufficient gratification from his pursuit and the consciousness of enlarging the bounds of human contemplation, and the magnitude of human power, and leaves to others to gather the golden fruit he may strew along his pathway. This fact is strikingly illustrated in the generous devotion by our illustrious visitor of the proceeds of his labors in this country to the advance of science.

In the foregoing remarks it is not our wish to disparage any other pursuit, or to diminish the love of ancient literature, but, on the contrary, we would cherish whatever tends to develop the human mind. We would carefully preserve the knowledge of the past, and transmit it to posterity, enlarged by the achievements of the present. We hold that every age of the world has had its mission, and has left its impress upon all the ages that have followed. The lessons taught by the Greeks have not been forgotten. The examples of beauty and the vestiges of truth they have bequeathed to us, still exist to ameliorate the condition and improve the moral character of a thousand times greater number of individuals than was effected by them in the palmy days of Hellenic development. But we should not unduly exalt the past, or claim for it a superiority over the present. There never was a time in which the realms of actual thought were so extended as at present, nor when so many individuals were occupied in the contemplation of abstract truths.

Such being the results proceeding from science as we have stated, it appears strange that so little encouragement is given to its prosecution, and that it should not be more liberally fostered by governments and wealthy individuals. In a new country like this, where a whole continent is to be subdued, and there is so great a demand for the practical application of science to art, it is not surprising that the great principles which underlie these applications while they can be borrowed from Europe should not at first receive much attention; but, since our country has become so much advanced in wealth and in intelligence, this state of things should no longer exist, and it is therefore proper on an occasion like this to call public attention to the importance and wants of abstract science.

In this country, science is almost exclusively prosecuted by those engaged in the laborious and exhaustive employment of imparting instruction. Science among us brings comparatively little emolument, and is accompanied with but little honor. High talents are therefore driven into other pursuits more remunerative and more favored with popular applause. Those who from a love of truth would pursue it for its own sake are so overworked with the drudgery of elementary teaching, and so poorly supplied with the implements of investigation, that it is not surprising that science has made comparatively *little* advance among us, but that, under existing conditions, it should have made *so much*. What is especially wanted at present is an improvement in our higher institutions of learning, and on this point permit me to dwell a few moments.

Three things are essential to a well-constituted college or university: 1. An unencumbered, free endowment, which shall liberally provide for the support of the faculty, and defray all the expenses of the operations of the establishment; 2. A faculty consisting of men of profound learning and powers of original thought and fluent expression; and—3. A full supply of all the objects and implements of instruction and research. I say a "free endowment," in contradistinction to one invested in buildings intended for external display more than for internal use, as is unhappily too often the case in this country.

The faculty should be men of intrinsic worth, chosen, not on account of influential connections, social position, denominational predilections, nor for any vague popular reputation, but especially in the line of science, from having given evidence of their power in the way of original research. A man of this class must be possessed of enthusiasm which in a measure he can scarcely fail to impart to his pupils. The latter, again, by a reflex action, will stimulate the teacher to new efforts. Furthermore, the reputation of the teacher is shared by his pupils; and to have sat under the instruction of a Cuvier, a Laplace, a Faraday, or a Herschel, is no small recommendation. It is to the men of which the faculties of the German universities are composed, that those establishments owe their reputation, and *they* are the attraction which draws pupils from every part of the world to these centres of high intelligence. But men of this character "are *not made*," but, like poets, "*born*." Profound learning is not sufficient; however versed a man may be in the knowledge of others, he is not of the first order unless he be endowed with the peculiar mental powers which enable him to originate new truths. When such men are found—and they exist in every community in a certain, perhaps small ratio, they should be consecrated to the advancement and diffusion of knowledge. They should be secured by our colleges and universities, and all the facilities given them for original investigation. They should be relieved from the drudgery of drilling in the elementary branches, and be assisted by tutors in the general instruction, being themselves only called upon to give a limited number of lectures on the general principles of the branch of knowledge under their care.

Again, no college or university is properly equipped that is not furnished with a complete series of the objects and implements of instruction and research. In regard to instruction, the impressions made through the eye are the most definite and indelible, and may serve as nuclei around which by association to group facts and suggestions the most varied.

In science, to present the actual phenomena of Nature and reproduce them before the eye of the pupil, instead of giving him a mere description of them, is as different in effect, as *travelling* in a foreign country is from merely obtaining a knowledge of it through the writings of others.

In reference to original research, as well as to higher instruction in science, besides apparatus of illustration, instruments of *precision* are required, without which the power of the investigator, however gifted, must be greatly limited.

In what I have said in regard to science in this country, I do not wish to be understood as undervaluing what has already been done. Indeed, in view of the small encouragement which has been given and the limited facilities which have been afforded, the contributions which have been made from this country, especially in the line of astronomy, geology, geodesy, topography, and natural history, are numerous and important. At the commencement of the General Government, in the union of the several States, a large demand was made for a certain degree of practical astronomical knowledge in determining the boundaries of the different States, and Territories; and, later, the establishment of the Coast Survey, and an Engineering Bureau, has tended to keep up an interest in investigations relative to these subjects. The wide extent of our national domain, and the gigantic scale on which its geological formations are presented, have served as the basis of valuable contributions to geology, mineralogy, botany, and zoology. The contributions that have been made within the last forty years to meteorology, especially in the simultaneous observations over the large extent of our country, and the subsequent comparison of results, have materially assisted in developing the laws of storms, and have almost advanced meteorology to the character of an exact science. While there have been no especial facilities for prosecuting chemistry or physics, yet American researches in these lines have not been unfruitful of results worthy of a place in the history of science.

But whatever may be said as regards the value of the contributions of this country to the scientific knowledge of the day, it must be admitted that there is a great popular craving among us for a knowledge of the results of scientific investigation, and that in no other part of the world could Prof. Tyndall have been more highly appreciated or more enthusiastically welcomed.

It must be to him a source of high gratification to have his sympathies so widely extended, and his kindly feelings so warmly reciprocated. There is a spirit of improvement awakened in this country in regard to scientific investigation which I doubt not will be stimulated into more active exercise by the visit of our illustrious friend, which will induce men who, by the exercise of peculiar talents, have accumulated wealth, to endow institutions for the special cultivation of scientific investigation, and to set apart with liberal support as the priests or interpreters of Nature, those who by special mental endowment are capable of benefiting their fellow-men by the discovery of new principles.

We trust the time is not far distant when the grand philosophical vision of the father of modern science, which has waited so long for its fulfilment, will be realized, "by the union and coöperation of all in building up and perfecting that House of Solomon" (as Bacon quaintly termed it), "the end of which is the knowledge of causes and of the secret motions of things, and the enlarging of the bounds of human empire to the effecting of all things possible."

While we have endeavored to show that abstract science is entitled to high appreciation and liberal support, we do not claim for it the power of solving questions belonging to other realms of thought. What we would claim for it, however, in addition to liberal appreciation and support, is, that it may be untrammelled in its investigations so long as they are conducted with the single intention of the discovery of truth, and according to the strict methods of inductive philosophy. Much harm has been done by the antagonism which has sometimes arisen between the expounders of science on the one hand, and those of theology on the other, and we would deprecate the tendency which exhibits itself in certain minds to foster feelings antagonistic to the researches into the phenomena of Nature, for fear they should disprove the interpretations of Holy Writ made long before the revelations of physical science, which might serve for a better exegesis of what has been revealed; and also the tendency in other minds to transcend the known, and to pronounce dogmatically as to the possibility of modes of existence on which physical research has not, and we think never can throw, positive light. We freely admit that the laws which relate to dead matter apply equally well to all living organic bodies, but we are constrained at the same time to believe in the existence of a mysterious something lying beyond this, working through the laws of Nature as it were by immediate intelligence and by prearrangement, producing results marked in the future by evidences of design.

The analogy between crystallization and organization has never impressed me as being well founded. If we allow the existence of atoms endowed with the simple force of attraction in right lines, these must, of mathematical necessity, group themselves in geometrical figures—three forming an equilateral plane triangle, four a solid tetrahedron, and so on. But this is very different from the case of atoms spontaneously grouping themselves in the form of eyes, ears, and limbs, instruments of optics, of acoustics, and of locomotion, or organs of thought and emotion.

In all cases of transformation of organic matter, a definite amount of potential energy is expended; for example, in the incubation of an egg, a considerable portion of the material within the shell runs down from an organic condition in combining with the oxygen of the atmosphere, into carbonic acid and water, and in this evolves the power or energy necessary to build up the future animal out of the remaining material.

The work accomplished in this operation is at the expense of the energy evolved by the chemical action; that is, this energy instead of evolving heat or other mechanical motions, when suffered to expend itself without direction, is, in this case, employed in accomplishing results of intellectual character, or, in other words, precisely such as are produced when the energy of coal is employed by an intelligent being in manufacturing articles intended for useful purposes. Again, when we pass from the phenomena of life to those of mental and moral emotions, we enter a region of still more absolute mystery, in which our light becomes darkness, and we are obliged to bow in profound humiliation, acknowledging that the highest flights of science can only reach the threshold of the temple of faith.

Gentlemen, I have restricted my remarks to a few divisions of the general subject of the importance of the cultivation of science, and leave it to others to develop other points of the same subject in their bearing on the welfare of man.

THE NEBULAR HYPOTHESIS.

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THE speculative views of Lambert and Kant led them to the adoption of a Nebular Hypothesis, and to the idea of a perpetual development in the regions of space. Sir William Herschel, after long hesitation, was ultimately led, by the surer path of observation and cautious induction, to the adoption of similar views, in relation to the existence of a self-luminous substance of a highly-attenuated nature, distributed through the celestial realms. At a later period, in 1811, he communicated to the Royal Society an exposition of his famous hypothesis of the transformation of nebulæ into stars.

Sir William Herschel made no attempt to extend his hypothesis to a cosmogony of our solar system. If, therefore, the "Nebular Hypothesis" is restricted to the theory which professes to explain the genesis of our solar system, it is only analogically related to the loftier speculations of Sir William Herschel, in regard to the processes of star-formation going on in the stellar realms. In this restricted sense, the "Nebular Hypothesis" is due to Laplace. This illustrious mathematician, with a modesty and diffidence befitting a true philosopher, endeavored to lay rational foundations for a cosmogony of the solar system. This sublime speculation has been egregiously misunderstood and misrepresented alike in itself and in its tendencies.

The lecturer proposed to disconnect Laplace's Nebular Hypothesis from the question of the general diffusion of cosmical vapor in the celestial regions. Indeed, the origin of Laplace's hypothesis did not lie in Herschel's speculations in relation to the transformation of nebulæ into stars and clusters of stars. In contemplating our solar system, he discerned numerous harmonies and adjustments, which were not accounted for by the law of gravitation, which induced him to infer that all its members were of one family—of a common origin. The Nebular Hypothesis was framed to explain and coördinate these facts, and, if possible, to refer them to established mechanical principles. Under this view, the lecturer considered the Nebular Hypothesis in two aspects—viz.: As a pure hypothesis, framed to explain the arrangements of the solar system; and as a physical reality, indicating the actual process by which the phenomena were evolved or produced.

Notwithstanding the number of orbs of which the solar system is composed, and the consequent almost infinite variety of their possible dispositions, the following coincidences—wholly independent of the law of gravitation—are found to obtain: 1. The sun rotates on his axis from west to east. 2. All the planets (now 104 in number) revolve about the sun from west to east. 3. All the planets (as far as known rotate on their axes from west to east. 4. All the satellites (excepting those of Uranus and Neptune) revolve about their primaries from west to east. 5. All the satellites (as far as known) rotate on their axes in the same direction in which their primaries turn on their axes. 6. All the planets (with the exception of a few minute asteroids) revolve about the sun, nearly in the plane of the solar equator. 7. All the satellites (as far as known) revolve about their primaries nearly in the planes of the equator of their respective planets. 8. All the planets (with the exception of a few asteroids) have orbits of small eccentricity. 9. All the satellites have, in like manner, orbits of small eccentricity.

These nine independent coincidences in the arrangements of more than 127 separate bodies, cannot be supposed to be fortuitous—they naturally suggest the existence of some grand and comprehensive law, pervading the whole solar system. That they are not consequences of the law of gravitation, is evident from the fact that the comets transgress every one of these laws which could be applicable to them. According to the laws of probability, the chances against the concurrence of so many unconnected phenomena are almost infinite. Laplace estimated that the chances were four millions of millions to one, that these were not arbitrary accicndtal phenomena. Since his time, facts of a similar bearing have largely accumulated, and the chances against their fortuitous concurrence are now almost beyond the power of numbers to express. "The coördination of these divers and unconnected phenomena—the grouping them into one coherent and harmonious scheme—the referring them to one common cause and origin, and thereby imparting to this fair work of the Eternal the semblance of a Unity worthy of a Divine Idea"—these were the sublime and lofty aims of the famous "Nebular Hypothesis" of Laplace. He imagined "that this consummate fabric—this gorgeous planetary scheme—like the blossom, had a bud—and deeper yet, that it had a mysterious germ, within which rested the necessities of its present glorious unfolding! . . . . He sought, by penetrating the deep recesses of the past, to reveal the mystery of its development, and conceived the bold thought of portraying the *modus operandi* of the genesis of our Solar System."

In its original form, the Nebular Hypothesis required three assumptions, viz.: 1. An agglomerated nebulous mass; 2. That this mass be rotating about its centre of gravity; and 3. That it be incandescent from excessive heat. The successors of Laplace have endeavored to simplify the hypothesis, by showing that rotation of the nebulous mass, and perhaps also its incandescence, may be simple consequences of the processes of aggregation.

The lecturer proceeded to show that if we suppose the great nebulous mass to have been a continuous gas or fluid, symmetrical in form, and either homogeneous or heterogeneous in structure, provided the component strata were homogeneous in themselves—"the fundamental principles of mechanics assure us that the process of cooling and condensation by contraction, would not generate a motion of rotation." Nay, more; he thought it was very difficult to conceive the mechanical possibility of a continuous gaseous or liquid mass of any form—whether homogeneous or otherwise—acquiring a motion of rotation by the internal motions of its several parts. The mass being isolated, and out of the sphere of external forces—all of its parts being in intercommunication through fluid continuity—how can we reconcile a generation of rotation in the whole mass, with the fundamental principles of the equality of action and reaction? Any force, that begins and ends in a body—whose parts are in continuous material connection—cannot impart motion to the whole mass—whatever relative movements might be communicated to portions of it.

The lecturer was disposed to look for the origin of the primitive rotation of the nebulous mass in the discontinuous structure of the primordial nebulous matter. Adopting Sir John Herschel's idea, that the nebulous condition indicates not the gaseous, but the cloudy form of matter, we must look upon nebulous masses as consisting of discrete portions of matter—of various density and bulk—aggregated into special forms, under the influence of mutual attraction. By the gradual subsidence and condensation of these discrete particles by the effect of gravity, a central aggregation or nucleus would be formed—the germ of our sun. Let us hasten to see what light this view throws upon the physical cause of the rotation of the primitive solar nebula. It is obvious that a crowd of aggregating bodies, animated by independent and partially-opposing impulses, must produce collision, destruction of velocity, and a subsidence toward the centre of attraction. It is also evident that those impulses which conspire or remain outstanding after such conflicts, must ultimately give rise to circulation or rotation of a permanent character about some axis. It will be observed that the causes imparting motion to the central mass are, in this view, entirely exterior to it. For the subsiding and conflicting bodies, being discrete and independent of each other, act like the impinging of a comet, or any cosmical mass, on the central nucleus. Under this aspect, the Nebular Hypothesis becomes identical with Sir John Herschel's "Theory of Sidereal Aggregation;" the only difference consisting in the magnitudes of the aggregating bodies.

Instead of supposing that the primitive or chaotic condition of matter was intensely hot, is it not more rational to suppose that it was originally deficient in heat or cold, and that the high temperature was subsequently developed during the processes which brought about its organization? According to the preceding view of the structure and constitution of a nebulous mass, the idea of the chaotic matter being maintained in a diffused and attenuated condition through the agency of heat, is by no means necessary. Indeed, the assumption that the primitive matter of the universe existed in a diffused gaseous condition, through the agency of excessive heat, is itself, *prima facie*, improbable. If it were absolutely universal, what became of the heat, and how did the cooling and condensation commence? Even if we suppose that the chaotic matter existed in enormous detached masses, what an inconceivable amount of heat must have been created, merely to be dissipated throughout the infinitudes of space! Such a view ill accords with our conceptions of the economy of the Creator's operations.

According to the views previously announced, the original concentration of the nebulous matter about a central nucleus was not the result of cooling and contraction, but of a gradual process of aggregation of discrete bodies under the action of mutually-attractive forces. Now, in the collisions and frictions necessarily incident to this process of aggregation, we have an indefinite supply of heat. The establishment of the "Dynamical Theory of Heat," on the sure basis of experiment and observation, assures us that when motion is checked or arrested, it is transformed into heat. Hence, we see that the collisions and destruction of velocity, incident to the process of aggregation, while imparting a motion of rotation to the nebulous mass, at the same time evolved heat, more or less, throughout its structure—and especially toward the nucleus, where the bodies, whose velocities had been checked, were gradually subsiding. The larger portion of the "dynamical energy" of the crowd of bodies aggregating toward the nucleus, was thus transformed into heat—a smaller portion remaining in the motion of rotation of the solar nebula. This view makes the heat- and light-producing process continuous and gradual, and the true gaseous and fused conditions of the nebula, subsequent states, induced by the evolution of intense heat.

We thus reach a lofty point of view. Given diffused or chaotic matter, and mutual attraction, and the whole machinery of the Nebular Hypothesis is set in action! The "star-dust," or "world-stuff" begins to aggregate—heat is evolved—rotation is imparted—and all the apparatus required for the formation of suns, planets, and satellites, is established! Assuming that the processes of aggregation and heat-evolution had so far progressed that the rotating spheroid consisted of a more or less continuous mass of liquid or gas, extending far beyond the orbit of Neptune, and we are furnished with all the conditions assumed by Laplace.

It is unnecessary to follow the lecturer in his exposition of Laplace's reasoning, by which it was shown, upon mechanical principles, that, as the rotating spheroid slowly contracted and condensed by the gravitation of its parts toward the centre, and the process of cooling at its surface, the rotation must necessarily be accelerated, and consequently the centrifugal force augmented, particularly at its equatorial parts. In fact, this could not be done without the use of illustrative diagrams. Suffice it to state, that the final result would be, the development of a system of planets, revolving in a common direction around a vast central solar mass, with subordinate systems of satellites circulating in a like direction around their primaries. These are precisely the arrangements which are found to exist in our solar system.

Assuming that the primitive solar nebula rotated on its axis, as the sun does, from west to east, the following consequences were deduced from the theory, viz.: 1. All the planets should move around the sun from west to east. 2. All the planets should rotate on their axes from west to east. 3. All the satellites should rotate on their axes from west to east. 4. All the planets should revolve about the sun in orbits nearly coincident with the plane of the solar equator. 5. All the satellites should revolve about their primaries nearly in the planes of the equators of their respective planets. 6. All the planets should revolve in orbits of small eccentricity. 7. All the satellites should revolve in orbits of small eccentricity. 8. The central mass—the sun—should rotate on his axis in less time than any of the planets revolve about him in their orbits. 9. The primary planets should revolve on their axes in less time than any of their satellites revolve around them; and 10. The central mass, left after the process of genesis was completed, should contain a much larger quantity of matter than the sum of the masses separated. All of these arrangements (with a few unimportant deviations), were shown to exist in the solar system. Recapitulating these coincidences, we obtain the following significant results, viz.:

8	planets	satisfy	3	of them,	making	24	coincidences.
6	"	"	1	"	"	6	"
3	"	"	1	"	"	3	"
5	"	"	1	"	"	5	"
96	asteroids	"	3	"	"	288	"
13	satellites	"	3	"	"	39	"
22	"	"	1	"	"	22	"
1	sun	"	3	"	"	3	"
					Total,	390	coincidences.

"We thus see that there are no less than 390 independent phenomena—of which the law of gravitation gives no account—which are simple consequences of the Nebular Hypothesis. In the aggregate, they imply a very large number of facts—complex—diverse—unconnected with each other—having no mutual dependence—all accounted for by a simple supposition, and the aid of the known laws of matter and motion." It can hardly be denied that, regarded as a pure hypothesis, framed to account for a certain set of facts, its remarkable success in explaining them invests it with a high degree of probability.

It was admitted that the theory had encountered some apparent difficulties—some want of coincidences—the most serious one being the retrograde direction of revolution of the satellites of Uranus. It was shown that this anomaly might be reconciled with the Nebular Hypothesis during the first stages of planet-formation.

But, it has been asked, may not these coincident phenomena be explained by other means than the Nebular Hypothesis? May they not be arrangements instituted by the Creator, for the purpose of giving perpetuity to our solar system, and making the planets suitable habitations for organized beings? And do we not transgress the legitimate domain of scientific research in attempting their explanation?

In reply to this, it was urged that such a view implies a total misconception of the doctrine of final causes. In such inquiries, "we are not to assume that we know the object of the Creator's design, and put this assumed purpose in the place of a physical cause." In these provinces of speculation, the principle of final causes is no longer the basis and guide, but the sequel and result of our physical reasonings. . . . As physical science advances, final causes do not disappear. The principle of design changes its mode of application, but loses none of its force; it is merely transferred from the region of facts to that of laws." We do not consider the sun as less intended to warm and vivify the tribes of plants and animals, because we find evidences that the earth and other planets were developed in the vast periods of past ages, from a common nebulous mass! We are rather, by the discovery of so general a law, led into a scene of wider design—of deeper contrivance—of more comprehensive adjustments. "The object of such views is not to lead to physical truth, but to connect such truth—obtained by its proper processes and methods—with our views of God—the Master of the universe."

But even admitting this application of the principle of final causes, it was shown that the conditions of stability of the solar system, and its adaptability to living beings, are totally insufficient to account for all the observed coincidences. There are many other phenomena in the arrangements of our system, which have no relations to these ends or purposes. It was shown that there are no less than seven sets of phenomena, of which the principle of final causes affords, as far as we can see, no explanation.

The Nebular Hypothesis not only accounts for and coördinates all the arrangements of the solar system, but the conditions of stability and adaptability to living beings are simple consequences of its mode of genesis! Does not the cheering doctrine of final causes—of design and purpose—become strengthened and invigorated by leading us to a view so comprehensive? "How simple the means—how multiform the effects—how far-reaching and grand the design!" How deeply they impress us with the wisdom, power, and glory of the Creator and Governor of the universe!

We now come to consider the physical reality of the fundamental assumption of the Nebular Hypothesis. Have nebulous masses a real existence in the universe? Is the Star-dust—the World-stuff—a physical reality, or a mere figment of the brain of the theorist? If the actual existence of self-luminous nebulous matter—the chaotic elements of future worlds and suns—can be established—the fundamental assumption of Laplace loses the character of a pure hypothesis: his conception becomes a physical theory, which, in proportion as it is verified by phenomena, approaches the domain of fact—a *vera causa*.

It was shown that the highly-diffused and attenuated matter constituting comets, as well as that constituting the zodiacal light—while affording some suggestive analogies to nebulous masses—do not furnish examples in all respects identical with the supposed nebula of Laplace. We are, therefore, compelled to fall back on Sir William Herschel's opinion, that there are numerous nebulæ which really consist—not of clusters of stars, but of a diffused, self-luminous, vaporiform matter. Such bodies are, beyond all question, self-luminous, but the question is, Are they clusters of stars or true nebulæ? In other terms, are they optically or physically nebulous?

For a long time, this question was keenly discussed, and opinions fluctuated in regard to the tenability of the fundamental assumption of the nebular hypothesis. It is well known that, since 1846, the tendency of telescopic observations, as revealed by the magnificent instruments of Lord Rosse, and corroborated by the splendid achromatic of Harvard University, has been to break down Sir William Herschel's distinction between stellar clusters and true nebulæ. After the sword-handle of Orion was broken into glittering fragments, shining with separate and distinct lustre, Sir John Herschel himself was disposed to abandon the opinion of his illustrious father.

But the development of a new and wonderful branch of physical science has recently furnished the most satisfactory proofs of the reality of such bodies. We allude to the application of Spectrum Analysis to the study of the celestial bodies. The well-matured speculations of Sir William Herschel, and the mathematical theory of Laplace, have been vindicated from the doubt under which they have been laboring, and the early nebulous condition of the cosmical matter has been demonstrated. The accomplished Sir John Herschel has been permitted to witness the complete verification of the previsions of his illustrious father; to see the link connecting the past with the present in the cosmogony of the universe—which seemed to have been almost ruptured by the extension of telescopic vision—restored and strengthened by this new branch of physical investigation.

Until recently the light from the heavenly bodies, even when collected by the largest telescopes, conveyed to us but very meagre information. With regard to the moon, sun, and some of the planets, in addition to their form and size, we have been able, by this means, to obtain some slight knowledge of their physical structure. But, with reference to the myriads of stars, clusters, and nebulæ, which people the depths of space, the telescope reveals little more than variety in color, brightness, and shape. (In relation to the nebulæ, this was illustrated by diagrams contrasting the appearance presented by the same objects when viewed in the telescopes of Sir John Herschel and of Lord Rosse.)

The discovery of "Spectrum Analysis"—the optical Analysis of Light—enables us to interpret symbols and indications hidden within the light itself. Wherever the tiny waves of light—the swift messengers of the celestial realms—can penetrate, they bear with them intelligence of their origin! "Bodies, so remote that astronomers fail to give us an idea of their distance, are brought, as it were, into our grasp, and are analyzed with certainty! We recognize in them the same elements which compose the soil we tread—the water we drink—the air we breathe!"

Before proceeding to explain the manner in which this new method of investigation decides the question of the existence of true nebulous masses in the regions of space, it is necessary to recall certain well-known and long-established principles in optical science. In 1675, the immortal Newton demonstrated the composite nature of solar light. When a ray of sunlight is made to pass through a glass prism, it is refracted and spread out into a fan-like band, so as to exhibit exquisite gradations of color, from red at one end to violet at the other. This constitutes the Prismatic or Solar Spectrum. In 1802, Wollaston discovered that this spectrum is not continuous, but is interrupted by a number of dark lines. In 1815, Fraunhofer, by great improvements in the optical arrangements employed, rediscovered these lines—ascertained that their relative distances from each other were fixed for sunlight—and succeeded in mapping no less than fifty of them as belonging to the solar spectrum. Since that time, the number of these lines has been increased to thousands. The sagacious Fraunhofer traced these same dark fixed lines in reflected as well as in direct solar light: he found them quite unaltered in position, in the spectrum of moonlight and Venus-light. He, likewise, discovered, that the spectra of the fixed stars contained dark lines differing from those seen in the solar spectrum. He thence drew the important conclusion that these lines have their origin in the luminary. Fraunhofer thus opened the inquiry; but the explanation and import of these lines were reserved for a subsequent epoch.

Modern investigations have established the existence of three orders of spectra depending upon the source of the light: 1. A continuous spectrum—uninterrupted by lines—is produced, when the light emanating from solid and liquid incandescent bodies is passed through a prism. 2. A spectrum interrupted by bright lines is produced when the light emanates from flames or ignited vapors and gases. 3. A spectrum interrupted by dark lines is produced, when light emanating from a source giving a continuous spectrum, is passed through gaseous or vaporous matter giving spectra of the second order.

Now, it has been found that, when various elements are volatilized in the flame of a lamp, the light gives a spectrum interrupted by bright lines—whose character and position are different for different elements. It has also been discovered that the dark lines of spectra of the third order correspond precisely in position with the bright lines in spectra of the second order: they thus indicate the existence of elements which are volatilized in the ignited vapors or gases. The coincidence of position of these bright and dark lines was first observed and described by Foucault, of Paris, in 1849; but their real significance was first indicated in 1859, by Kirchhoff, of Heidelberg. These delicate lines carry across the immeasurable abysses of the celestial spaces evidences of their origin!

The numerous lines of the spectrum are separated from one another—the fan of light is opened out—its entire pattern is brought distinctly under view—and all of its minute details are revealed—by transmitting the light through a succession of prisms: this constitutes the Spectroscope. (This was illustrated by a diagram.)

By means of the spectroscope, no less than fourteen terrestrial elements have been identified as existing in the sun's atmosphere. Mr. Willian Huggins and Prof. W. A. Miller, by ingenious modifications of this instrument, have been able to extend spectrum analysis to more than sixty of the brighter fixed stars. Like our sun, they give spectra with dark lines; thus indicating that the stars (as the sun) must have intensely heated solid or liquid nuclei, surrounded by ignited gaseous atmospheres.

Encouraged by his success with the fixed stars, Mr. William Huggins applied the potent method of spectrum analysis to the examination of the nebulæ. He was rewarded by a most important discovery in relation to the physical constitution of these wonderful objects. On the 29th of August, 1864, he applied his spectroscope to a planetary nebula in Draco. He was astonished to find that there was no appearance of a band of colored light, such as a star would give; but, in place of this, there were three isolated bright lines on a dark ground—a true gaseous or vaporous spectrum. In other words, the object was not a cluster of stars, but a true nebula. Mr. Huggins was not slow in following up this line of investigation. During the two years succeeding his first observation, he examined the spectra of more than sixty nebulæ and clusters. Of this number, about twenty gave spectra with bright lines; that is, were gaseous bodies. The remaining forty gave stellar spectra. Among the true nebulæ may be mentioned, the Annular Nebula in Lyra; the Dumb-bell Nebula; and the great Nebula in the Sword-handle of Orion—concerning the nature of which there has been so much discussion.

These spectrum investigations afford tangible and unmistakable evidence that there are in space, masses of ignited gaseous or vaporous matter of prodigious extent, shining by their own light, and resembling the vast nebula which the Nebular Hypothesis declares to have been the original condition of our solar system. The nebulous matter, assumed as the basis of the hypothesis, is no figment of the theorist!

What great results have been achieved by the power of means apparently the most trivial! Immense objects, seemingly unattainable, have been grasped by the smallest conceivable handle! A little instrument, which is scarcely any thing more than a small triangular piece of glass, solves questions which hundreds of thousands of dollars expended in telescopes, and years of observation, could not have settled! Penetrating into the illimitable depths of space, it reveals to us something of the physical and chemical constitution of stellar clusters and nebulæ, so remote, that the light which the spectroscope analyzes, must have left them thousands, perhaps millions, of years ago!

The lecturer concluded with the following reflections, which are given without abridgment:

In contemplating the vastness of the sidereal universe, every person, in every age and country, must recognize as irresistibly natural, the train of thought expressed by the Hebrew Psalmist, when he exclaims: "When I consider thy heavens, the work of thy fingers, the moon and the stars, which thou hast ordained; what is man, that thou art mindful of him? and the son of man, that thou visitest him?" (Psalm viii. 3, 4.)

How incalculably has this withering sense of insignificance been augmented by modern telescopic excursions into the remote recesses of the stellar universe! When, by measurements, in which the evidence of the method advances *pari passu* with the precision of the results, the volume of the earth is reduced to less than one-millionth part of the volume of the sun; when the sun himself, transported to the region of the stars, takes up a very modest place among the thousand of millions of those bodies revealed to us by the telescope; when the ninety-five millions of miles which separate the earth from the sun, by reason of their comparative smallness, have become a base totally insufficient for ascertaining the dimensions of the visible universe, when even the swiftness of light barely suffices for the common valuations of science; when, in short, by a chain of irresistible proofs, certain stars and nebulæ have retired to distances that light could not traverse in less than millions of years—we feel as if annihilated by the immensity of the scale of the universe! In assigning to man, and to the planet he inhabits, so small—so insignificant—a position in the material world, science seems only to have made progress to humiliate and to humble us!

Let us accept the lesson of humiliation, with a proper sense of reverence! But, while humbling ourselves in the presence of the overwhelming vastness of God's creation, let us not degrade ourselves: let us not imagine that so insignificant—so ephemeral a being—groping about on so minute a speck in the universe—is totally unworthy of a Creator's care; or entertain the debasing idea that there is no life—no hope—beyond this transient state of existence! Such a view is not the legitimate result of the proper sense of humility which true science demands. She teaches us that grand humility which annihilates self, and places the soul as a child-like learner in the face of God's universe! Like the sacred Shepherd, with unsandalled feet, we advance with reverential awe upon the holy ground, and receive assurances that our minute sphere is benignly noticed by the eye of Omniscience; that, amid the surrounding grandeur, man is not overlooked!

But let us not forget, that there is another aspect under which such contemplations may be viewed, which is calculated to exalt man in the scale of creation. When we reflect on the extreme feebleness of the natural means by the help of which so many great problems have been attacked and solved: if we ask ourselves how such results have been attained; how have we been enabled to assure ourselves of this stupendous scale of creation—of the resplendent glories of the illimitable realms of space—the feeble being resumes all his wonted dignity! By the side of such wonderful achievements of the mind, what signifies the weakness and fragility of our body; what signifies the dimensions of the planet—our residence—the grain of sand on which it has happened to us to appear for a few moments!

From this point of view, man is exalted to his true dignity, through his spiritual and intellectual nature. A mind capable of accomplishing such results must indeed be an emanation from Deity! We must have within us some feeble spark of Divinity! Yes, there is a life and a hope beyond and above this transient existence!

> "'Tis the Divinity that stirs within us,
> 'Tis Heaven itself that points out an hereafter,
> And intimates Eternity to man."

Yes, the lofty aspirations of humanity are not delusions; they are realities. They link us with a purer order of existence, which makes us heirs of immortality. We repose under a confident and unwavering assurance that, in God's own time, these earth-mists will be dispersed, and the dim twilight of conjecture will yield to the glorious, unclouded noonday of knowledge.—*The California Teacher—Abstract of a Lecture.*

RIVER AND LAKE TERRACES.

TRAVELLERS along the river-valleys of New England, and in other sections of our Northern States, will observe that the banks in many places rise by a series of terraces, which at a distance resemble the steps of an amphitheatre. Carved with singular uniformity upon the slopes, they are everywhere a striking and beautiful feature of these most picturesque and beautiful landscapes. In the valleys of the Connecticut, Merrimac, St. Lawrence, Kennebec, Hudson, and innumerable other streams, these levels have been utilized as sites for villages, country-seats, forest, and cultivation.

Northampton, Brattleboro, and Springfield, are built on terraces; and part of the charming village of North Conway, at the gate of the White Mountains, stands upon a similar level. Dartmouth College is upon an elevated terrace.

Terraces occur on both sides of the Niagara River, and on the east side four levels are described, the highest being 38 feet above the top of the American Fall. They occur also on the Hudson Highlands at Cornwall 180 feet, and at Cozzens 130 feet above tide-level. The Catskill Mountains are fringed with terraces almost to their summits; and on the east side of the Hudson, at Albany, eight distinct levels are passed on the line of the Boston and Albany Railway before reaching the summit station.

On Hoosac Mountain is a terrace 1,813 feet above the level of the sea, and near it an ancient beach 200 feet higher. They occur at Quebec, 500 feet; at Montreal, 400 feet; and, on the Genesee River, 1,410 feet above the ocean-level.

But terraces abound on lake-margins with the same distinctness as on the banks of rivers. Prof. Agassiz counted fifteen on the shore of Lake Superior, and the writer counted six, beautifully defined, at Portage Lake. Visitors at Watkins Glen may notice terraces sculptured on the amphitheatre of hills at the head of Seneca Lake, whose geological history is contemporary with that of the great gorge, the object of their visit. In Northern Utah lake-terraces are found, according to Hayden, nearly a mile above the ocean, and on islands in Barrow's Straits they occur at 1,000 feet elevation.

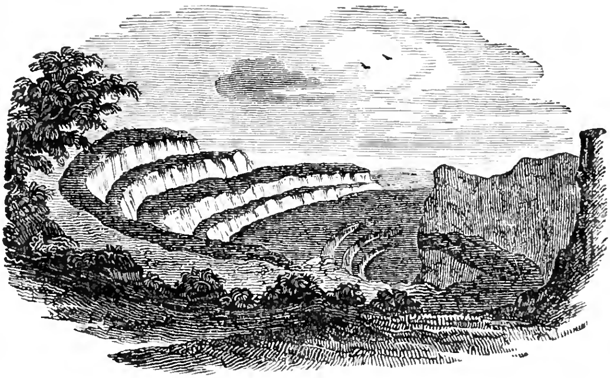
On some of the great Western prairies terraces extend like vast coast-lines bounding the plain.

Nor are they confined to North America. They have been noticed on the slopes of the Ural and Altaï Mountains, around the Dead Sea, on the banks of the river Jordan, on the mountain-sides in the Great Sahara, and on the banks of the Nile above the first cataract.

The ocean, too, has its terraces. Darwin observed that, around Patagonia, the ocean had eaten deep into the rocky coast "a series of step-like plains." Roads are carried up the Cordillera on elevated terraces to a height of 9,000 feet.

These formations, so widely distributed and so uniform in their aspects, have an important geological significance. They are evidently among the latest results of the dynamic agents which have modified, and are still modifying, the surface of the globe. Those along the banks of rivers have been formed during the erosion of the valleys. Their history, therefore, begins with the development of the present

Fig. 1.



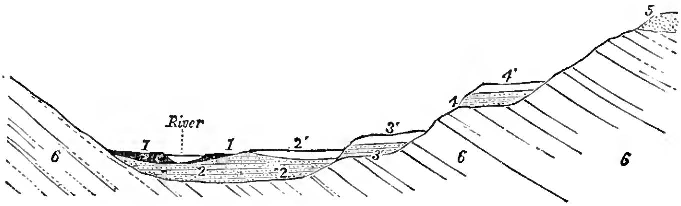
Terraces in Limestone Cliffs, worn by Waves.

river-systems, and comprises what is known in geology as the "Terrace Epoch." They are most abundant and perfect in the drift latitudes—that is, where the continental floors are deeply covered by the waste and *débris* of the Glacial Period, which closely preceded that of the Terraces. If we examine the valley of a gently-flowing river, we may study all the processes by which it was formed, and step-like terraces distributed along its banks.

There is the channel along which the stream is flowing. By the side of it, at intervals, are verdure-covered meadows and deposits of shingle and sand, overflowed during periods of rain and freshet. These constitute what may be termed the river-flats or flood-plains. Something is added to it during each overflow. Meanwhile, the river-channel is deepening by the wearing action of the current and transportation of the materials of its bed. At length the waters are discharged along the channel, and no longer overflow the flood-plain, which becomes at once a terrace, the last formed and newest of the series, the oldest of which may be more than a thousand feet up the bank. Fig. 2 shows a section of a river-valley with terraces on one side only, a circumstance which frequently arises from sinuosities of the stream.

The newly-made terrace now really forms the bank or banks of the stream, and is itself slowly worn away and distributed elsewhere by the abrasion of annual freshets. Portions of it may thus disappear, but other portions remain.

FIG. 2.



TERRACED RIVER-VALLEY.—1, 2', 3', 4', and 5, are Terraces.

It is obvious that terrace-formations occur in greatest perfection where the stream is not very rapid. Where it flows as a torrent, a flood-plain or delta may form only at its mouth. Sometimes, however, a swift stream is checked by the accumulations of *débris* or by rocky gorges, forming lake-like basins around which terrace-formations occur with great uniformity and beauty. The Connecticut River is 1,589 feet higher at its source than at its mouth; and, according to Prof. Hitchcock's excellent report on the Surface Geology of New England, twenty-two such basins, or levels, occur in its descent.

It is evident, as we have observed, that the highest terrace of a series is the one first formed and the oldest, but, when formed, was equally, with the last one, the flats, or flood-plain, of the river; whence it follows that the river was then much higher as regards the general level of the land than now. Its present deep valley was not excavated, but it by no means follows that the river was any higher as regards the level of the sea. A change of level has, indeed, taken place, but it has been of the land, not of the ocean. No truth in geology is better established than this perpetual oscillation of the crust of the globe, and from the unchanging ocean-level is measured the extent of the movement.

The process by which a river-valley is excavated, and terraces formed upon its banks, is directly connected with this elevation of the land. Indeed, it could occur only during a period of elevation, and may have commenced with the emergence of the land above the waters, for then would begin the flowing of streams and their concentration into larger ones, forming at last our magnificent system of rivers. During a period of subsidence, however, the rivers disappear, as their valleys are filled, and the land is overflowed by the invading ocean. Nor is proof wanting of submergence of a very large portion of this continent, especially that which is north of the fortieth parallel, directly following the Glacial and preceding the Terrace Epoch; and nowhere is that fact more apparent than in New England.

The occurrence of ancient beaches above the terraces on Hoosac Mountain, and among the White and Green Mountains 2,200 and 2,600 feet above the ocean, proves its former presence and the movement of its currents and waves.

At that period the site of the present rivers was the bottom of an ocean. It was during the progress of that period of continental depression and submergence that the glacial drift was modified and redistributed, forming enormous deposits, filling old basins and river-valleys, so that when the land emerged from the waters it was comparatively level, a few mountain-peaks rising above the plain.

It is at this point, as we have seen, that the present river-system with its terraced valleys begins, and the phenomena may occur in the following order:

1. Elevated beaches, indicating ancient sea-shores.
2. The highest river-terraces.
3. Continuous excavation of river-valleys, and formation of flats, or flood-plains.
4. Elevation of those plains above the overflow of the river, forming terraces.

The process of formation we have already described; nor does it appear that any dynamic agent was then in operation which is not in operation now. The work has been continuous.

The superposition of terraces early suggested the idea that their origin was due to a succession of sudden elevations of the land rather than to a continuous movement, and such, indeed, may have been the case in some instances. But their usual want of uniformity through long distances and of correspondence on opposite sides of the valley induces the conclusion that their immediate distribution is controlled by local circumstances, while the general cause has been a continuous and gradual elevation of the land, and the equally continuous action of running water. Currents of rivers are thrown from side to side by ice-borne bowlders and accumulations of *débris*, and pebbles will become so adjusted in the river's bed as to resist erosion, as shown in Fig. 3.

Fig. 3.

Showing the Position assumed by Pebbles in the Bed of a Stream.

This is one of the causes of the sinuosities of rivers. The water, as Sir Charles Lyell observes, is thus frequently forced to cut new channels, by which means new terrace flats may be formed by redistribution of materials.

The transporting power of running water depends on its velocity. Hopkins, cited by Prof. Dana, says that its force varies as the sixth power of its velocity—that is, doubling the rate, increases the force sixty-four times. "If a stream running 10 miles an hour would just move a block of five tons' weight, one of 20 miles would move one of 320 tons." When shallow streams are suddenly swollen to torrents, bowlders of considerable size are borne along with heavy roar—are broken by collision, and ground to pebbles and sand. Hence we find that heavy rock-masses are abundant near the sources of a river, finer materials along its valley, fine sand and silt at its mouth. The material thus comminuted is prepared for distribution over the terrace-flats and plains along the river's bed.

The following table is from Mather's "Report on the Geology of the State of New York:"

A stream having a velocity of—

3	inches	per second	wears away fine tough clay
6	"	"	removes fine sand.
12	"	"	removes gravel.
24	"	"	removes pebbles one inch in diameter.
36	"	"	moves angular fragments having a diameter of two or three inches.

The latter velocity is, however, very moderate, being little over two miles an hour. In estimating the transporting power of rivers, we must consider the important fact that rocks lose nearly one-third of their weight in water.

The formation of terraces on the borders of lakes has, equally with those along the banks of rivers, arisen from elevation of the land. By this means the drainage of Lake Superior became possible, and its terraces represent former levels of its waters. Nor less interesting is the fact that the great plains of Northern Africa, including the Sahara and the valley of Egypt, were emerging from the sea while the Nile was excavating its valley and carving into terraces the sands of the Nubian Desert more than 200 feet above the present bed of the river. The wave-eaten shores of Patagonia have been elevated above the ocean, and its terrace-plains, equally with those of lake and river valleys, constitute an epoch of geological history, and record the most profound of the earth's secular changes.

APPLIED SANITARY SCIENCE.

By J. R. BLACK, M.D.

IN the intellectual field there are two distinct classes of laborers: the discoverers, or those who pursue science for its own sake; and the appliers, or those who seek to make the knowledge it confers useful, and so turn it into a direct source of profit to themselves, and, in a general way, to the public. The genius each displays differs from the other: the one being delighted in finding out and making his way into the unknown, while the pleasure of the other consists in seizing results, and putting them into shape, so that they may be servants to our will. The history of electricity strikingly displays these distinct aptitudes and pursuits. Volta, Franklin, Arago, and Faraday, were leading discoverers of the properties and laws of electricity. They cared far less about the every-day use which might be made of the newly-discovered force, than of gaining a complete insight into its nature, and of making it the means of unlocking other secrets of the natural world. On the other hand, Morse and Wheatstone thought only of electricity as a means to an end, or of reaching, through some ingenious contrivance, the means of rendering human communication, at distant points, practically instantaneous.

A knowledge of the leading facts upon which sanitary science is founded is, at least, as old as history itself. It antedates the time of Moses; many of the rules of hygiene having been taught by the Egyptian priests. But more especially within the past two centuries has the knowledge of the ways in which disease is produced, and may be avoided, been corrected and extended. It is within this period that the first attempt was made in Europe to establish quarantines. The sum of the precautions taken in London during the middle ages to guard against the ravages of the plague, was the isolation of infected houses, and putting a red cross on house-doors, on which were inscribed the words, "Lord, have mercy on us."

The physician of to-day, who has devoted half as much thought to the prevention of disease as to its cure, firmly believes in human ability to avoid nearly all the ills to which flesh is now subject. Given a good constitution, and the conditions of health or sickness are almost wholly in our own power. He believes this, and on precisely the same grounds that the geologist believes that fossils are not what was once universally believed, the primary result of the action of a plastic or creative force in Nature. A like belief exists in the popular mind in reference to health and longevity, though in a less positive form. Families known to be of good constitution, and of ancestry noted for their length of days, are not expected to be sickly and short-lived. When any member of such a family does become a permanent invalid, and likely soon to die, it is a familiar expression, and notoriously true, that he or she has abused the endowment inherited.

Passing over the evidence which has convinced those the most competent to judge in reference to the prevalence of disease—the physicians—to their conclusion, that if all possessed good constitutions, and lived as they ought to live, in accordance with hygienic law, there would be no disease, or next to none, and death would not come upon the human family through a morbid process, but by the only truly natural mode of dying—old age; the question arises, How do men come by good constitutions? Through a course of life by progenitors for several generations, precisely the opposite of that course which makes a bad constitution out of a good one. Any one who has attained to life's meridian will be able to recall examples of good constitutions converted into bad ones. Children, parents, and grandparents, in some families, often stand thus in regard to constitutions:

Grandparents scarcely know what sickness is, and die of old age;

Parents: constitutions much impaired, often sick, and die in middle life;

Children: constitutions very defective, and are rarely well a week at a time.

This is the downward career of life-force, which almost every one has witnessed; the upward career being the result of a precisely opposite course. In place of abusing the constitution there is the most careful husbanding of its resources, and avoidance of all the causes which will impair its vigor. The purity and strength which such a course of conduct begets is transmitted; the child starts in the world on a higher plane of life-force than the parents did; and if the offspring continue to carry out the reformation thus inaugurated, the result will be to bring back the pristine vigor, health, and longevity, which an opposite course had destroyed.

Such are some of the elementary truths forced upon the attention by every-day experience on the great problem of obliterating sickness and death by disease. As has been stated, these elements of sanitary science have long been known. But in spite of this, and of the facts that this science has of late been purged of many errors, and its bearings and capabilities greatly extended, disease, deformity, decrepitude, and untimely death, prevail almost as much as ever. Where, then, is the weak point in sanitary science? Is it in the imperfection of the science itself, or is it in its applications? Reverting to the history of electrical discovery and its applications, will give us aid in solving the question. We have seen that the discovery of the great truths about the electrical force employed one class of scientific experts, and applying these truths employed another class of scientific experts. Now, we have had in abundance the discoverers of the truths of sanitary law, but we have not, nor can we have, as in electricity, experts who can carry out for the advantage of all, the benefits which hygienic law is capable of conferring. There cannot be, in sanitary matters, ingenious contrivances, by which a certain class of men can manipulate health and long life into their fellow-beings. Its truths, if applied at all, must be mainly applied by those who desire its benefits; or every one must apply the science for himself or herself, else nearly all the knowledge there may be on the subject will be as if it were not. Here we have plainly before the mind the great and peculiarly weak point, so far as the practical benefits are concerned, which this science may be capable of conferring. To make it profitable and useful, or, in other words, to make it an applied science in a community, that community must be made, one and all, experts in its knowledge and in its applications.

This last consideration should lead educators to bestow a preëminent importance to a thorough course of instruction in hygiene. It is all well enough for the young to learn more or less about the philosophy of electricity and magnetism, but, as the great majority of them in after-life will make very little, if any, use of this knowledge, its importance practically dwindles to very small proportions. Wholly different is it in the case of sanitary science. Every one can make of it in after-life most important, and ultimately momentous uses, not occasionally, but during every day and hour of life. And, if thus applied, its benefits would transcend those of any other branch of knowledge; it would tend to make man a master of himself, of his pains, deformities, and mortal afflictions.

We have said that the applications of sanitary science must be made *mainly* by the individual members of society. This is true of the kind of air breathed, of the food and drinks partaken, of the clothing worn, etc., etc. But where human beings are clustered together, their sanitary relations are so intimate that it becomes absolutely necessary for the general good to define and regulate some sanitary matters by law, which each member of a community cannot, as an individual, regulate for himself. It is not possible, for example, for one in a densely-populated place, to enforce regulations for a supply of wholesome water, for carrying off to a safe distance all the refuse and noxious matters of a great city, or to protect himself from the presence of persons suffering from infectious diseases. It is here plainly the duty of the State to exercise supervision for the general good, and to protect all, as far as may be possible, against evils which a few persons may fight against in vain. There is absolutely no difference, except in the matter of will, between the danger of allowing a person who has a mania for putting poison into the drinking-water of a city, by which many perish, and one who puts the poison of small-pox into the air of a city by which hundreds are slain. In the former case, even if it were the work of an idiot, or of an irresponsible person, and if he were known to be travelling over the country, liable at any moment to enter a city, would not the officers of the law be considered exceedingly derelict in duty if they did not carefully guard against his entrance? And, if such a class of persons were in a city infecting others with their mania, would not all applaud the law and the efforts of its officers in securely confining them where they could do no harm, taking from them the means by which they injured and destroyed the lives of others? This is precisely what ought to be done with every one in a densely-populated place laboring under an infectious or contagious disease. When out of a city, such dangerously-affected persons should be watchfully excluded until cured of their disorder; and, when in, a cordon should be placed around them, so that the community would be in no danger; all the while carefully stamping out with disinfectants the means or the germs by which disease and death are carried from house to house.

It should for these reasons be a maxim with the law-making power to protect the health and lives of the people, whenever individual effort is powerless or insufficient; and, moreover, to provide that pure air, wholesome drink and food, should be made possible to every inhabitant of a town or city. If the refuse matter and *excreta* of a city are not promptly and carefully removed; if the streets are not of the proper width, and regularly cleansed; if houses are allowed to be so constructed that effective ventilation is impossible; if the water-supply is insufficient, or tainted with organic matter; and if persons are allowed free entrance, suffering with dangerous infectious diseases, and no well-directed efforts are made to destroy the noxious matters thus introduced, misery, disease, and a fearful rate of mortality, will be the normal results. The few who make diligent efforts to apply the rules of sanity are powerless in removing the obvious causes of the prevailing misery and death-gloom, and, like Lot, for safety, must flee the city.

With a private and public hygiene thoroughly understood and effectively maintained, there is not an intelligent physician in our land who would not acknowledge that the result would be to diminish the prevalence of disease at least one-half, and to send the average expectation of life, at a bound, up a decade of years.

Taking into consideration the fact that it is within the power of sanitary regulations to prevent yellow fever, as was shown in New Orleans while under occupancy during the late war by the Union forces for more than two years, where over 100,000 unacclimated soldiers were stationed, or passed through the city, without a single case of the disease originating there; that it is possible to stamp out the germs of Asiatic cholera and small-pox, and say, "Thus far shalt thou go, and no farther;" and taking into consideration that the average duration of life has been extended during the past two centuries from nineteen to thirty-one years, by a slow appreciation and imperfect application of sanitary law alone; taking these, and many other facts of a like character, into consideration, it does not seem too much to say that it is within the power of any one with a moderately good constitution to say whether he will choose to cut short his days and die the violent death of disease, or whether he will extend the powers of his body to their normal limits, and so die from the effects of old age, or from the gradual wearing out of the most imperfect organ of his body.

Pecuniarily, the results of properly-applied sanitary law would be immensely successful; the cent of prevention would be more than worth the dollar of cure. It is estimated that from a half to three-fourths of the inhabitants of our principal cities are sick some time during each year of ordinary salubrity. The loss of time which thereby results, the expense of nurses and medicines, and, above all, the permanent impairment of the health and shortening of life which thereby ensue, are fruitful sources of the worst misery and the deepest indigence. These conditions become, in turn, the great nurseries for crime, and for filling our poor-houses, asylums, hospitals, and penitentiaries. During the years when an epidemic scourges a city, its business becomes for the time paralyzed, and a serious check is put upon its growth and prosperity.

But, more than these, sickness throughout the United States supports in comparative affluence, at least, 75,000 persons with their families. The physicians and dentists amount in round numbers, according to the last census, to 55,000, and the druggists, pharmaceutists, and patent-medicine venders, to about 20,000 more. Add to all this the munificent charities maintained for those who are directly or indirectly sufferers from the effects of preventable diseases, such as the deaf, the blind, the insane, and the imbecile asylums, and the aggregate outlay for avoidable evils assumes enormous proportions.

In reference to health and sickness, the civilization of the nineteenth century presents this remarkable spectacle: millions of dollars annually spent, indescribable torments and anguish endured from an evil which it is possible, but never seriously attempted, to remove. The dark shadow of a barbarous ignorance yet overspreads the popular mind, that sickness is somehow produced by evil causes, whose dreadful attacks we may patiently watch and fight with drugs, but whose ultimate destruction belongs alone to the gods. The danger of an attack by some dreadful disease is yet looked upon with a feeling akin to superstition, not with the calm confidence of security which a thorough knowledge of cause and effect alone can bestow. Slowly, oh, how slowly! does the human mind awaken to the truth that in this, as in every thing else pertaining to the natural world, nothing happens by chance, nothing of arbitrary will, but all is subject to immutable law. This truth once fully recognized and acted upon, man would exhibit the same power and success in subduing in his own body the one great obstacle to his weal, as he has shown in subduing the obstacles to his weal in the external world, and he will then become the most healthy instead of the most sickly of beings.

The proper means for accelerating such a hygienic reformation consists in making it possible for all to become experts in the application of the science of life. In effecting this, the State has the two great requisites in its own hands: first, to educate and train the youth of our country so that they may realize the importance, and be enabled to apply, sanitary science for themselves; and, second, to make it possible, wherever there is a dense population, for every one to carry the laws of hygiene into effect, and to protect the people against those who have disregarded its injunctions, and so have become focii for multiplying and disseminating the seeds of infectious diseases.

BARBARISM IN ENGLISH EDUCATION.

By E. E. WHITE.

PROF. W. H. YOUNG, formerly of Athens, Ohio, now United States consul at Carlsruhe for Baden and Alsace-Lorraine, has sent us a very interesting epitome of the recent odd discussion in the English papers, chiefly in the *Times*, of the oddest feature of English public schools. The discussion contains so much that is English, unique, and suggestive, that we regret that we are obliged to condense the epitome to bring it within our space. We have made as few changes as possible, but, that Prof. Young may not be responsible for the sketch in its present shape, we have given it an editorial position.

The term public school is commonly applied in England to such schools as Eton, Rugby, Harrow, Winchester, etc., which correspond with an American endowed boys' academy on the dormitory plan. Each school comprises several "houses" and about six classes called "forms," and is under the immediate management and instruction of ten to twenty assistant "masters" presided over by a "head-master," and subject to a corporate board of control. In all of these schools Monitorial Discipline has prevailed more or less for centuries, with this striking feature, that all the boys in the lower "forms" are subject, not only in ordinary school discipline, but for personal service of whatever kind, as cleaning rooms, brushing clothes, bringing wood and water, all kinds of errand-running, etc., to the "sixth form," commonly limited in number from fifteen to thirty of the best of the most advanced boys, who are clothed with authority, and are held responsible for keeping order at all times, in study, in dormitory, on the play-ground, etc. This service by the lower form is called "fagging," and is enforced with rigor just as other discipline—the ashen rod being in constant use. Of the "sixth-form" boys a designated few, called in the school "preposters" or "prefects" and in sports "leaders" or "captains," are of still higher authority—a sort of court of appeal, and the real disciplinarians of the school. A boy when abused may appeal to these, next to an "assistant master" (teacher), and finally to the "head-master" or principal; but these appeals are, in fact, almost never made. The "code of honor" is against it, and an English boy will bear almost any amount of cuffing, kicking, and beating, before he will appeal. Of course such a system is liable to the grossest abuse.

Further, in these, as in other English schools, physical prowess in sports ranks little, if any, behind mental excellence. The "prefects" in the schools are "captains" in the field-sports, and feel themselves responsible, rather to the English sport-loving public, than to the school authorities, for the athletic proficiency of their several divisions. All of these sports involve a large amount of slang that must be familiarly understood to secure successful coöperation in such games as cricket, football, etc.

The case of discipline which gave rise to the recent discussion, is this: A prefect at Winchester sent for a "house" (the boys of a particular building) to examine them in their "notions," i. e., perhaps, in their general school-boy proficiency in matters out of study. One boy refused to come, on the ground that, being a senior fifth-form boy, he could not be fagged. The prefects held a meeting, decided his conduct rebellious, and that he must be "tunded"—that is, should be whipped with ground-ash rods. The boy appealed to the head-master, who told him he must submit to the "tunding." The number of "cuts" which a prefect may give, is theoretically limited to twelve; in this case thirty were given.

A Mr. Maude reports the matter to the London *Times* as a specimen of "licensed tyranny," worse than any "bullying" (by which the English understand a large boy imposing on a small one), a gross relic of past centuries, disgracing English public schools, and demanding the interference of English public opinion for its suppression. He says a "tunding" is far worse than any master's flogging; the ash rod is as large as the finger, three feet long, seasoned until tough as whalebone, and that not less than four must have been broken over the boy's back, leaving it in a condition horrible to be thought upon. The head-master, when appealed to afterward, condemned the decision of the prefects, pronounced the punishment excessive, but only required of the "tunding" prefect a private apology, instead of expelling him and punishing his associates. Mr. Maude had been five years at Winchester, and remembered scores of these "tundings," but never one so gross as that described.

Next a Mr. Fischer, in the *Times*, applauds Mr. Maude's "admirable letter," condemning without stint the "cruel and cowardly iniquity" long prevailing at Winchester; could give cases where the punishment had been more barbarous than garroter-flogging at Newgate; for the latter was inflicted by law, within legal limits, and in the presence of responsible officials, while the former was in violation of all law, and in the absence of all authority or protection to shield the lad from the anger of his school-fellows; boys should be punished by the masters or in their presence, and the latter should not be allowed to delegate such authority to other boys; the system is brutalizing to punisher and punished—the one hardened by indulgence in cruelty, the other only maliciously biding his turn to inflict on others the harm he has received, and both made brutal and cowardly men.

A Mr. Lechmere deplores the public censure likely to fall upon his revered preceptors of a former generation as a result of Mr. Maude's painful letter. No such torture as "tunding" was known at this peaceful time; was four years a junior at Winchester, and never knew a severer punishment than a moderate knuckle rap on the head, inflicted by prefects deemed "bullies."

An "Old Wykehamist" (Winchester was founded by Mr. Wykeham), who recently spent six years at Winchester, admits the main facts of the "deplorable case" reported by Mr. Maude, but protests against his conclusions as to the general condition of things at the school. The power of the prefects is limited by the right of appeal and their own sense of a grave responsibility, and "tundings are rarely and reluctantly inflicted, and only for grave moral offences and grave breaches of discipline." The system is perhaps wrong, because liable to abuse, but the "brutality," which Mr. Maude had so justly stigmatized, was very exceptional, as was proved by its general condemnation by even the friends of the system.

These letters call out the "victim," who speaks for himself, avowedly of his own will and motion, "in defence of my school." He thinks that a "Winchester tunding" is not, as alleged by Mr. Maude, "the most dreadful punishment imaginable." He says:

> "The tunding I received in the fracas, a month ago, had no such terrible effect as imagined. Played football after two days without the least inconvenience. Ground ashes not as 'tough as whalebone,' but slight sticks rarely lasting for more than three or four strokes. The punishment I received is universally admitted (and readily by the prefect himself) to have been excessive; yet I firmly believe, as does every one else here, that there was no tyranny or brutality in the matter. On the contrary, it was done in an honest, though mistaken impression, that serious insubordination was intended by my refusal to obey him; hence, while his action may be condemned, he himself and his motives deserve respect," etc.

In the letters to his father, which are published, he states that he was little hurt; that he cared nothing for the "licking;" had contended for a principle, and, when this was decided against him, he went promptly for his tunding. The prefect wanted to "argue the case," but he told him he had come for his "licking," and wanted it at once. It had since been admitted, on all hands, that the vote was wrong, and the punishment excessive in the number of strokes, but he was thoroughly disgusted with the fuss made over so small a matter.

In the course of the discussion, the "father of the victim" states that he had written Dr. Riddle (head-master of the school) immediately on hearing of the case, asking that the prefect be required, at least, to make a public apology to the boy. The doctor replied in a letter of twelve closely-written pages, admitting and deploring the facts, which were the result of "grave error of judgment and zeal for discipline." Not satisfied with this, he (the father) called a bishop into counsel, through whose intercession Dr. Riddle wrote again, saying the prefect had apologized to "the victim" in his presence, and adding, somewhat reprovingly, that the matter were better left where it was. He wrote again, offering to let the matter drop, if the apology were made known to the school. This letter being unanswered, after three weeks he resorted to the press.

These letters and statements subjected the system to a sharp discussion. "C. F." thinks the system not a bad one, if two things are clearly understood, namely, that an appeal will always be heard, and the prefect's punishing be limited to six cuts. The first rule would check abuse of power; the second would enable the prefects to settle many offences "out of court," thus preventing the brutality sometimes disgracing schools. "M. A. Oxon" was at Winchester five years during the "peaceful times," spoken of by Mr. Lechmere, and could testify that the "tortures of tunding" were then not infrequent. For "going out of bounds during play-hours," he and others had once undergone a prefect's tunding, in which he received twenty-five to thirty cuts, "laid on with such a will" that his jacket was cut to ribbons, and was never worn again," and his "arms and back were black and blue with wheals. . . . We were not, however, milksops in those days, and we bore with Spartan fortitude, and without a murmur, a punishment which now makes a cowardly, rascally 'garroter' howl and cry to the attendant surgeon for mercy." He had, however, hoped, until enlightened by Mr. Maude, that these tortures were gone by—the relics of a less civilized age. He describes the system as it was in his day, and adds that, while he endured it and was none the worse, he would not like to have a child of his subjected to a similar discipline. "W." gives a chapter of his experience, from which it appears that he was subjected to the bullying of his school-fellows. He states that he can give many instances of "prefect tyranny." "An Older Wykehamist" answers "An Old Wykehamist," and asks, "What's the use of an appeal *after* a thrashing?" and adds that an appeal before would provoke the ire of the prefects and the jeers of companions. He states that it was only three years since a prefect tunded, at one time, thirty or more boys for some trivial offence, and that he himself had received more than one hundred and sixty tundings, of from four to sixteen cuts each, in seven and a half years' attendance at Winchester!

Mr. Maude writes a second letter, answering the charges of "exaggeration." He reasserts that there is no limit to the power exercised by the prefects, and shows that the right of appeal is of little value. He gives cases showing the barbarity of the system. About fifty boys were "licked" one afternoon for being absent from an "irregular" roll-call, "the floor of the room looking like a fagot-yard." The head-master disapproved of the irregular roll-call, but excused the prefects "on the ground of an excess of zeal in performance of duty!" In one case the prefect gave a boy several cuts on the face ("facers"), because he was supposed to be "padded."

Edmund D. Wyckham states that he frequently witnessed abominable cruelty in the "peaceful times" of Dr. Williams; once saw a boy tunded with a cricket-stump and lamed for life. The boys, on this occasion, rebelled, rescued the victim, and fell upon the prefects, and cuffed and kicked them out of the Commons' Hall. After the boy had sufficiently recovered, he was publicly flogged by Dr. Williams for having resented a prefect! "An Old Winchester Prefect" gives similar testimony, and adds that the system is "an indefensible and barbarous practice," which should be ended at once and forever."

The system is as vigorously defended. "An Old School Disciplinarian" believes tunding to be infinitely better than caning by a master and less dangerous than knuckle-hitting on the head; "save me from sly kicks and boxes." The system creates good feeling between the seniors and juniors—gives the former responsibility; the latter protection from bullies—and is "a good training for the world." Instead of making boys "weak milksops," it makes them "Englishmen like their ancestors." "A Wykehamist" is proud of the old school, and believes that prefects are high-minded, deliberate, and just. His family had been connected with Winchester for fifty years, and he had never before heard a complaint.

"W." thinks the less a master "thrashes" the better—it takes a rare man to counterbalance the mischief done by "perpetual lickings." When the boys do the flogging, the result is very different. They know each other's tricks and ways, and can be more just. The system protects boys from brutality. When in school he was brutally kicked by a big bully whenever sent above him in class. Such treatment was not possible at Winchester. "*The great distinguishing character of every judiciously-managed English school is, that the boys are sure of being properly kicked!* . . . By all means let the masters *control* the system and effectually punish its abuse, but as 'kicking' will go on in every big school, let my boys go where it is reduced to a system, in the hands of a recognized class."

"A Civilian," one of Dr. Arnold's Rugby boys, is gratified that, while many see no cure for the abuse of the system but its abolition, others see a good use in the government of the public schools through prefects. He was six and a half years at Rugby, and only knew two or three cases of gross injustice or cruelty, but remembers scores of cases of sharp caning of "fags" for impertinence, neglect of duty, etc. "This punishment was infinitely preferred to one hundred lines of Homer or Virgil." Under this system, hundreds of boys govern themselves "without the continued interference of the eminent man at the head of the school."

"Expertus" contrasts, at length, the monitorial or prefectorial system with the "system of lock and key, usher and spy, and Jesuitical surveillance." While the former is liable to abuse and needs to be carefully guarded, it is "wonderfully strong in the argument from general success, from the characters which it has helped to train, and from the qualities it has naturalized in Englishmen."

A former "Acting Head-Master at Rugby," Sir Bonamy Brice, also thinks that the excellence of the system has been abundantly proved by its success. To train great schools to govern themselves is a task of great responsibility, and mistakes will occur, as in all human government. He asserts that it would be easy to array a terrible catalogue of abuses or failures in the opposite system.

A number of other letters, *pro* and *con*, have been published, among them a card by Dr. Riddle, stating that the whole matter had been referred to the Governing Body, then in session, for examination and action. The decision, which we have not yet seen, was looked for with great interest when our correspondent wrote. It is probable that this discussion will result in a modification of the monitorial system, but we do not look for its immediate abolition. It is too characteristic of the English people.—*The National Teacher.*

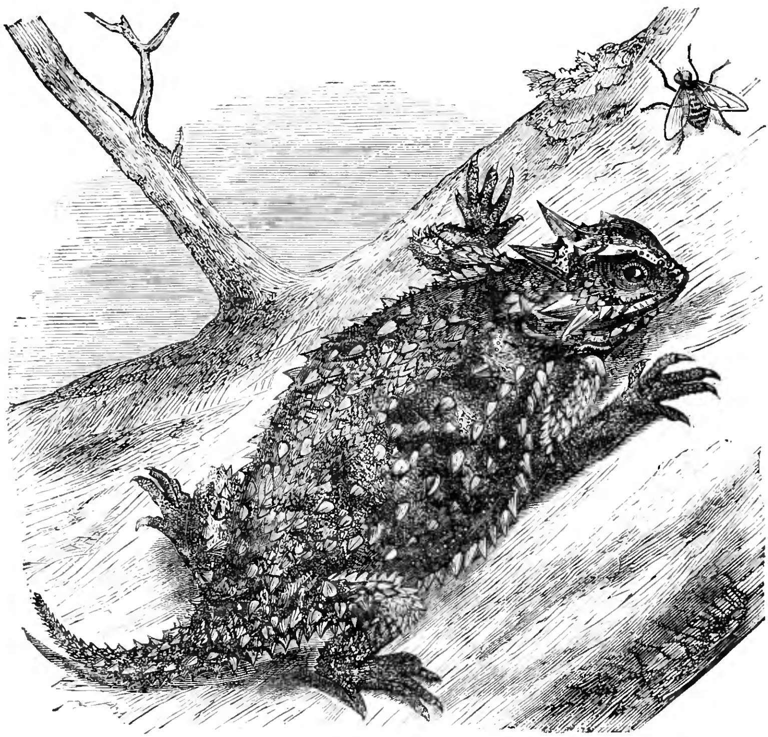
THE HORNED FROG.

By FRANK BUCKLAND.

IN July, 1872, a sensational paragraph went the rounds of the papers that a "horned frog" had arrived at the Zoological Gardens; so I went to see it, and here, kind reader, you have a portrait of this celebrated animal.

In the first place, any one can see that the little beast, though carrying horns, is not a frog at all, but a lizard. It rejoices in the name of the "Crowned Tapayaxin" (*Phrynosoma cornutum*), from φρυνος, a toad, and σωμα, a body. This is not a bad name when it is construed, for it really is very like a toad in general appearance. It belongs to a family of Saurian reptiles (*Agamidæ*), this species being widely distributed in Asia, Africa, Australia, and South America. Why Nature has made these little creatures so hideous, as some would call them—though I call nothing hideous—I do not know. The *Moloch horridus* of Australia is also covered with spines, and looks even more formidable than our friend the horned frog, and yet they are quite harmless, and will hurt nothing but insects. If the fly in the picture is not speedily off about his business, Mr. Horned Frog will snap him up before, as the Yankees say, "he knew what hurt him." Holland, the civil and obliging keeper at the reptile-house at the Zoological, took the horned frog out of his box, and, as he sat upon my arm, I made notes about him.

Imagine a large bug, about four inches long and two inches across, with a tapering tail, which he can cock up after the manner of a scorpion, or the beetle known as the "devil's coach-horse," and you have some idea of the "Crowned Tapayaxin." The body is very flat, though, I believe, he can blow himself out quite fat if he likes, like the frog in Æsop's fables trying to make himself as big as a cow; and he is covered all over with a number of spines, which are not unlike the spines on a blackthorn-bush. The edges of the flattened body are armed with a row of sharp prickles like the teeth of a saw; the head, which the little beast twists about in a Punch-like manner, is separated from the body by a short neck. Near the nape of the neck there are two sharp-pointed horns directed backward; the sides of the neck are armed with three or four shorter horns, so that the animal appears to have on a collar such as we see depicted upon the necks of wolf-hounds



The Horned Frog.

in Reidinger's splendid old German hunting pictures. The general color is like that of the toad, and he has a mottled belly, like that poor old toad about which so many "crammers" have been told relative to his being found buried in coal, stone, trees, etc.—antediluvian toads, "who swam about in the limpid streams wherein Adam bathed his sturdy limbs," etc. Toads, nevertheless, will stand a deal of burying; and so will horned frogs, for the individual whose likeness is now before you came by post all the way from Santiago, in Southern California. He was packed in a thin pasteboard box, and it is a wonder that he had not been smashed by the metal stamp-obliterators of the post officials.

By-the-way, curious things are sent me by post. Every week I receive fish of some kind or another by post: young salmon, young trout, young whitebait; also young pheasants, three-legged kittens, six-legged kittens, no-headed kittens; and they generally smell frightfully. The postman always knows my letters without reading the address. Sometimes live things are sent me by post. I lately received a scorpion, caught alive at Woolwich. He was packed in a jeweller's box, and when he arrived was poisonous enough to sting a mouse severely; and, once, some kind person killed a viper, and put him into a paper sweet-stuff box; but, during the journey, the scotched viper came to life, and had to be killed again by the postmaster-general, who wrote me an official note about it. I once heard of a pair of jack-boots being sent by parcels post. What next, I can't tell. Send what you like, my friends, only pay the postage, and, if you send vipers or scorpions, kill them first.

When at home, the habits of the horned frog are, I believe, very much the same as the toad's, lurking about stones, ruins, rocks, etc. Their spines, I believe, are given them for neither offence nor defence, but simply for the purpose of concealment from their enemies. The polar bear among the icebergs wears a coat as white as snow for concealment. It is exceedingly difficult to distinguish a sitting partridge when crouched down in a ploughed field. The tiger carries stripes like the jungle. The grouse is like the heather. In fact, most animals have coats given them to conceal them from their enemies, and it is more than probable that the spines of this little lizard serve for the same purpose.

I do not observe that in the so-called educational programme the subject of natural history is in any way introduced. This is, I think, a great mistake. Children and young people are naturally fond of animals, but they are too often brought up to kill and destroy any thing that looks, as they call it, ugly. I have known ladies scream, and even sometimes nearly faint, if they see an unfortunate spider, and then they go and kill the spider. Others are afraid of mice, frogs, and other harmless creatures. If these individuals had in their youth been taught how there was "evidence of the power, wisdom, and goodness of the Creator" in all created things, they would look upon these common ones with wonder and admiration, instead of being foolish enough to be frightened—or pretend to be frightened—at them.—*Leisure Hour.*

ON THE TRANSFUSION OF BLOOD.

By GUSTAVE LEMATTRE.

TRANSLATED FROM THE FRENCH, BY A. R. MACDONOUGH, ESQ.

IN all ages the most different opinions as to the seat and the principle of life have been expressed; yet, the systems bequeathed to us by the ancients on this subject contain a general belief, simple enough to be very widely shared, and seemingly well founded enough to endure for centuries. One fact of commonest observation—death resulting from hæmorrhage—gave rise to the notion that life dwells solely in the blood. Homer's heroes breathed out their souls with their blood; among the Hebrews, as among the Greeks, offering the sacrifice of a life, and shedding the blood of a victim, were equivalent expressions. On this point the religions of the West have consecrated the belief of all ages and all people; a verse in Leviticus thus sums it up: "The life of all flesh is in the blood."

From Galen to Harvey, men of science supposed that the heart only sends out the fluid of the blood from the centre to the surface. In their theories, the blood was incessantly formed and renewed within the liver, and was impelled by centrifugal force into the veins and arteries alike. Harvey first demonstrated that the blood returned in its course. "It moves," he said, "in the same circle, as the planets all describe the same orbit in moving through space." The idea of the transfusion of blood takes its starting-point from the discovery of Harvey. As soon as it was known that the blood can return to the heart, and be taken up again by the vessels, what was more natural than to seek to introduce it into a diseased body? Is not the blood still regarded as the sole principle of life, as it was in the early ages of medicine? And, since it can be transfused in kind, we shall be able to restore health, to heal disorders, perhaps, even to lengthen life. In a moment of pride the human mind believes it has penetrated the secret of life, and supposes that henceforward it will be its master. The most famous alchemists of the middle ages never surrendered themselves to hopes so wild. Besides, the sixteenth and seventeenth centuries saw the birth of so many discoveries in natural sciences, that nothing seemed impossible. The schools of medicine enter with feverish ardor on these questions, so full of promise; but, amid the light that bursts upon them, they often neglect that severe observation of facts which led to the discovery of the circulation. Physicians of that day trouble themselves very little with inquiries whether the ancient notions about the blood are true or false; they accept them without reserve, and publish them abroad with those forms of discussion and those obsolete principles which brought upon them the well-deserved ridicule of our satirists. Medicine and physiology in that era were treated under the form of philosophic argument, science and imagination were blended, and "reasoning banished reason." The history of transfusion, at its beginning, looks like an important but empirical discovery; new experience rests simply on scholastic discussions, the true mingles with the false, and, after the spectacle of a barren contest presented by detractors and enthusiasts, transfusion was proscribed, and doomed to oblivion; and it will be long before its recovery, for the true scientific method has not yet been found.

In the last half-century we have returned to the method of observation; nor is that method now, as it was in Harvey's time, the privilege of a few *savants ;* it has become the guide of all men of science in our day, and the real cause of scientific progress. Amid the general development of the sciences, transfusion has come up once more, transformed and widened; it will not satisfy the extravagant hopes indulged at first, but it will throw a broad light on the problem of health and disease. The principles on which this grand experience now rests are well settled—the functions of the blood have been clearly determined. We know that life dwells in every fragment of our being; the mass of nerves, the flesh of our muscles, the tissue of our glands, need the indispensable assistance of the blood, yet live by themselves. If general anatomy has followed out the work of Bichat, in studying the elements of dead Nature, physiology has realized Haller's conception, in analyzing the functions of these elements. Comparative study of animal and vegetable organization and the independent development of the tissues, after the evolution of the germ, has supplied general views upon the life of the parts; physiological dissection on the living animal, and particularly the mode in which poisons act, has completed the former results, and shown that each element in the organism has its individual activity. The experience of transfusion gains greater importance at this day, proportioned to the advanced state of science. Transfusion is not simply an operation practised on man; it finds its peculiar reason for existing as a process in scientific investigation. By it the properties of tissues and organs are analyzed, the independent life of the elements is once more made plain, and, when the secrets of the mechanism of our organization have thus been laid bare, transfusion is no longer an experimental remedy—it has become a process of reasoning.

At a time like our own, while the movement of minds is turning, with almost exclusive devotion, toward the justly-valued labors of Germany, it is not without interest to recall a course of discoveries peculiarly French. The history of transfusion in the nineteenth century, after the account of the fruitless efforts made in the seventeenth, has the advantage, besides, of allowing us to judge of the worth of methods by the nature of their results. These scientific triumphs of late date have hitherto been preserved only in special publications; but they are of too general an interest to be reserved for physiologists and physicians; they must enter into the wide domain of Science.

In the order of scientific facts a great discovery never remains isolated, but opens unknown horizons, and leads to useful applications, by the conquest of new principles. No one, nowadays, is ignorant that the labors of Ampère in electricity and magnetism created the telegraph. In Harvey's time, circulation was accepted, spite of protests by the faculty and the disciples of Galen; a genius like Descartes publishes it in his famous "Discourse on Method;" demonstration by experiment confirms the position of theory in every point; and the most important consequences immediately follow. They affect the knowledge of drugs and poisons, the anatomy of man, and the medical art that heals him. It was easily understood that medicinal and injurious substances will act more promptly if introduced directly into the vessels, and Fabricius, a doctor of Dantzic, infused purgative salts into the veins. Fracassati, a professor of anatomy at Pisa, injected alcohol, spirits of vitriol, oil of sulphur and of tartar. These experiments did not advance the healing art much, but they led to one important consequence, probably unlooked for by their authors: they were the commencement of a process which allows us to study the nature of poisons; and the history of poisoning afterward took a new direction.

To the physician and the anatomist the process of transfusion was directly and immediately useful. A century earlier, the illustrious Andreas Vesalius had created human anatomy; after the publication of Harvey's works, the arteries and veins were studied in preference. In the class-room where dissections are going on, it is out of the question to transfuse living blood; but, for the advantage of following the course and distribution of the vessels, it is useful to inject them with such colored matters as will solidify. The Dutch Frederic Ruysch is the leader in this advance. In the land of Rembrandt the art of harmonizing colors aims not merely to bring the human countenance to life again on canvas; the anatomist of Leyden so well understands the secret of injections that, by imparting color to the interior of the tissues, he will restore the semblance of life to inanimate bodies; when, near the end of his long career, Ruysch put to press in Amsterdam the remarkable book in which he describes the wonders of the anatomical museum of his native town, like an artist content with the perfection of his work, he exclaims, at the first page, "I have babies there that have been embalmed for twenty years; they are so rosy and fresh that you would say they are not dead, but asleep."

Ruysch's anatomical preparations, of which the secret is now lost, were contemporary with that marvellous experience, also founded on the discovery of Harvey—we mean transfusion of actual blood. About 1660 the notions in medicine of the ancients were strongly and persistently maintained, the blood more than ever believed to be the principle of life, and, with the knowledge of its circulation in the organism, comes the suggestion "to transfer blood from a young to an old person, from a healthy to a sick one, from cold to warm, from bold to timid people, from tamed to wild animals." But Galen's words are fully accepted; the theory of "animal spirits" rules unquestioned, and Descartes has given the system new vigor. That philosopher holds that there are in us two things—the spiritual life, comprising the soul, and the material life, formed by *spirits*, which he ingeniously compares to the restless particles of a wavering flame An unknown disciple of the great master, De Gurue, maintains the ideas of the new school in speaking of the transfusion of blood. "The blood of animals," he says, "containing a great quantity of *spirits*, cannot be mingled with that in the body of another animal of the same kind without fermentation, and cannot ferment without causing fever." For some persons, as Martin de la Martinière, the transfusion of blood is a barbarism, and those who practise it are "butchers and cannibals." Others think of it, with Eutyphronis, that it errs by oversetting traditions. This "practice," he says, "cannot be allowed, short of altering all ancient medicine." The partisans of bleeding, disciples of Guy Patin, thought that transfusion of blood would overwhelm the patient, and increase what should be taken away from him. The eclectics, in fine, believe that this operation brings its supporters and its opponents into agreement: the first, because it carries off corrupt blood; and the last, because, by the supply of new blood in place of that removed, the strength of the patient is not lessened.

All these theoretical discussions might have continued forever, had not Dr. Denis cut them short in 1667. He looks for the solution of most questions in physics by experience, not by argument. Zeno affirms that every thing in the world is immovable. Diogenes walks, for his only answer. Denis allows no other rule of action; he will not lose time in refuting the reasons of those who have written against the operation, but will oppose them by experience alone. The first two transfusions successfully practised on man are recorded in "a letter written to M. de Montmor, privy councillor to the king, and chief master of requests, by J. Denis, doctor of medicine, professor of philosophy and the mathematics." It is worth while to introduce, in few words, the eminent man to whom this work was addressed. M. de Montmor, a member and one of the founders of the French Academy, lived in the centre of scientific movement. Gassendi honored him with his friendship, and when that learned philosopher died, after many personal labors in the most varied branches of knowledge, De Montmor published a complete edition of his works. In the years preceding and following the foundation of the Academy of Sciences, before and after 1666, his house was a centre at which physicists and *savants* gathered every week to discuss the interesting questions of the day, and the society thus formed had its rules intended to aid the progress of science. A few years before, a Benedictine monk, Robert des Gabets, had preached a sermon there on transfusion of the blood. The king's councillor took interest in a discovery of which he foresaw the range, and gave the new experimenter the support of his influence.

"The first trial," Denis says, "was made on a young man, fifteen or sixteen years old. This youth was attacked by a slow fever, for which the doctors had bled him twenty times. He had become dull and sleepy, from the treatment, to the point of stupidity. Some little warmth was felt during the operation. Eight ounces of blood were taken from him, and arterial blood from the carotid of a lamb was immediately introduced by the same opening. He got up about ten o'clock, dined with excellent appetite, and went to sleep at four in the afternoon. He bled slightly from the nose."

This operation having succeeded, Denis tried a second, but more from curiosity than necessity this time. The author relates it himself as concisely as before. "The transfusion was effected upon a chair-porter, of vigorous constitution, forty-five years old. Ten ounces of blood were taken from him, and lamb's blood substituted. The man complained of no pain during the operation, and was delighted beyond measure with the new invention, which seemed to him very ingenious. When it was all over, he declared that he never felt better. Employment offering about noon, he carried a sedan as usual for the rest of the day. Next day he begged that no one but himself might be taken as the subject of new experiments."

Three years before, transfusion of blood had been practised by Lower in England, but only on dogs. Denis repeated with these animals the experiments he had made on men. These were varied in the most interesting ways. He not only transfused the blood of one animal into the veins of another; but, from the 8th to the 14th of March, in 1667, he caused the same blood to pass into three different dogs successively. Granting the correctness of the views then prevalent, he then realized the famous Pythagorean fable of the transmigration of souls. The experimenter was also bent on making his discoveries generally known, proposing to make trials in public, and, for this purpose, he fixed for the first day of his lectures "Saturday, the 19th of March, of the same year, at two in the afternoon, on the quay of the Augustins." History does not inform us whether Denis carried out his plan; but the *Journal des Savants* gives a tedious account of a controversy that broke out more fiercely. In this previous war of ideas, facts are neglected and forgotten, arguments are only dealt with, and they control opinions. Denis declared at the outset that he would depend solely on experiment; but, at the same time, with a contradiction explained by the tendencies of the times, he comes forth into the scientific arena with the usual weapons—he discusses. The works devoted to this warm contest are all inserted in the *Journal des Savants*;

and such pages, long ago forgotten, show into what extravagances the fancies of the so-called scientific mind may be betrayed. Reading them, we involuntarily repeat the poet's line:

"The learned fool outfools the fool untrained."

The absurd was carried to its farthest limits in the arguments of a master of arts of the Paris University, named G. Lamy. "Since the blood of a calf," he says, "is made up of many different particles fitted to nourish the different parts of the body, if this blood is thrown into a man's veins, what will become of the particles of blood intended by Nature to produce horns? The case is not like that of a calf's flesh used for food, because those particles that are unfit for man's nourishment are altered in the stomach by coction. In the next place, since the mind and habits usually follow the bodily temperament, there is danger lest the blood of a calf, transfused into a man's veins, may give him also the stupidity and brutal dispositions of that animal."

Lamy finds followers among the opponents of circulation, his argumentative deductions are connected and consequent, but his starting-point is arbitrary and wrong. It is true his adversaries' reasoning is to blame for the same fault, but it will be accepted, if for nothing else, because it is addressed to those innovators who follow Harvey. A fragment of one of Denis's letters, on the question of the transfusion of blood, is worth quoting: "In the practice of this operation we only copy Nature, which, for the support of the embryo, makes a constant transfusion of the mother's blood into the child through the umbilical cord. Applying transfusion is only feeding one's self in a shorter way than usual; that is, it is putting ready-made blood into the veins instead of taking aliment that will turn into blood after several changes. The blood of animals is better for men than men's own blood; the reason is, that men, being agitated by various passions, and irregular in the way of living, must have more impure blood than beasts, which are less subject to such disorders. Corrupted blood is never found in animals' veins, while some corruption is always noticed in men's blood, how healthy soever they may be, and even in that of little children, because, having been fed with their mother's blood and milk, they have sucked in corruption with their nourishment."

All these quotations are curious, though they express mere obsolete ideas, because they show how far from the mark scientific discussions may wander, if they rest only on argument. Once started on that road, transfusion of the blood could run no long career. It yielded in a singular way. An isolated fact was enough to cause its fall. One of Dr. Denis's patients went mad after undergoing the operation of transfusion. His adversaries seized this accident as a weapon, and, Denis not having a diploma from the University of Paris, they procured a condemnation of the new doctrine. Transfusion suffers the same fate as antimony, a century later. On the petition of the Faculty after decision by the Parliament, Du Châtelet, the deputy prosecutor, publishes an edict proscribing it in the name of the law. What was the real cause of the downfall of the system? That it rested on mistaken physiological ideas. The blood was still regarded as the sole principle of instinct, intellect, and life. The physician who practised transfusion could only defend it by hypotheses, and justify its employment by explanations and reasonings. The labors of our own time alone can give it lasting life; transfusion will revive two hundred years later to a new and vigorous existence, for it will rest on the best-established truths of physiology.

The light thrown by Harvey upon the knowledge of life did not give a complete account of the mechanism of our organization; the opening of an era of progress by grand discoveries awaited the coming of Lavoisier, at the close of the last century. General physiology was founded at that period, and the office and functions of the blood were soon learned by degrees and clearly settled. Between 1815 and 1830 the history of transfusion passes into a new phase. Atwood, Blundell, and Diffenbach, make it generally known by important works. In France two eminent *savants*, Prevost and Dumas, devote themselves to new researches, of which the "Annals of Chemistry," for 1821, preserve the record; but the transfusion of blood has made decisive steps only within the last twenty years, due particularly to the labors of a modern physiologist, Brown-Séquard. We shall sketch the bold and interesting experiments he employed in attacking and dealing so successfully with the most difficult problems of life; the history of physiology hardly presents a more exciting and instructive page. For its full comprehension, the nature and functions of the blood must first be explained.

As it circulates within the vessels, the blood is to be regarded as a fluid in which an innumerable quantity of colored corpuscles are floating. On account of their shape, these little bodies are called globules, and they are invisible without the aid of magnifiers; in fact, their diameter scarcely exceeds two ten-thousandths of an inch. The vehicle of these globules has the scientific name of *plasma;* the matters elaborated by the digestive apparatus, and the products of decomposition of the tissues, are the essential components of this liquid; albuminoid substances, analogous to white of egg, fats, sugars, salts of a mineral nature, appear in it under different forms, and constantly repair it; while the excretory ducts as constantly carry off from it those particles that become useless to life. The elements of our tissues have their nutrition kept up by a constant movement of supply and withdrawal, new molecules replace the old ones, and acts of assimilation and disassimilation find by turns in the plasma their point of origin and completion. The blood-globule is nourished just as the constituent parts of the glands, the muscles, the nerves, and the brain are, and the only difference to be noted in this respect is that the process takes place within the very plasma itself, while the other elements are parted from it by the thin membrane of the capillary vessels. The globule has so distinct an existence of its own, that the chemical principles composing it are not found in its plasmatic medium. The various reactions shown by these little bodies in presence of chemical agents lead to the belief that they are found in the plasma in all stages of their development; their dimensions are not the same at the different ages of our organization. When the human germ is in process of evolution, the first lineaments of the vessels are traced in the depths of the tissues, and the heart begins to beat; the sanguine fluid is then formed, but the globules it contains are much larger than they will be after birth and in adult age. During this embryonic life the newly-formed blood does not communicate with the vessels in the maternal system—the two circulations being juxtaposed, but independent; there is not, as the belief in the seventeenth century was, a natural transfusion of the mother's blood into that of the embryo, because the solid particles or globules of each circulate and remain in each of unequal size. The study of the blood-elements in the animal series is interesting; they are found larger in fish and reptiles than in birds and mammals, whose vital activity depends on other powers. In spite of the resemblances presented by the sanguine fluid in these different groups, the blood of a fish could not vivify the body of a reptile for any length of time, nor could a bird's blood be substituted for a mammal's. The animal species whose nutritive fluid is mutually transfused must be closely related as regards natural classification: the globule which emigrates into a foreign medium can only become acclimated there in so far as its conditions of existence are not profoundly modified.

The blood-globule not only lives its individual life within the plasma, but it needs, in order to complete its function of vivifying every part of the body, to absorb oxygen from the air, and it then takes that bright vermilion color which is characteristic. The phenomenon of that new coloring is an essentially vital act, a chemical reaction taking place between two bodies, one solid, the other gaseous. Precisely the same thing happens with the commonest copper coin placed in contact with the air—it absorbs a gas, and its surface is soon covered by a colored product. In the lower animals that have copper in their blood, the vine parasite, for instance, the globules take a bluish color on contact with air. The same phenomenon is remarked in the vegetable kingdom; indigo, which is white in the plant, turns blue when exposed to the air, and many coloring substances are formed in the same way. The red globule contains iron, and the chemical action taking place in it may perhaps be compared to the formation of rust. Exposed to atmospheric air, it takes a dark-red color, while continuing crimson in the arteries. Deep in the tissues, the oxygen of the globule is disengaged; combustion occurs with production of heat, but without flame, as is the case with starch; the blood becomes venous and darkish; then, sent back to the vessels of the lungs, it resumes its arterial coloring with the vital air.

In connection with the history of transfusion it is important to know the quantity of blood contained in the organism; this has been estimated, by approximation, and attempts have been made to ascertain it in the human subject. A criminal named Langguht was beheaded at Munich, July 7, 1855: about eleven pounds of blood were collected by Professor Bischoff. The weight of the body was one hundred and forty pounds; the proportion of blood being one thirteenth. This estimate has been accepted by many physiologists, although some believe it is too low. Nothing certain can be arrived at on the subject; does not the quantity of blood in our bodies vary according to very many conditions? It does not remain the same before and after eating, while asleep and while awake. In hibernating animals, as the marmot, or the dormouse, if the weight of the body decreases one-fourth in the period of rest, that of the blood is considerably reduced. The same fact is observed in fasting, the globules losing size and color. Disease produces a similar result, and nothing is more correct than the commonly-held opinion that "grief and privation consume the blood." The precise ideas we now have of the nature of this fluid have largely corrected Broussais's errors, and more than one practitioner in our day would assent to Galen's precept, that "in bleeding the measure of a half-pint must not be exceeded, and in any case the veins of a patient under fourteen must be spared." The study of transfusion proves the importance of the sanguine fluid better than any general considerations. We shall presently point out those well-settled cases in which the physician may practise the operation; but the reader is now prepared to understand how each part of the body derives supplies of life from contact with this fluid. The functions of the tissues will be briefly analyzed in turn; glands, muscles, nerves, spinal marrow, brain, will display their special activity. We shall see how the blood-globules feed singly all these flames, which blend and mingle to light the torch of life.

Secretion takes place by means of the glandular tissue. This function is connected with nutrition, and in the lower products of organized matter is identical with it. The simplest vegetables, and the lowest animals, are instances of this blending. In the higher degrees of animated beings, the elements of secretion separate and maintain their own life, finding in the surrounding air or the moistening fluids the conditions of their nourishment and work. In perfect organizations the glandular tissue becomes more complex, receiving nerves and vessels; natural transfusion of the blood begins to play an important part. The size and secreting energy of the glands are directly related to the quantity of blood passing through them; thus the kidneys, incessantly at work, have a highly-developed arterial system. The blood is renewed in the glands as in all the tissues, and the dilatable walls of the vessels admit it in different proportions, according to the state of rest or activity of the organ. In this case, as in all others, particular facts are merely the expression of a more general law. The flow of blood increases when a stimulant exerts its action. When a glandular element acts with energy, it produces a high degree of fulness of blood in all the neighboring parts; and physiologists have thoroughly proved this fact in the case of the salivary glands of animals. In a state of rest, the congestion of these glands is slight, the blood dark in the veins issuing from them; the organ is then gaining growth. When the animal taken for experiment emits saliva under the influence of artificial stimulus, the glands, on the contrary, fill with blood, the vessels grow turgid, and take a high vermilion color. Thus variations in the supply of blood always correspond with degrees in secreting activity, and secretion ceases when the blood no longer comes to the glands. If the vessels of the liver are obliterated, bile ceases to be formed; if the arteries of the kidneys are compressed, secretion by those organs stops. The statement of the conditions of the problem suffices to suggest its solution; the blood is a medium whence the glands draw the principles of their growth and functions; the circulation of the sanguine fluid within the glandular tissue is a true transfusion kept up incessantly by the heart, and which only artificial transfusion can be a substitute for.

Nutrition and secretion by their constant work keep up the organized state of vegetable and animal matter. Plants possess only these two functions, and we may almost say the same thing as to animals while asleep; but these are not the only functions assigned to the waking animal, which comes into relations with the external world, through motion, sensibility, and intelligence. The muscular fibre, the special organ of motion, has its activity, independent of the nervous system; local transfusion confirms this scientific view, which now rests on manifold proofs. Like the secreting element, the muscular fibre is distinct in some lower animals; the microscope detects it in that state in the transparent body of the infusoria called vorticelli. In the higher degrees of the animal series this fibre is found in connection with nerves and vessels, and, though it enjoys an excitability peculiar to itself, it receives an impulse to movement from the motor nerve. The contact of the muscular fibre with blood-vessels is very close; but the chemical composition of the blood that moistens it varies according to the quantity of work yielded; thus it is indispensable that new fluid should be constantly transfused into the net-work of veins in the muscle. If the motor fibre is at rest, the blood passing through it is scarcely modified. If it is in a state of half contraction, the oxygen decreases in the blood, and the carbonic acid increases. If contraction is evident and powerful, combustion and production of carbonic acid are then at their maximum; the blood of the veins is extremely dark—the muscle is growing and acting both at once.

These are modifications which the muscular fibre undergoes during life. When death occurs and the blood is no longer renewed, muscular irritability disappears after a time which varies, and in an order which is fixed. The left ventricle of the heart first ceases to be excitable, then the intestine, the bladder, the iris, the muscles of animal life; the right auricle of the heart dies last; it is the *ultimum moriens.* The organic matter making up what is called the flesh decomposes, and is thenceforth governed entirely by chemical forces. The juices it contains become acid, coagulations take place, and then comes on the condition called by the name of corpse-like rigidity. Thus changed, the muscle is no longer excitable; but, if it is subjected at this instant to a current of arterial blood, it immediately revives, rigidity disappears, the muscle-fluids regain their former composition, and the individual activity of the fibre displays itself anew. Experiments establishing this great fact have been tried, not only on animals, but also on man even, and under circumstances that present some difficulty in the recital; the dramatic side of the subject is vivid enough to allow of a strictly scientific narration by itself. We will relate the transfusions performed by Brown-Séquard on two persons beheaded at Paris in June and July, 1851.

The first experiment was tried on a man aged twenty. He was beheaded at eight o'clock in the morning; eleven hours later all trace of irritability had disappeared from most of the muscles of the body. Injection into the muscles was begun at ten minutes past nine in the evening; the quantity of blood (which the operator took from his own veins) was enough for a limited part of the body; he therefore confined his experiment to the hand. Injection was made by the artery in which the pulse is usually sought, a little above the wrist, and, of course, in the direction of the fingers; it was urged at first quite fast, then slowly. The blood which went in bright colored, passed out dark from the vein, as is the case in life. The operation continued thirty-five minutes, and, ten minutes after that time, irritability had returned; a movement in the muscles of the hand could be artificially excited.

With the second subject, injection of the blood of a healthy dog was made; the blood had been first deprived of its coagulable matter, and beaten up in the air; there was about a pound of it. The subject was a strong man, forty years old. Death had occurred at eight o'clock in the morning; at twenty-five minutes past ten in the evening rigidity was complete, without a trace of contractility under the influence of stimulus. The arm was amputated, and at twenty minutes past eleven Brown-Séquard effected injection by the brachial artery. The skin at first took a livid color, but very soon the roots of the hair grew erect, giving the effect of goose-flesh, as it is called. This artificial circulation was so entirely successful that the veins on the back of the hand presented a bluish tinge; a beating like that of the pulse lifted the main artery of the wrist, muscular life revived; the fingers soon lost their stiffness, and at forty-five minutes after eleven irritability had reappeared in the muscles of the arm; it was still perceptible at four in the morning of the next day.

Experiment has never more clearly proved that the blood is essential to muscular life. In the limbs of these subjects the organic matter was decomposed, and all vital manifestation had become impossible. A flow of blood throughout them was effected, and at once this muscular flesh becomes contractile again; the special activity of the motor fibre is reanimated, and its functions performed as in life. It will, of course, be objected that the muscular element receives its conditions of activity from the motor nerves, and that the blood-globules only vivified it indirectly, by restoring excitability to the nerves; but has not the mode of action of *curare* proved that the life of the muscle persisted after the physiological death of the nerve? If the arteries of the lower limbs of a living animal are tightened by a compress, the withdrawal of the blood will in the same way cause the properties of the nerves to disappear before those of the muscles; an artificial stimulus, directly applied to the muscular fibre, will still produce movement, after nervous excitability has ceased to exist. If you then remove the compress, you set the flow of the blood free, and the peculiar action of the motor nerves is completely restored. Thus the life of the nervous element itself has been successively extinguished and revived; after that the inciting stimulus from the train of the spinal marrow may be transmitted through the medium of this conductor, which possesses a real autonomy.

The nerves of general sensation, like the nerves of motion, demand the contact of arterial blood. The anatomical distribution of these nerve-elements does not allow the action of the sanguine fluid upon them to be studied as to their surfaces; yet sensation constitutes too well-defined a function not to be the object of experimental analysis, as motion is; this analysis is made by the help of transfusion upon the spinal marrow, the organ that receives all impressions made on the skin. Physiologists have used an ingenious process to prevent the blood from moistening this nervous centre: they inject a liquid filled with an inert powder into the vessels, in a uniform direction; the capillary parts of the circulation are soon clogged, the spinal marrow ceases to be in relations with the blood, and ceases at once to receive impressions from the skin. The same phenomenon is observed when all the blood-vessels that go from the main artery of the body to this nervous centre are artificially destroyed; the return of sensation takes place only when arterial blood is restored to the spinal cord. This fact is also proved by the transfusion of new blood into the veins of an animal that has yielded to a hæmorrhage. Again, another experiment, made in the following way, furnishes a proof of it. Two dogs were submitted to the section of the nervous centre which contains the *vital knot*, occasioning death. The appearance of death was produced as soon as the starting-point of the respiratory nerves was deeply injured. By slow degrees the nervous tissues lose their properties, and, before they are entirely extinct, the spinal cords of the two animals are exposed. One is subjected to the action of oxygen gas, and its sensibility increases; the other is influenced by hydrogen gas, and its sensibility remains unchanged. These facts show with absolute certainty that the nervous centres find their conditions of activity in the oxygen of the blood, or, to speak more precisely, the oxygen of the blood-globule.

The brain, the organ of the highest manifestations of life, performs its action like the spinal cord, and an elaborate net-work of blood-vessels distributes the nutritive fluid throughout all its parts. Yet the mass of the brain does not keep its functional activity constantly at work. The whole organism rests after the day's labor; the brain, when not waking, preserves only its life of nutrition; therefore the religions of ancient Greece, not without reason, regarded Sleep as the brother of Death. The quantity of blood transfused into that organ during these two conditions, so different, of sleep and wakefulness, is not the same. Dr. Pierquin had the opportunity of making observations upon a woman in whom disease had destroyed a large part of the bones of the skull, and deprived the brain of its membranous covering; the nerve-mass, quite exposed, shone with that brilliant lustre observed in all living tissue. While at rest in sleep, the substance of the brain was pink, almost pale; it was depressed, not protruding beyond its bony case. At once, when all the organs were quiet, the patient uttered a few words in a low voice; she was dreaming, and in a few seconds the appearance of the brain completely changed; the nerve-mass was lifted, and prominent externally; the blood-vessels, grown turgid, were doubled in size; the whitish tinge no longer prevails; the eye sees an intensely red surface. The tide of blood increases or lessens in its flow, according to the vividness of the dream. When the whole organism returns to quiet, the lively colors of the infused blood fade away by degrees, and the former paleness of the organ is observed again. The succession of these phenomena permitted the conclusion that increasing action of the cerebral cells attracts a considerable quantity of blood to them.

The general circulation in the brain is weak during sleep; in fainting it suffers complete suppression, and every one must have noticed the effects that result in this organ from the abstraction of blood. The least emotion, the smell of a flower, can bring on impressions that react on the heart, and for a moment suspend its movements; the blood then ceases to stimulate the brain, and paleness of the face indicates the bloodlessness of the deeper parts. The organism no longer puts forth that outward activity which is peculiar to life; it droops, no intellectual manifestations occur, no impressions from light or sound are felt; but let a current of cool, fresh air touch the face, and life revives, the heart resumes it movements, color comes to the cheeks, and the phenomena of intellect and sensation reappear in the inverse order of their cessation. The English surgeon, Astley Cooper, produced similar phenomena in dogs by compressing the arteries of the brain at the neck; the animal fell into utter insensibility, and seemed to die. On suspending compression, cerebral life immediately returned; yet this was but an imperfect representation of what takes place in fainting. It was reserved for one of our own physiologists to go more deeply into the mechanism of the phenomenon. To bring life back again for a moment to a head severed from the body, and to restore it by the arterial blood, this was the problem which Brown-Séquard proposed and solved. The details of this memorable experiment were these: A dog is beheaded, and the head, still warm, separated from the trunk at the junction between the neck and chest. The evidences of life disappear by degrees, the eye losing its expression last. An electric current sent through the remaining part of the spinal cord no longer excites any contractions, the respiratory movements of the nostrils and lips cease entirely. After ten minutes have elapsed, Brown-Séquard adjusts to the four arteries of the head an arrangement of tubes communicating with blood deprived of its coagulable part, and charged with oxygen. By the help of artificial mechanism, imitating the action of the heart, the experimenter makes the blood circulate throughout the brain and spinal cord. A very few moments pass before irregular quiverings give life to the face, growing more decided, and at length movements reappear in all the muscles, and the eyes resume motion. "All these movements," says Brown-Séquard, "seem directed by the will." The experiment was continued for a quarter of an hour, and during all that time the vital manifestations and the appearance of their being voluntary continued. They soon ceased after the injection was stopped, and then followed the group of phenomena observed in dying, the pupil contracted and again dilated, and the last effort of life was a strong convulsion of all the facial muscles.

The naturalist experiences the strongest emotions at the sight of so extraordinary a spectacle. The physician now understands the necessity of contact between arterialized blood and the matter of the brain. He knows why a reclining position is proper in cases of fainting, giving easy access for the vivifying fluid to the brain. He knows that by throwing water on the face he will act upon the nervous centres, reanimate the movements of the heart, and cause circulation of blood in the mass of the brain. The philosopher asks himself one of those questions which are as old as the world, and more than ever of present interest, since the animated discussions of Barthez and Gabanis: Does or does not organized matter engender the phenomena which it manifests? A grave problem, which Claude Bernard, in his admirable "Report on the Progress of Physiology," seems to us to have solved. That *savant* holds that the brain of the animal subjected to the experiment of transfusion of the blood acts like a complicated piece of mechanism upon the restoration of the blood belonging to it: the cerebral organ is only the instrument of the intellect, and the human machine marks life, as a clock marks time.

A physiological dissection, like that which transfusion of blood may be said, in some sort, to perform upon the glandular, nervous, and muscular systems, how complete soever it may be, has no value, unless the results of the analysis are combined; the experimental cutting up of the human body ought to end by recomposing the whole of it. That is the mode of procedure in the physical sciences. The colorless beam of white light is separated through the prism as it is by the drops of water that form the rainbow, and after passing through the glass it spreads into a wonderful gathering of colored rays. Each ray is studied in its properties, calorific, chemic, or luminous; then, when the work of analysis is ended, another prism directs all these rays in an inverse course toward convergence and the beam of colorless light is re-formed. It is so with the organism and its constituent parts. The individual life of the glands, the muscles, the nerves, the brain, is demonstrated by the aid of local transfusion, and the synthesis of the living being is accomplished at once by general transfusion. The blood coming from the heart is distributed into all parts of the body, no longer confined by art in a fixed space; thus the partial lives of the tissues and organs are simultaneously renewed, and the life of the individual becomes an admirable collective unity.

These important results, which the physiologist regards from the high point of view of theory, the physician meets on practical ground and in his patient's presence. And clinical triumphs have confirmed scientific views, which find their reasonable explanation partly in our knowledge of the normal life of the elements, partly in the morbid changes they are subject to. Transfusion of blood has sometimes served as an heroic remedy for arterial hæmorrhages, and losses of blood occurring after confinement. In these situations there is no injury to the elements of the nervous tissues, the glands and muscles; thus the supply of new blood restores life to them; it is replenishing a lamp, with its machinery all in order. When, on the contrary, the glands, muscles, and nerves, are changed in the first place, and the injury to the blood is the consequence of alteration in the tissues, instead of being its cause, transfusion cannot be as serviceable; it is almost always powerless; and, to repeat our comparison, the process is like pouring oil into a lamp more or less out of order in its inner construction.

Transfusion is not only employed to replace blood lost by a patient, but used also to substitute pure for vitiated blood. It is successfully applied to resist poisoning by carbonic oxide. This gas, formed by the combustion of charcoal and the oxygen of air, is a powerful poison. Breathed in moderate quantity, it induces death by well-defined action; the carbonic oxide, acting on the blood-globules, displaces their oxygen, and forms a stable combination with them, which is inert as regards vital properties. The constituent elements of the organs soon cease to act, and they die as they do after arterial hæmorrhage. For some hours, immediately after the poisoning, the blood-globules only are concerned, the other tissues remaining untouched; it will be enough, then, to restore a healthy state, to empty the vascular system, and replace the poisoned blood by new blood, and life will revive. Thus the history of transfusion once more proves that triumphs in the healing art may find their starting-point in the physiologist's table, as advances in industrial art often originate in the chemist's alembic.

In the centuries regarded as a whole, the epoch of Harvey and our own seem to belong to a similar period. The demonstration by physiology of the individual life of the parts, and the practical applications of transfusion, are wholly modern, as the circulation of the blood itself is. In ancient days the general belief was, that the life dwells in the blood, andyet some ancients seem to have had a suspicion that the elements of the organization live of themselves, and that, perhaps, the blood has a movement of circulation. Yet the ancients observed the life of the parts only in their outward forms. It is as a child studies the works of a watch: give it to him, and he is satisfied to hear it tick; open it, and he follows with his eye the movement of the wheels, but does not go further than to note appearances. Progress comes with age, and the child, seeing the same watch when he is a grown man, asks why and how it goes; taught by experience, by dint of perseverance and labor, he takes off and replaces every wheel, gains a precise idea of the mechanism of each part, and the arrangement of the whole is then clearly understood. Men of science in our times have studied the human machine so: the life of the parts has not only been observed, but traced and detected in its most secret machinery. Transfusion of blood, so useful in this respect, never acquired any true scientific importance in the seventeenth century. At first it appears as a universal panacea, aiming at the mastery of life, and triumph over disease itself. We have seen how the mere imaginings of that idle dream passed away. In our day the true method, the method of observation, is rightly honored, and scientific questions, no longer agitated with mere parade of eloquence, are modestly studied by their facts in the seclusion of laboratories. Transfusion again comes up, but not with its old extravagant pretensions; it no longer aspires to give universal, indefinite life. Reduced to the simple duty of a scientific process, it unveils the most mysterious secrets of the organization; it throws light upon the life of the parts; it demonstrates that each element in the organism lives of itself, and finds in the blood the conditions required for its action.—*Revue des Deux Mondes.*

SCIENCE AND OUR EDUCATIONAL SYSTEM.[1]

By F. A. P. BARNARD, LL. D.,

PRESIDENT OF COLUMBIA COLLEGE.

MR. PRESIDENT: I am expected to deal, this evening, with a theme which, under the actual circumstances, it is somewhat difficult to handle. The degree to which our systems of education tend to foster or discourage original investigation into the truths of Nature is a topic which might better befit an assembly more gravely disposed than the present. *Dulce est desipere in loco*—it is pleasant to put on the cap and bells when circumstances favor, says Horace, and he says quite truly; but he does not say, *difficile est sapere inter pocula*—it is hard to imitate the solemnity of Minerva's bird, when champagne is on the board, as I think he ought to have said, and as he would, perhaps, have said if prosody had allowed, and which would have been equally true. I shall not aim at such an imitation. I do not mean to be didactic if I can help it. If I am so, I trust you will be indulgent.

I say, then, that our long-established and time-honored system of liberal education—and when I speak of the system I mean the whole system, embracing not only the colleges, but the tributary schools of the lower grade as well—does not tend to form original investigators of Nature's truths; and the reason that it does not is, that it inverts the natural order of proceeding in the business of mental culture, and fails to stimulate in season the powers of observation. And when I say this, I must not be charged with treason to my craft—at least, not with treason spoken for the first time here—for I have uttered the same sentiment more than once before in the solemn assemblies of the craft itself.

I suppose, Mr. President, that at a very early period of your life you may have devoted, like so many other juvenile citizens, a portion of your otherwise unemployed time to experiments in horticulture. In planting leguminous seeds you could not have failed to observe that the young plants come up with their cotyledons on their heads. If, in pondering this phenomenon, you arrived at the same conclusion that I did, you must have believed that Nature had made a mistake, and so have pulled up your plants and replanted them upside down. Men and women are but children of a larger growth. They see the

[1] Address at the Tyndall Banquet.

tender intellect shooting up in like manner, with the perceptive faculties all alive at top; and they, too, seem to think that Nature has made a mistake, and so they treat the mind as the child treats his bean-plant, and turn it upside down to make it grow better. They bury the promising young buds deep in a musty mould formed of the decay of centuries, under the delusion that out of such *débris* they may gather some wholesome nourishment; when we know all that they want is the light and warmth of the sun to stimulate them, and the free air of heaven in which to unfold themselves. What heartless cruelty pursues the little child-martyr every day and all the day long, at home or at school alike; in this place bidden to mind his book and not to look out of the window—in that, told to hold his tongue and to remember that children must not ask questions! A lash from a whalebone-switch upon the tender little fingers too eagerly outstretched could not sting more keenly, or be felt with a sharper sense of wrong, than such a rebuke coming across the no less eagerly extended tentacles of the dawning and inquiring intellect.

Now, a system of education founded on a principle like this is not going to fit men to engage successfully in that hazardous game of life in which, in Prof. Huxley's beautiful simile, we are all of us represented as playing with an unseen antagonist, who enforces against us relentlessly every minutest rule of the game, whether known to us or not. Still less can it fit them to bring to light new rules of this difficult game, never yet detected by any human intelligence. Yet it is precisely of this kind of men that the world has present need. For, grand as are the triumphs of scientific investigation already achieved, it is impossible to doubt that there are still grander yet behind to reward the zealous laborers of the time to come. I know that it sometimes seems to us otherwise; I know that the very grandeur of the achievements of the past makes us sometimes doubtful of the future; for it is generally true that the portals of Nature's secret chambers, yet unexplored, are only dimly discernible before they are unlocked.

I remember a time—it is now long gone by—when this skeptical feeling as to the possibilities of large scientific progress in the time to come was extremely prevalent—so prevalent that a learned professor of a neighboring college thought it worth his while to combat, in an energetic public address, the discouraging notion that Nature has no longer any important secrets to yield. Subsequent history has magnificently corroborated his argument. For that was a time when, as yet, no Faraday had drawn a living spark from the lifeless magnet; no Daniell, or Grove, or Bunsen, had given us an enduring source of electro-dynamic power; no Ohm had taught us how to measure such a power when obtained; no Bessel had detected the parallaxes of the fixed stars; no Adams or Leverrier had thrown his grapple into space, and felt the influence of an unseen planet trembling, to use the beautiful language of Herschel, along the delicate line of his analysis; no Draper, or Daguerre, or Talbot, had revealed the wonders of actinism; no Mayer or Joule had laid a sure foundation for the grand doctrine of the conservation of force; no Carpenter had unravelled the intricacies of nervous physiology, or analyzed the relations of mind and brain; no Agassiz had ridden down the Alps on the backs of the glaciers and proved their steady flow; no Darwin had lifted the veil from the mysteries of organic development; no Schiaparelli or Newton had put the harness of universal gravitation upon the wayward movements of the shooting-stars; no Mallet had presented an intelligible theory of volcanic flames and of the earth's convulsive tremors; no Kirchhoff had furnished a key to the intimate constitution of celestial bodies or a gauge of stellar drift; no Huggins, or Secchi, or Young, had applied the key thus presented to enter the secret chambers of the sun, the comets, the fixed stars, and the nebulæ; no Stokes had made the darkness visible which lies beyond the violet; no Tyndall had done the same for the darkness beyond the red, or had measured the heat-absorbing powers of aëriform bodies, or shown how the tremors of the ether shake asunder the elements of vapors. In short, that period of presumed scientific omniscience seems now, as we look back to it, but the faint dawning of a day of glorious discovery, which we dare not, even yet, pronounce to be approaching its meridian.

How much of all this has been due to our system of education? Among the great promoters of scientific progress before or since, how large is the number who may, in strict propriety, be said to have educated themselves? Take, for illustration, such familiar names as those of William Herschel, and Franklin, and Rumford, and Rittenhouse, and Davy, and Faraday, and Henry. Is it not evident that Nature herself, to those who will follow her teachings, is a better guide to the study of her own phenomena than all the training of our schools? And is not this because Nature invariably begins with the training of the observing faculties? Is it not because the ample page which she spreads out before the learner is written all over, not with words, but with substantial realities? Is it not because her lessons reach beyond the simple understanding and impress the immediate intuition?—that what she furnishes is something better than barren information passively received — it is positive knowledge actively gathered?

If, then, in the future we would fit man properly to cultivate Nature, and not leave scientific research, as, to a great extent, we have done heretofore, to the hazard of chance, we must cultivate her own processes. Our earliest teachings must be things and not words. The objects first presented to the tender mind must be such as address the senses, and such as it can grasp. Store it first abundantly with the material of thought, and the process of thinking will be spontaneous and easy.

This is not to depreciate the value of other subjects or of other modes of culture. It is only to refer them to their proper place. Grammar, philology, logic, human history, *belles-lettres*, philosophy—all these things will be seized with avidity and pursued with pleasure by a mind judiciously prepared to receive them. On this point we shall do well to learn, and I believe we are beginning to learn something, from contemporary peoples upon the Continent of Europe. Object-teaching is beginning to be introduced, if only sparingly, into our primary schools. It should be so introduced universally. And in all our schools, but especially in those in which the foundation is laid of what is called a liberal education, the knowledge of visible things should be made to precede the study of the artificial structure of language, and the intricacies of grammatical rules and forms.

The knowledge of visible things—I repeat these words that I may emphasize them, and, when I repeat them, observe that I mean *knowledge* of visible things, and not information about them—knowledge acquired by the learner's own conscious efforts, not crammed into his mind in set forms of words out of books. Our methods of education manifest a strong tendency in these modern times to degenerate in such a sort of cramming. Forty years ago, the printed helps to learning, now supplied to the young men of our colleges in so lavish profusion, were almost unknown; and teachers lent about as little aid, at least during the earlier years, as books. What the student learned then he learned for himself by positive hard labor. Now we have made the task so easy, we have built so many royal roads to learning in all its departments, that it may be well doubted if the young men of our day, with all their helps, acquire as much as those of that earlier period acquired without them.

The moral of this experience is that mental culture is not secured by pouring information into passive recipients; it comes from stimulating the mind to gather knowledge for itself. When our systems of education shall have been remodelled from top to bottom, with due attention to this principle, then, if we have minds among us which are capable of pursuing Nature into her yet uncaptured strongholds, we shall find them out and set them at their work. Then neither "mute inglorious Miltons" on the one hand, nor on the other silent, unsuspected Keplers, nor Newtons "guiltless" of universal gravitation, shall live unconscious of their powers, or die and make no sign. Then the progress of science will no longer be dependent, as in the past it has been to so great a degree, on the chance struggles of genius rebelling against circumstances, such as have given us a Herschel, a Franklin, a Hugh Miller, or a Henry; nor will the world be any more astonished to see the most brilliant of the triumphs of the intellect achieved by men who have cloven their own way to the forefront, in defiance of all its educational traditions; as it has seen in the case of a Rumford, a Davy, a Faraday, and a Tyndall.

THE TROGLODYTES, OR CAVE-DWELLERS OF FRANCE.[1]

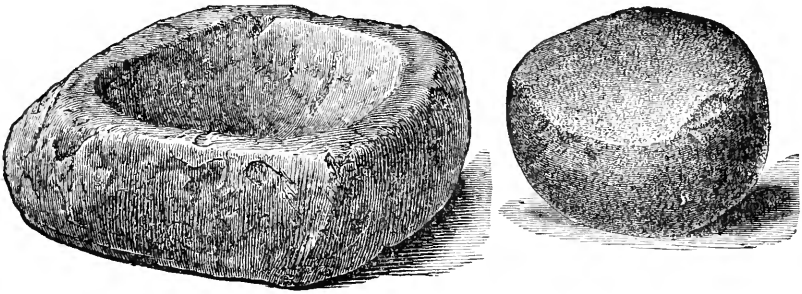
By PAUL BROCA.

TRANSLATED FROM THE FRENCH, BY J. FITZGERALD, A. M.

1. *Their Manner of Life.*

IN the southwest of France, at no great distance from the river Vézère, are situated the caves which were inhabited by a race of Troglodytes toward the close of the Quaternary geological period. The openings of these caves faced all points of the compass, except the north. They were inhabited throughout the entire year, as is shown by the remnants still found there of young reindeer, in every stage of development. From the teeth, bones, and budding horns of these animals, we can determine their age, and the season of the year when they were killed; and the evidence of this kind furnished us by the contents of the caves shows that the Troglodytes had a fixed abode; or, in other words, that they were not nomadic in their habits.

Fig. 1.



Pestle and Mortar.

When the inhabitants of the caves went fishing or hunting, they closed up the door-ways to exclude beasts of prey. Only one bone has been found, and that at La Madelaine, which bears any tokens of having been gnawed by a wild beast. It shows the marks of a hyena's teeth, the animal having in some way gained admittance to the cave. Hyenas were scarce in the time of our Troglodytes, but wolves and foxes abounded; and we should find the marks of their teeth upon the bones strewed about in the caves, were it not that the inhabitants

[1] This article is a part of the elaborate address before the French Association for the Advancement of Science, by M. Paul Broca, one of the most eminent anthropologists of Europe.

kept their dwellings carefully shut against such intruders. But what were the means employed to keep them out? In sepulchral caves we find the entrance closed by a stone slab; but a dwelling-place would require a door more easily opened and shut than that. Besides, we find no trace whatsoever of stone doors, and therefore it is supposed that the Troglodytes barricaded their door-ways with hurdles.

They lived by the chase, and by fishing. But, did they use vegetable food? We cannot find any evidence that they did. There have been discovered, it is true, in the caves of Les Eyzies, Laugerie-Basse, and La Madelaine, a number of stones—granite, freestone and quartzite—worn round and smooth by rubbing, which exhibit on one side a pretty regular depression, in the form of a cupule, and not unlike a small mortar (Fig. 1). Some have supposed that this cupule might have been intended to receive the end of a piece of dry wood, which would then be whirled between the hands to produce fire, according to the well-known process in use among the ancient Aryans, and among some savage tribes of the present day. But the depression is too shallow, considering its diameter, to have served such a purpose, and hence we take these stones to have been mortars, while other round stones, of dimensions answering to the cupules, would serve as pestles. Hence came the supposition that the Troglodytes brayed grain for food: but every thing goes to show that they were unacquainted with agriculture. It is far more probable that they used the mortars to pound fish, or to grind pigments.

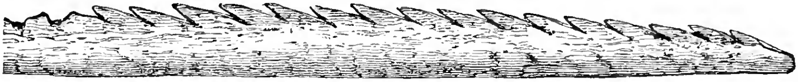
Their chief occupation and their principal resource was the chase. The remnants of bones accumulated in the soil forming the floor of the caves, show that they hunted animals of every size, from the little bird to the mammoth. That old giant of the early Quaternary period still survived, but had now become rare. For a long time it was supposed that the mammoth became extinct about the middle of that period; and when it was announced that several teeth of that animal and sundry pieces of wrought ivory had been discovered in the most recent Troglodytic stations of the Vézère, many persons were of opinion that these remains must have come down from an earlier period, and been gathered by our Troglodytes, just as the inhabitants of Siberia do at present. But it must be remembered that the carcasses of mammoths found in Siberia have been preserved by the extreme cold, and consequently their flesh and ivory are still fresh, whereas, *fossil* ivory is so cracked and foliated as to be useless for the purposes of art. Now, the climate of France in the Reindeer Age, though still frigid, had long ceased to be glacial; and, even though the men of that period had been accustomed to dig the earth—and they were not—the fossil ivory they might have found would have been unserviceable. Therefore, the mammoths, whose ivory they wrought, must have been contemporary with themselves. Of this conclusion we have a decisive proof in the plate of ivory discovered at the La Madelaine, in 1864, by

E. Lartet, De Verneuil, and Falconer. It will be seen to contain an engraved design of the mammoth, as his carcass is to this day found on the banks of the Lena. (*See* vol. i. of The Popular Science Monthly, p. 215.)

The Troglodytes of the Reindeer Age had but rarely the opportunity of measuring strength with the mammoth. Their game was more commonly the aurochs, the horse, the ox; and doubtless it was in the pursuit of these great animals that they used their long spears tipped with flint. Still, nearly all their weapons were light, and mostly tipped with reindeer-horn. The bow became their principal weapon, in proportion as the animals they hunted grew more timid and wary. Their arrows were of two kinds: a small one, with pointed tip, without a barb, for small game and birds; and a large one, with two rows of barbs, for hunting the reindeer. The rest of their equipment consisted of light lances with blunt heads, darts with conical points, and long, sharp daggers, for close quarters. They had also a whistle to summon their companions in the chase; this was made of reindeer-bone.

That our Troglodytes followed fishing also is shown by the number of fish-bones found in their caves; but, strange to say, salmon was their only fish. At the present day salmon does not go up the Vézère, nor is it found in the Dordogne as far up as the mouth of the Vézère. There is every reason for believing that these ancient fishers did not use a line, for with a line the fisherman takes fish of every kind. If they employed only the harpoon, we can well understand why they could take only large fish, and why among these they should select the salmon, whose flesh they prized most. But did they fish from boats? We have no evidence bearing on this point; but the Vézère was so closely confined by steep banks, that the salmon might easily be harpooned from the shore. The harpoon used by our Troglodytes was a small dart of reindeer-horn, with barbs on one side only, and having a projection at its base, to fasten it to the line.

Fig. 2.



Bone Harpoon from Terra Del Fuego.

On returning from the chase or from fishing, the Troglodytes got ready the feast in their cave. The carcasses of reindeer and the smaller game were brought in whole, but large-sized animals, the horse or the ox, being too heavy to carry away whole, were cut up on the spot, the head and legs being carried off, and the rest of the skeleton left behind. Hence, among the leavings found in the caves, we scarcely ever meet with any bones from the trunk of large mammals, while every part of the skeleton of reindeer and smaller animals is to be found. The soil in the caverns, wherever it contains crushed bones, contains also an immense amount of charred wood. This mixture of bones and charcoal occurs so generally, so uniformly, that it is not easy to suppose that the Troglodytes lighted fires merely for the purpose of keeping themselves warm. They must have lighted fires daily at all seasons of the year, and hence it is likely that they cooked their food.

We are unable to say whether they got their fire from flint, or from wood by friction. They had no pottery, and could not boil their provisions over the fire. And yet they did not roast their meat either, for you will rarely find in their caves a calcined bone, or only such bones as were evidently burned by mere chance. They may have boiled their meats in wooden troughs, bringing the water to a boil by casting into it red-hot stones. But I think it more likely that they cooked their meat beneath the ashes, as is still the custom of many savage tribes.

A tid-bit for them was the brain of animals, or the marrow, as is evidenced by the fact that all the skulls are cracked and all the marrow-bones (and they only) broken. All savages have a special liking for marrow, and have a peculiar way of cracking the bones containing it. The chief is always the first to suck the marrow-bone. Our Troglodytes had little wedge-shaped pieces of flint, which they used as hatchets to break these bones. We find also in their caves an implement of reindeer-horn which was probably used for getting out the marrow, though archæologists are divided as to its purpose.

After a meal, the Troglodytes left the bones scattered about the floor. In a warm climate these remnants would have given out an insupportable stench; but in those early times the temperature was very low in France, and our Troglodytes were not paragons of cleanliness. To their uncleanly habits we are indebted for what we know about their food. Their chief staple was reindeer meat; but they also eat the flesh of the horse, the aurochs, several species of the ox, the chamois, the wild-goat, and even some carnivora. They used also fish, and, by means of the bow and arrow, they could take winged game. The caves contain the remains of birds of many different species. But, among all these bones, we find no human remains; and, hence, we know that our good Troglodytes were not cannibals. That supreme delight of the savage soul was all unknown to them—devouring a vanquished foeman. I record this with pleasure, albeit I attach no exceptional importance to the question of anthropophagy. In the eyes of the philosopher the crime is not in devouring, but in killing a human being. Judging from the style of weapons these Troglodytes employed, we should say that they were quiet folk, not given to war.

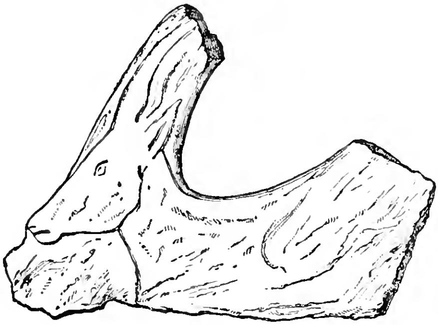
It has been supposed that they wore no clothing, as all the human figures portrayed by their artists are nude (Fig. 5). This, however, proves just nothing, because it proves too much. By parity of reasoning, the Greeks would have gone naked also. But we find in the caves all the necessary outfit of the (Troglodytic) tailor. There are needles of bone and of reindeer-horn, some of them being mere awls, but

Fig. 3.

Drawing of a Fish on Reindeer-Horn.—(From La Madelaine.)

others having an eye to hold the thread. Some of these needles were very slender, and a needle-case, made of a bone from a bird, has been found, which might contain several of them. Lartet and Christy discovered the mode of manufacturing these needles. They give an engraving of the metacarpal of a horse, having a number of parallel cuttings lengthwise, all executed with a fine saw. The work was incomplete, but it is evident that here we have needles in process of manufacture.

Fig 4.



Drawing of an Ibex.—(La Madelaine.)

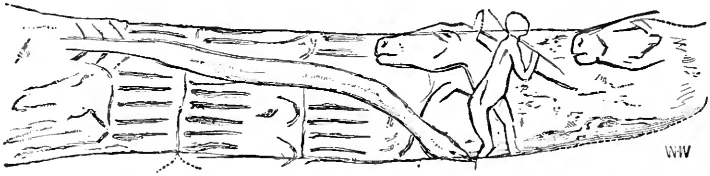
The threads they used were doubtless of various kinds. But did they employ for this purpose vegetable fibres, or fine strips of hide? It is possible, or even probable, that they used both; but this at least is certain, that they made threads, or, at all events, cords, out of tendons. They removed carefully from the members of animals the long tendons, as is shown by the scratches on the bone at the point of insertion.

Needle-work implies clothing, not simply that primitive garment which consists of an animal's skin thrown over the shoulders, but a more complete vesture, made up of sundry skins. The quantity of needles and awls, and of scrapers for preparing skins for use, which we meet with in the caves, shows that the use of clothing was general among our Troglodytes.

But further, they wore ornaments, which perhaps served as marks of distinction. Thus, they had collars and bracelets made of pierced shells, hung on a string. Such shells have been found in most of the caves, and they occur in great numbers in the ancient place of sepulture at Cromagnon. Pieces of ivory, nicely fashioned, and bored with two holes, would appear to have been used to fasten the collar; and no doubt this is not the only outcropping of petty vanity of attire among our Troglodytes. Most savages have the habit of painting and tattooing their bodies; nor is the latter practice yet quite extinct among civilized races. In the caves are found several pieces of the bloodstone, showing signs of having been scraped. Hence we conclude that they prepared a red paint, and made constant use of it, probably in ornamenting their persons. Probably they also practised tattooing, for, when their artists picture, as they often do, the hand and forearm on a man on reindeer-horn, the lower part of the forearm bears a figure which may well be taken to represent a tattoo.

It has been already shown that our Troglodytes were not nomads; and, though individuals may have wandered abroad, the tribe never travelled to any distance away from their cave. Hence they must have acquired by barter objects coming from remote parts. The shells of their necklaces came from the Atlantic coast. They also used rock-crystal, which must have come from the Pyrenees, the Alps, or the mountains of Auvergne. Thus it is seen that the Troglodytes had relations with distant localities.

Fig. 5.



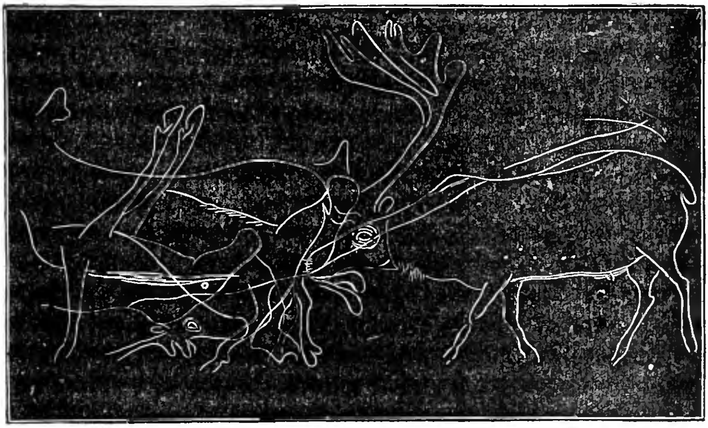
Group of Figures—Snake or Eel, Man, and Two Horse-Heads.—(La Madelaine.)

If they had any religious belief, it has left no trace. They wore talismans or amulets, however, the incisor-teeth of wolves or reindeer, the ox, or the horse, with a hole in them, through which a string was passed. Similar talismans are still worn by savage huntsmen, to insure good luck in the pursuit of game. In Italy, down to the present day, a swine's tooth, set in silver, is attached to the swaddling-clothes of new-born infants, as a charm against the Evil Eye, and afterward serves as a *hochet*, when the child is cutting its teeth. If the wolves' and other animals' teeth we find in the caves were talismans, our Troglodytes had at least a superstition, and, though I am no theologian, I will say that it is difficult to decide just where superstition ends and religion begins.

In burying their dead, the contemporaries of our Troglodytes in other localities practiced certain funeral rites; and consoled themselves for their loss by partaking of a feast on a little platform in front of the sepulchral cave—a kind of solace not yet quite out of vogue. Only one place of burial has as yet been discovered in the neighborhood of the Vézère, namely, at Cromagnon. This is a mere nook beneath an overhanging rock; and flints and shell ornaments are found buried with the bodies. We find here no remnants of any stone enclosure.

Society among the Troglodytes had its hierarchical organization, with dignitaries of various grades. The three caves at Les Eyzies, Laugerie-Basse and La Madelaine contain the proofs of this assertion, in the shape of large pieces of reindeer horn, artistically fashioned, and commonly known as *bâtons de commandement*, commanders' truncheons. Several of these instruments have been found; they are all of one common type, their surface being highly ornamented with figures of animals, or of hunting-scenes, and are pierced with large

FIG. 6.



GROUP OF REINDEER.

round holes, from one to four in number. The purpose of these remarkable objects is matter of much dispute. It is true they much resemble the *pogamagan*, or tomahawk of the Mackenzie River Esquimaux, but the *pogamagan* is both longer, thicker, and far more solid, than the *bâtons de commandement*. The latter are too frail to be used for any mechanical purpose, and therefore they were most probably only insignia of rank, like the king's or the chief's sceptre, or the marshal's *bâton*. But there are so many of them, that we cannot regard them as regal insignia, and hence they may have been marks of hierarchical dignity, the holes denoting the rank, like the bars or stars on a military officer's shoulder-straps. Thus the *bâton* without a hole would indicate the lowest grade of dignity, those with one or more holes indicating a higher and higher office, until we reach the fourth grade, indicated by four holes. The ornamentation commonly surrounds these holes, and this circumstance would seem to show that the *bâton* was made for some personage already clothed with official rank. But sometimes the hole is seen to have been pierced afterward, breaking up the lines and disfiguring the design. Thus we have a *bâton* bearing the figure of a horse, which is found broken in two by one of these perforations. The happy owner of the truncheon had gained promotion!

This ascending scale of degrees and ranks (which is the sure evidence of a numerous society) may, no doubt, have been of service in war, but it is very likely that its chief object was the organization of hunting expeditions, as the chase was the great employment of the tribe. In a climate colder than ours, the game would keep for a considerable time, in winter especially. Hence the caves held a more or less abundant supply of victuals, and a manager in chief was needed, to prevent waste and to make equitable distribution of the store. We find rods of reindeer-horn with a number of notches cut in regular series, which would appear to have been the managers' day-books. These rods, commonly known as *marques de chasse* (tallies of the chase), much resemble the *marques* used by bakers in small country villages in France at the present day. There has been also found in one of the caves a broad plate of ivory, having on its sharp edges a series of notches, and on its flat sides several rows of points, which would also appear to have been tallies.

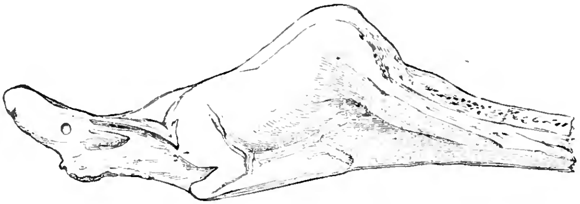
Owing to this social organization and administration of affairs, Troglodytic society, though it embraced a numerous membership, lived comfortably enough. They had such an abundance of food that they could choose the best pieces, rejecting what was of inferior quality. Thus, they threw away the feet of animals, though these contain a considerable amount of nutritive substance. Hence we see that they had plenty to eat: and, as thus the whole time of the tribe need not have been taken up with the business of making provision for the body's wants, they could enjoy repose now and then—could enjoy leisure—and leisure, when improved intelligently, gives rise to the arts.

2. *The Arts among the Troglodytes.*

To Egypt no longer pertains the glory of having been the originator of the arts. It was with profound astonishment that the world learned, some years since, that long, long before the artists of Egypt, the men of the Age of the Reindeer had cultivated design, engraving, and even sculpture. At first, their works were greeted only with plaudits of admiration; but now, recovered as we are from this first impression, we are forced to admit that in those ancient days, as in our own, there were not wanting bad artists; and, yet, amid a number of coarse designs, there are not a few which are truly worthy of note, and which betray an able hand, and an eye trained to observe Nature.

Designing undoubtedly preceded sculpture among the Troglodytes, and their figures in relief are much fewer in number and less perfect than their engraved sketches. These latter figures generally form the ornamentation of the *bâton de commandement*, or of the hafts of daggers; but sometimes they are found on stone slabs, or on plates of ivory or of reindeer-horn, which would appear to have been prepared

Fig. 7.



Handle of a Poniard.

simply to receive the engravings. Nearly all the designs represent objects in Nature, though some of them are simply ornamental linés, zigzags, curves, etc. Three small brank-ursines, engraved on a piece of reindeer-horn, would appear to represent a polypetal flower; but all the other figures represent animals. The reindeer occurs most frequently, the ox and the aurochs being more rare. These various animals are readily distinguishable in the engraved figures, their respective gait and motion being oftentimes reproduced with considerable exactness and elegance. Sometimes they are isolated, being represented, without any order, over the entire surface of some instrument; but, again, they are found grouped together, engaged in combat, etc. (Fig. 6). The engraving of the mammoth was found, in 1864, in the cave of La Madelaine. The head of the animal is given with remarkable exactitude. The Marquis de Vibraye has since discovered a *bâton de commandement*, with a mammoth's head sculptured on it. These two pieces are the only ones representing the mammoth which have come down to our time from the hands of the Troglodytic artists, but they suffice to show that the animal was not yet extinct.

Figures of fish are not rare, and they all, with one exception, represent the salmon. Élie Massénat found at Laugerie-Basse the shoulder-blade of an ox, bearing a rude sketch of a fishing-scene—a man casting a harpoon at some aquatic animal, a porpoise, apparently. This design has a special interest, as going to show that our Troglodytes fished with the harpoon.

In sketching the human figure (which they did but rarely), these artists, who exhibited such skill in animal-sketching, do not show to much advantage. There is one *study* of a head, representing a grotesque profile. Two other figures represent the forearm and hand, four fingers being visible, and the thumb concealed. Add to these the fishing-scene and two hunting-scenes, and you have the complete list of figures relating to man in the Troglodytic Museum.

As I have already said, sculptures are of rarer occurrence here than engraved designs. Of the former we have not above half a dozen, all found at Laugerie-Basse. One of these, the property of the Marquis de Vibraye, represents a woman, and all the others represent animals, viz., a reindeer, head of the same animal, head of a mammoth (referred to already), and also one of some unknown animal. Finally, we have M. Massénat's latest discovery, known as the *Bœufs Jumeaux* (twin-oxen), which represents a pair of oxen, or, perhaps, of aurochsen.

These sculptures are sometimes incomplete, and always ill executed; but in the art of design the artists display surprising ability. They sketched the human figure badly, but they studied carefully the form and the gait of animals, which they sometimes reproduced with a degree of exactitude, elegance, and spirit, which evince the true artistic sentiment.

THE STUDY OF SOCIOLOGY.

By HERBERT SPENCER.

IX.—*The Bias of Patriotism.*

"OUR country, right or wrong," is a sentiment not unfrequently expressed on the other side of the Atlantic; and, if I remember rightly, an equivalent sentiment was some years ago uttered in our own House of Commons, by one who rejoices, or at least who once rejoiced, in the title of philosophical radical.

Whoever entertains such a sentiment has not that equilibrium of feeling required for dealing scientifically with social phenomena. To see how things stand, apart from personal and national interests, is essential before there can be reached those balanced judgments respecting the course of human affairs in general, which constitute Sociology. To be convinced of this, it needs but to take a case remote from our own. Ask how the members of an aboriginal tribe regard that tide of civilization which sweeps them away. Ask what the North-American Indians said about the spread of the white man over their territories, or what the ancient Britons thought of the invasions which dispossessed them of England; and it becomes clear that events which, looked at from an un-national point of view, were steps toward a higher life, seemed from a national point of view entirely evil. Admitting the truth so easily perceived in these cases, we must admit that only in proportion as we emancipate ourselves from the bias of patriotism, and consider our own society as one among many, having their histories and their futures, and some of them, perhaps, having better claims than we have to the inheritance of the earth—only in proportion as we do this, shall we recognize those sociological truths which have nothing to do with particular nations or particular races.

So to emancipate ourselves is extremely difficult. It is with patriotism as we lately saw it to be with the sentiment that causes political subordination: the very existence of a society implies predominance of it. The two sentiments join in producing that social cohesion without which there cannot be coöperation and organization. A nationality is made possible only by the feeling which the units have for the whole they form. Indeed, we may say that the feeling has been gradually increased by the continual destroying of types of men whose attachments to their societies were relatively small; and who were, therefore, incapable of making adequate sacrifices on behalf of their societies. Here, again, we are reminded that the citizen, by his incorporation in a body politic, is in a great degree coerced into such sentiments and beliefs as further its preservation: unless this is the average result, the body politic will not be preserved. Hence another obstacle in the way of Social Science. We have to allow for the aberrations of judgment caused by the sentiment of patriotism.

Patriotism is nationally that which egoism is individually—has, in fact, the same root; and along with kindred benefits brings kindred evils. Estimation of one's society is a reflex of self-estimation; and assertion of one's society's claims is an indirect assertion of one's own claims as a part of it. The pride a citizen feels in a national achievement, is the pride belonging to a nation capable of that achievement: the belonging to such a nation having the tacit implication that in in himself there exists the superiority of nature displayed. And the anger aroused in him by an aggression on his nation is an anger against something which threatens to injure him by injuring his nation.

As, lately, we saw that a duly-adjusted egoism is essential; so now, we may see that a duly-adjusted patriotism is essential. Self-regard in excess produces two classes of evils: by prompting undue assertion of personal claims it breeds aggression and antagonism; and by creating undue estimation of personal powers it excites futile efforts that end in catastrophes. Deficient self-regard produces two opposite classes of evils: by not asserting personal claims, it invites aggression, so fostering selfishness in others; and by not adequately valuing personal powers it causes a falling short of attainable benefits. Similarly with patriotism. From too much, there result national aggressiveness and national vanity. Along with too little, there goes an insufficient tendency to maintain national claims leading to trespasses by other nations; and there goes an undervaluing of national capacity and institutions, which is discouraging to effort and progress.

The effects of patriotic feeling which here concern us, are those it works on belief rather than those it works on conduct. As disproportionate egoism, by distorting a man's conceptions of self and of others, vitiates his conclusions respecting human nature and human actions; so disproportionate patriotism, by distorting his conceptions of his own society and of other societies, vitiates the conclusions respecting the natures and actions of societies. And from the opposite extremes there result opposite distortions: which, however, are comparatively infrequent and much less detrimental.

Here we come upon one of the many ways in which the corporate conscience proves itself less developed than the individual conscience. For, while excess of egoism is everywhere regarded as a fault, excess of patriotism is nowhere regarded as a fault. A man who recognizes his own errors of conduct and his own deficiencies of faculty, shows a trait of character considered praiseworthy; but to admit that our doings toward other nations have been wrong is reprobated as unpatriotic. Defending the acts of another people with whom we have a difference, seems to most citizens something like treason; and they use offensive comparisons concerning birds and their nests, by way of condemning those who ascribe misconduct to our own people rather than to the people with whom we are at variance. Not only do they exhibit the unchecked sway of this reflex egoism which constitutes patriotism—not only are they unconscious that there is any thing blameworthy in giving the rein to this feeling; but they think the blameworthiness is in those who restrain it, and try to see what may be said on both sides. Judge, then, how seriously the patriotic bias, thus perverting our judgments about international actions, necessarily perverts our judgments about the characters of other societies, and so vitiates sociological conclusions.

We have to guard ourselves against this bias. To this end let us take some examples of the errors attributable to it.

What mistaken estimates of other races may result from over-estimation of one's own race, will be most vividly shown by a case in which we are ourselves valued at a very low rate by a race we hold to be far inferior to us. Here is an instance supplied by a tribe of negroes:

> "They amused themselves by remarking on the sly, 'The white man is an old ape.' The African will say of the European, 'He looks like folks' (men), and the answer will often be, 'No, he don't.' . . . . While the Caucasian doubts the humanity of the Hamite, the latter repays the compliment in kind."[1]

[1] Burton's "Abeokuta," vol. ii., pp. 43, 44.

Does any one think this instance so far out of the ordinary track of error, as to have no instruction for us? To see the contrary he has but to look at the caricatures of Frenchmen that were common a generation ago, or to remember the popular statement then current respecting the relative strengths of French and English. Such reminders will convince him that the reflex self-esteem we call patriotism, has had, among ourselves, perverting effects sufficiently striking. And even now there are kindred opinions which the facts, when examined, do not bear out: instance the opinion respecting personal beauty. That the bias thus causing misjudgments in cases where it is checked by direct perception, causes greater misjudgments where direct perception cannot check it, needs no proof. How great are the mistakes it generates, all histories of international struggles show us, both by the contradictory estimates the two sides form of their respective leaders and by the contradictory estimates the two sides form of their deeds. Take an example:

"Of the character in which Wallace first became formidable, the accounts in literature are distractingly conflicting. With the chroniclers of his own country, who write after the War of Independence, he is raised to the highest pinnacle of magnanimity and heroism. To the English contemporary chroniclers he is a pestilent ruffian; a disturber of the peace of society; an outrager of all laws and social duties; finally, a robber—the head of one of many bands of robbers and marauders then infesting Scotland."[1]

That, along with such opposite distortions of belief about conspicuous persons, there go opposite distortions of belief about the conduct of the peoples they belong to, the accounts of every war demonstrate. Like the one-sidedness shown within our own society by the remembrance among Protestants of Roman Catholic cruelties only, and the remembrance among Roman Catholics of Protestant cruelties only, is the one-sidedness shown in the traditions preserved by each nation concerning the barbarities of nations it has fought with. As in old times the Normans, savage themselves, were shocked at the vindictiveness of the English when driven to bay; so in recent times the French have enlarged on the atrocities committed by Spanish guerrillas, and the Russians on the atrocities the Circassians perpetrated. In this conflict between the views of those who commit savage acts, and the views of those on whom they are committed, we clearly perceive the bias of patriotism where both sides are aliens; but we fail to perceive it where we are ourselves concerned as actors. Every one old enough remembers the reprobation vented here when the French in Algiers dealt so cruelly with Arabs who refused to submit—lighting fires at the mouths of caves in which they had taken refuge; but we do not see a like barbarity in deeds of our own in India, such as the executing a group of rebel sepoys by fusillade, and then setting fire to the heap of them because they were not

[1] Burton's "History of Scotland," vol. ii., pp. 281, 282.

all dead,[1] or in the wholesale shootings and burnings of houses, after the suppression of the Jamaica insurrection. Listen to what is said at home about such deeds in our own colonies, and you find that habitually they are held to have been justified by the necessities of the case. Listen to what is said about such deeds when other nations are guilty of them, and you find the same persons indignantly declare that no alleged necessities could form a justification. Nay, the bias produces perversions of judgment even more extreme. Feelings and deeds we laud as virtuous when they are not in antagonism with our own interests and power, we think vicious feelings and deeds when our own interests and power are endangered by them. Equally in the mythical story of Tell, and in any account not mythical, we read with glowing admiration of the successful rising of an oppressed race; but admiration is changed into indignation if the race is one held down by ourselves. We can see nothing save crime in the endeavor of the Hindoos to throw off our yoke; and we recognize no excuse for the efforts of the Irish to establish their independent nationality. We entirely ignore the fact that the motives are, in all such cases, the same, and, in the abstract, are to be judged apart from results.

A bias which thus vitiates even the perceptions of physical appearances, which so greatly distorts the beliefs about conspicuous antagonists and their deeds, which leads us to reprobate in other nations severities and cruelties that we applaud when committed by our own agents, and which makes us regard acts of intrinsically the same kind as wrong or right according as they are or are not directed against ourselves, is a bias which inevitably perverts our sociological ideas. The institutions of a despised people cannot be judged with fairness; and if, as often happens, the contempt is unwarranted, or but partially warranted, such value as their institutions have will certainly be underestimated. When antagonism has bred hatred toward another nation, and has, consequently, bred a desire to justify the hatred by ascribing a hateful character to members of that nation, it inevitably happens that the political arrangements under which they live, the religion they profess, and the habits peculiar to them, become associated in thought with this hateful character—become themselves hateful, and cannot therefore have their natures studied with the calmness required by science.

An example will make this clear. The reflex egoism we name patriotism, causing, among other things, a high valuation of the religious creed nationally professed, makes us overrate the effects this creed has produced, and makes us underrate the effects produced by other creeds, and by influences of other orders. The notions respecting savage and civilized races, in which we are brought up, show this.

[1] I make this statement on the authority of a letter read to me at the time by an Indian officer, written by a brother officer in India.

The word savage, originally meaning wild or uncultivated, has come to mean cruel and blood-thirsty, because of the representations habitually made that wild or uncultivated tribes of men are cruel and blood-thirsty. And ferocity having come to be thought of as a constant attribute of uncivilized races, which are also distinguished by not having our religion, it is tacitly assumed that the absence of our religion is the cause of this ferocity. But if, struggling successfully against the bias of patriotism, we correct the evidence which that bias has garbled, we find ourselves obliged to receive this assumption with great qualifications.

When, for instance, we read Cook's account of the Tahitians, as first visited by him, we are surprised to meet with some traits among them, higher than those of their civilized visitors. Though some pilfering was committed by them, it was not so serious as that of which the sailors were guilty in stealing the iron bolts out of their own ship to pay the native women. And when, after Cook had enacted a penalty for theft, the natives complained of one of his own crew—when this sailor, convicted of the offence he was charged with, was condemned to be whipped, the natives tried to get him off, and, failing to do this, shed tears on seeing preparations for the punishment. If, again, we compare critically the accounts of Cook's death, we see clearly enough that the Sandwich-Islanders behaved amicably until they had been ill-used, and had reason to fear further ill-usage. The experiences of many other travellers similarly show us that friendly conduct on the part of uncivilized races, when first visited, is very general; and that their subsequent unfriendly conduct, when it occurs, is nothing but retaliation for injuries received from the civilized. Such a fact as that the natives of Queen Charlotte's Island did not attack Captain Carteret's party till after they had received just cause of offence,[1] may be taken as typical of the histories of transactions between wild races and cultivated races. When we inquire into the case of the missionary Williams, "the Martyr of Erromanga," we discover that his murder, dilated upon as proving the wickedness of unreclaimed natures, was a revenge for injuries previously suffered from wicked Europeans. Here are a few testimonies respecting the relative behaviors of civilized and uncivilized:

> "After we had killed a man at the Marquesas, grievously wounded one at Easter Island, hooked a third with a boat-hook at Tonga-tabu, wounded one at Namocka, another at Mallicollo, and killed another at Tauna; the several inhabitants behaved in a civil and harmless manner to us, though they might have taken ample revenge by cutting off our straggling parties."[2]
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> "Excepting at Cafta, where I was for a time supposed to come with hostile intent, I was treated inhospitably by no one during all my travels, excepting by Europeans, who had nothing against me but my apparent poverty."[3]

[1] Hawkesworth's "Voyages," vol i., p. 573. [2] Forster's "Observations," etc., p. 406.
[3] Parkyns's "Abyssinia," vol. ii., p. 431.

"In February, 1812, the people of Winnebah (Gold Coast) seized their commandant, Mr. Meredith," and so maltreated him that he died. The town and fort were destroyed by the English. "For many years afterward, English vessels passing Winnebah were in the habit of pouring a broadside into the town, to inspire the natives with an idea of the severe vengeance which would be exacted for the spilling of European blood."[1]

Or, instead of these separate testimonies, take the opinion of one who collected many testimonies. Referring to the kind treatment experienced by Encisco from the natives of Cartagena (on the coast of New Granada), who a few years before had been cruelly treated by the Spaniards, Washington Irving says:

"When we recall the bloody and indiscriminate vengeance wreaked upon this people by Ojida and his followers for their justifiable resistance of invasion, and compare it with their placable and considerate spirit when an opportunity for revenge presented itself, we confess we feel a momentary doubt whether the arbitrary appellation of savage is always applied to the right party."[2]

The reasonableness of this doubt will scarcely be questioned, after reading of the diabolical cruelties committed by the invading Europeans in America; as, for instance, in St. Domingo, where the French made the natives kneel in rows along the edge of a deep trench and shot them batch after batch, until the trench was full, or, as an easier method, tied numbers of them together, took them out to sea, and tumbled them overboard; and where the Spaniards treated so horribly the enslaved natives, that these killed themselves wholesale: the various modes of suicide being shown in Spanish drawings.

Does the Englishman say that these, and hosts of like demoniacal misdeeds, are the misdeeds of other civilized races in other times; and that they are attributable to that corrupted religion which he repudiates? If so, he may be reminded that sundry of the above facts are facts against ourselves. He may be reminded, too, that the purer religion he professes has not prevented a kindred treatment of the North American Indians by our own race. And he may be put to the blush by accounts of barbarities going on in our own colonies at the present time. Without detailing these, however, it will suffice to recall the most recent notorious case—that of the kidnappings and murders in the South Seas. Here we find repeated the typical relations; betrayals of many natives and merciless sacrifices of their lives; eventual retaliation by the natives to a small extent; a consequent charge against the natives of atrocious murder; and then a wholesale massacre of them, innocent and guilty together.

See, then, how the bias of patriotism indirectly produces erroneous views of the effects of an institution. Blinded by national self-love to the badness of our conduct toward inferior races, while remem-

[1] Cruickshank, "Eighteen Years on the Gold Coast of Africa," vol. i., p. 100.

[2] "Companions of Columbus," p. 115.

bering what there is of good in our conduct; forgetting how well these inferior races have usually behaved to us, and remembering only their misbehavior, which we refrain from tracing to its cause in our own transgressions; we overvalue our own natures as compared with theirs. And then, looking at the two as respectively Christian and heathen, we overrate the good done by Christian institutions (which has doubtless been great), and we underrate the advance that has been made without them. We do this habitually in other cases. As, for instance, when we ignore evidence furnished by the history of Buddhism; respecting the founder of which Canon Liddon lately told his hearers that "it might be impossible for honest Christians to think over the career of this heathen prince without some keen feelings of humiliation and shame."[1] And ignoring all such evidence, we get one-sided impressions. Thus our sociological conceptions are distorted—do not correspond with the facts; that is, are unscientific.

To illustrate some among the many effects wrought by the bias of patriotism in other nations, and to show how mischievous are the beliefs it fosters, I may here cite evidence furnished by France and by Germany.

Contemplate that undue self-estimation which the French have shown us. Observe what has resulted from that exalted idea of French power which the writings of M. Thiers did so much to maintain and increase. When we remember how, by causing undervaluation of other nations, it led to a disregard of their ideas and an ignorance of their doings—when we remember how, in the late war, the French, confident of victory, had maps of German territory but not of their own, and suffered catastrophes from this and other kinds of unpreparedness; we see what fatal evils this reflex self-esteem may produce when in excess. So, too, on studying the way in which it has influenced French thought in other directions. Looking at Crimean battle-pieces, in which French soldiers are shown to have achieved every thing—looking at a picture like Ingres's "Crowning of Homer," and noting French poets conspicuous in the foreground, while the figure of Shakespeare in one corner is half in and half out of the picture—reading the names of great men of all nations inscribed on the string-course running round the *Palais de l'Industrie*, and finding many unfamiliar French names, while (strange oversight, as we must suppose) the name of Newton is conspicuous by its absence; we see exemplified a national sentiment which, generating the belief that things not French deserve little attention, acts injuriously on French thought and French progress. From Victor Hugo's magniloquent description of France as the savior of nations, down to the declamations of those who urged that were Paris destroyed the light of civilization would be extinguished, we see, throughout, the conviction that France is the great teacher, and by implication needs not to be a learner. The diffusion

[1] *Times*, January 22, 1873.

of French ideas is an essential thing for other nations; while the absorption of ideas from other nations is not an essential thing for France: the truth being, rather, that French ideas, more than most other ideas, stand in need of foreign influence to qualify the undue definiteness and dogmatic character they habitually display. That such a tone of feeling, and the mode of thinking appropriate to it, should vitiate sociological speculation, is a matter of course. If there needs proof, we have a conspicuous one in the writings of M. Comte; where excessive self-estimation under its direct form, and under that reflex form constituting patriotism, has led to astounding sociological misconceptions. If we contemplate that scheme of Positivist reorganization and federation in which France was, of course, to be the leader—if we note the fact that M. Comte expected the transformation he so rigorously formulated to take place during the life of his own generation; and if, then, we remember what has since happened, and consider what are the probabilities of the future, we shall not fail to see how great are the perversions of sociological belief this bias may produce.

How national self-esteem, exalted by success in war, warps sociological opinion, is again shown of late in Germany. As a German professor writes to me, "there is, alas, no want of signs" that the "happy contrast to French self-sufficiency" which Germany heretofore displayed, is disappearing "since the glory of the late victories." The German liberals, he says, "overflow with talk of Germanism, German unity, the German nation, the German Empire, the German army and the German navy, the German Church, and German science. . . . They ridicule Frenchmen, and what animates them is, after all, the French spirit translated into German." And, then, to illustrate the injurious reaction on German thought, and on the estimates of foreign nations and their doings, he describes his discussion with an esteemed German professor of philosophy, against whom he was contending that the psychical and ethical sciences would gain in progress and influence by international communion, like that among the physico-mathematical sciences. He, "to my astonishment, declared that, even if such a union were possible, he did not think it desirable, as it would interfere too much with the peculiarity of German thought. . . . Second to Germany," he said, "it was Italy, which, in the immediate future, was most likely to promote philosophy. . . . It appeared that what made him prefer the Italians . . . . was nothing else than his having observed that in Italy they were acquainted with every philosophical treatise published in Germany, however unimportant." And, thus, adds my correspondent, "the finest German characteristics are disappearing in an exaggerated Teutonomania." One other truth his comments on German feeling make manifest. There is indirectly an antagonism between the sentiment of nationality and the sentiment of individuality; the result of which is that exaltation of the one involves depression of the other, and a decreased regard for the institutions it originates. Speaking of the "so-called National Liberals," he says: "A friend of mine was lately present at a discussion, in the course of which a professor of philosophy, of the University of ——, was very eloquently, and with perfect seriousness, contending that only one thing was now wanting to complete our German institutions—a national costume. Other people, who, no doubt, are fully aware of the ridiculousness of such things, are, nevertheless, guilty of an equally absurd, and even more intolerable encroachment on individual liberty; since, by proposing to establish a national church, they aim at constraining the adherents of the various religious bodies into a spiritual uniform. Indeed, I should hardly have thought it possible that a German government could encourage such monstrous propositions, if they had not been expounded to me at the Ministry of Public Worship."

Saying no more about patriotism and its perverting effects on sociological judgments, which are indeed so conspicuous all through history as scarcely to need pointing out, let me devote the remaining space to the perverting effects of the opposite feeling—anti-patriotism. Though the distortions of opinion hence resulting are less serious, still they have to be guarded against.

In England the bias of anti-patriotism does not diminish in a marked way the admiration we have for our political institutions, but only here and there prompts the wish for a strong government, to secure the envied benefits ascribed to strong governments abroad. Nor does it appreciably modify the general attachment to our religious institutions, but, only in a few who dislike independence, shows itself in advocacy of an authoritative ecclesiastical system fitted to remedy what they lament as a chaos of religious beliefs. In other directions, however, it is displayed so frequently and conspicuously as to affect public opinion in an injurious way. In respect to the higher orders of intellectual achievement, undervaluation of ourselves has become a fashion, and the errors it fosters react detrimentally on the estimates we make of our social *régime*, and on our sociological beliefs in general.

What is the origin of this undue self-depreciation? In some cases, no doubt, it results from disgust at the jaunty self-satisfaction caused by the bias of patriotism, when excessive. In other cases, it grows out of affectation: to speak slightingly of what is English seems to imply wide knowledge of what is foreign, and brings a reputation for culture. In the remaining cases, it is due to ignorance. Passing over such of these self-depreciatory estimates of our powers and achievements as have partial justifications, I will limit myself to one which has no justification. Among the classes here indicated, it is the custom to speak disparagingly of the part we play in discovery and invention. There is an assertion occasionally to be met with in public journals, that the French invent and we improve. Not long since, it was confessed by the Attorney-General that the English are not a scientific nation. Recently the *Times*, commenting on a speech of Mr. Gladstone, said: "There is truth, however, in the assertion that we are backward in appreciating and pursuing abstract knowledge."[1] Such statements exhibit the bias of anti-patriotism creating a belief that is wholly indefensible. As we shall presently see, they are flatly contradicted by facts, and can be accounted for only by supposing that those who make them have had a culture exclusively literary.

A convenient way of dealing with this bias of anti-patriotism will be to take an individual example of it. More than any other, Mr. Matthew Arnold has of late made himself an exponent of the feeling. His motive cannot be too highly respected, and for much that he has said in reproof of the vainglorious, entire approval may rightly be felt. Many grave defects in our social state, many absurdities in our modes of action, many errors in our estimates of ourselves, are to be pointed out, and dwelt upon, and great good is done by a writer who efficiently executes the task of making us feel our shortcomings. In his condemnation of the ascetic view of life which still prevails here, one may entirely agree. The undue estimation of material prosperity common with us is a fault justly insisted on by him. And the overweening confidence so often shown in a divine favor gained by our greater national piety, is also an attitude of mind deservedly to be reprobated. But, by reaction, Mr. Arnold is, I think carried too far in the direction of anti-patriotism, and weakens the effect of his criticism by generating a re-reaction. Let us glance at some of his views:

The mode of procedure generally followed by Mr. Arnold is not that of judicially balancing the evidence, but that of meeting the expression of self-satisfied patriotism by some few facts calculated to cause dissatisfaction: not considering what is their quantitative value. To reprove a piece of national self-laudation uttered by Mr. Roebuck, he comments on the murder of an illegitimate child by its mother, reported in the same paper. Now this would be effective if infanticide were peculiar to England, or if he could show a larger proportion of infanticide here than elsewhere; but his criticism is at once cancelled on calling to mind the developed system of baby-farming round Paris, and the extensive getting-rid of infants to which it is instrumental. By following Mr. Arnold's method, it would be easy to dispose of his conclusions. Suppose, for instance, that I were to set down the many murders committed in England by foreigners, within our own memories, including those by Courvoisier, by Mrs. Manning, by Barthélemi, near Fitzroy Square, by a Frenchman, in Foley Place (about 1854–'57), that by Müller, that by Kohl, in the Essex marshes, that by Lani, in a brothel near the Haymarket, that by Marguérite Diblanc, the tragedy of the two young Germans (Mai and Nagel), at Chelsea, ending with

[1] *Times*, December 23, 1872.

the recent one in Great Coram Street—suppose I were to compare the ratio borne by this number of murderers to the number of foreigners in England with the answering ratio among our own people; and suppose I were to take this as a test of the Continental culture Mr. Arnold so much admires. Probably, he would not think the test quite relevant, and yet it would be quite as relevant as that he uses—perhaps somewhat more relevant. Suppose, again, that, by way of criticism on German administration, I were to dwell on the catastrophe at Berlin, where, during the celebration of victory, fourteen sight-seers were killed, and some hundreds injured; or, suppose I were further to judge it by the disclosures of the leading Berlin physician, Virchow, who shows that one out of every three children born in Berlin dies the first year, and whose statistics prove the general mortality to be increasing so rapidly that, while "in 1854 the death-rate was 1,000, in 1851–'64 it rose to 1,164, and in 1864–'68 to 1,817"[1]—suppose, I say, that I took these facts as proof of failure in the social system Mr. Arnold would have us copy. Possibly he would not be much shaken, though it seems to me that this evidence would be more to the point than a case of infanticide among ourselves. Further, suppose I were to test French administration by the statistics of mortality in the Crimea, as given at the late meeting of the French Association for the Advancement of Science, by M. Le Fort, who pointed out that—

"During those six months of winter, 1855–'56, when hostilities were almost suspended, the English having only 165 wounded in six months, and the French 323, the English army, thanks to the precautions taken, had but few men in the hospitals and lost only 606, while the French army witnessed the outbreak of the typhus in its midst, though it might have been avoided, and lost, from disease alone, 21,190 men."

and who further, respecting the relative mortalities from operations, said that—

"In the Crimea the English and French armies were exposed to the same wants, to the same atmospheric changes, and yet what a difference of mortality in surgical cases! The English lost 24 per cent. of their cases of arm-amputations, while we lost double that number, or 55 per cent. The same is to be said of amputations of the leg: 35 per cent. against 71."

—suppose, I say, that I were thus to deal with the notion that "they manage these things better in France." Mr. Arnold would, very likely, not abandon his belief. And yet this contrast would certainly be as damaging as the fact about the girl Wragg, to which he more than once refers so emphatically. Surely it is manifest enough that, by selecting the evidence, any society may be relatively blackened, and any other society relatively whitened.

From Mr. Arnold's method let us turn to some of his specific statements: taking first the statement that the English are deficient in ideas.

[1] *Lancet*, December 28, 1872.

He says: "There is the world of ideas, and there is the world of practice; the French are often for suppressing the one, and the English the other."[1] Admitting the success of the English in action, Mr. Arnold thinks that it goes along with want of faith in speculative conclusions. But by putting ideas and practice in this antithesis, he implies his acceptance of the notion that effectual practice does not depend on superiority of ideas. This is an erroneous notion. Methods that answer are preceded by thoughts that are true. A successful enterprise presupposes an imagination of all the factors, and conditions, and results; which differs from the imagination leading to an unsuccessful enterprise in this, that what will happen is clearly and completely foreseen, instead of being foreseen vaguely and incompletely: there is greater ideality. Every scheme is an idea; every scheme, more or less new, implies an idea more or less original; every scheme proceeded with, implies an idea vivid enough to prompt action; and every scheme which succeeds, implies an idea so accurate and exhaustive that the results correspond with it. When an English company accommodates Amsterdam with water—an element the Dutch are very familiar with, and in the management of which they, centuries ago, gave us lessons—must we not say that, by leaving us to supply their chief city, they show a want of confidence in results ideally seen? Is it replied that the Dutch are not an ideal people? Then take the Italians. How happens it that such a pressing need as the draining of Naples has never suggested to Italian rulers or Italian people the taking of measures to achieve it; and how happens it that the idea of draining Naples, instead of emanating from French or Germans, supposed by Mr. Arnold to have more faith in ideas, emanates from a company of Englishmen, who are now proposing to do the work without cost to the municipality?[2] Or what shall we infer as to relative faith in ideas, on learning that even within their respective territories the French and Germans wait for us to undertake new things for them? When we find that Toulouse and Bordeaux were lighted with gas by an English company, must we not infer lack of ideas in the people of those places? When we find that a body of Englishmen, the Rhone Hydraulic Company, seeing that at Bellegarde there are rapids having a fall of forty feet, made a tunnel carrying a fourth of the river, and so got 10,000 horse-power, which they are selling to manufacturers; and when we ask why this source of wealth was not utilized by the French themselves; must we not say that it was because the idea did not occur to them, or because it was not vivid and complete enough to prompt the enterprise? And when, on going north, we discover that not only in Belgium and Holland are the chief towns, Brussels, Antwerp, Lille, Ghent, Rotterdam, Amsterdam, Haarlem, etc., lighted by our Continental Gas Association, but that this combination of Englishmen lights many towns in Germany also—Hanover, Aix-la-Chapelle, Stolberg,

[1] "Essays in Criticism," p. 12.

[2] *Times*, January 22, 1873.

Cologne, Frankfort, Vienna, nay, that even the headquarters of *geist*, Berlin itself, had to wait for light until this Company supplied it, must we not say that more faith in ideas was shown by English than by Germans? Germans have plenty of energy, are not without desire to make money, and knew that gas was used in England; and, if neither they nor their Governments undertook the work, we must infer that the benefits and means were inadequately conceived. English enterprises have often been led by ideas that looked wholly unpractical; as when the first English steamer astonished the people of Bonn by making its appearance there, so initiating the Rhine steam-navigation; or as when the first English steamer started across the Atlantic. Instead of our practice being unideal, the ideas which guide it sometimes verge on the romantic. Fishing-up a cable from the bottom of an ocean three miles deep, was an idea seemingly more fitted for the "The Arabian Nights" than for actual life; yet success proved how truly those who conducted the operation had put together their ideas in correspondence with the facts—the true test of vivid imagination.

To show the groundlessness of the notion that new ideas are not evolved and appreciated as much in England as elsewhere, I am tempted here to enumerate our modern inventions of all orders; from those directly aiming at material results, such as Trevethick's first locomotive, up to the calculating-machines of Babbage and the logic-machine of Jevons, quite remote from practice in their objects. But, merely asserting that those who go through the list will find that neither in number nor in importance do they yield to those of any nation during the same period, I refrain from details. Partly I do this because the space required for specifying them would be too great; and partly because inventions, mostly having immediate bearings on practice, would perhaps not be thought by Mr. Arnold to prove fertility of idea: though, considering that each machine is a theory before it becomes a concrete fact, this would be a position difficult to defend. To avoid all possible objection, I will limit myself to scientific discovery, from which the element of practice is excluded; and, to meet the impression that scientific discovery in recent days has not maintained its former pace, I will name only our achievements since 1800.

Taking first the Abstract Sciences, let us ask what has been done in Logic. We have the brief but pregnant statement of inductive methods by Sir John Herschel, leading to the definite systematization of them by Mr. Mill; and we have, in the work of Prof. Bain, elaborately-illustrated applications of logical methods to science and to the business of life. Deductive Logic, too, has been developed by a further conception. The doctrine of the quantification of the predicate, set forth in 1827 by Mr. George Bentham, and again set forth under a numerical form by Prof. De Morgan, is a doctrine supplementary to that of Aristotle; and the recognition of it has made it easier than before to see that Deductive Logic is a science of the relations implied by the inclusions, exclusions, and overlappings of classes.[1] Even were this all, the instalment of progress would be large for a single generation. But it is by no means all. In the work by Prof. Boole, "Investigation of the Laws of Thought," the application to Logic of methods like those of Mathematics, constitutes another step far greater in originality and in importance than any taken since Aristotle. So that, strangely enough, the assertion quoted above, that "we are backward in appreciating and pursuing abstract knowledge," and this complaint of Mr. Arnold that our life is wanting in ideas, come at a time when we have lately done more to advance the most abstract and purely-ideal science than has been done anywhere else, or during any past period!

In the other division of Abstract Science—Mathematics—a recent revival of activity has brought results sufficiently striking. Though, during a long period, the bias of patriotism and an undue reverence for that form of the higher calculus which Newton initiated, greatly retarded us; yet since the recommencement of progress, some five-and-twenty years ago, Englishmen have again come to the front. Sir W. R. Hamilton's method of Quaternions is a new instrument of research; and, whether or not as valuable as some think, undoubtedly adds a large region to the world of known mathematical truth. And then, more important still, there are the achievements of Cayley and Sylvester in the development of the higher algebra. From competent and unbiassed judges I learn that the Theory of Invariants, and the methods of investigation which have grown out of it, constitute a step in mathematical progress larger than any made since the Differential Calculus. Thus, without enumerating the minor achievements of others, there is ample proof that abstract science, of this order also, is flourishing among us in great vigor.

Nor, on passing to the Abstract-Concrete sciences, do we find any better ground for this belief entertained by Mr. Arnold and others. Though Huyghens conceived of light as constituted of undulations, yet he was wrong in conceiving the undulations as allied in form to those of sound; and it remained for Dr. Young to establish the true theory. Respecting the principle of interference of the rays of light propounded by Young, Sir John Herschel says: "Regarded as a physical law [it] has hardly its equal for beauty, simplicity, and extent of application, in the whole circle of science;" and of Young's all-impor-

[1] Most readers of logic will, I suppose, be surprised on missing from the above sentence the name of Sir W. Hamilton. They will not be more surprised than I was myself on recently learning that Mr. George Bentham's work, "Outline of a New System of Logic," was published six years before the earliest of Sir W. Hamilton's logical writings, and that Sir W. Hamilton reviewed it. The case adds another to the multitudinous ones in which the world credits the wrong man; and persists in crediting him in defiance of evidence.

tant discovery that the luminiferous undulations are lateral not longitudinal, he says that it showed "a sagacity which would have done honor to Newton himself." Just naming the discovery of latent heat by Black, the discrimination by Wollaston of quantity and intensity in electricity, and the disclosure of electrolysis by Nicholson and Carlisle (all of them cardinal discoveries) and passing over minor contributions to physical science, we come to the great contributions of Faraday—magneto-electricity, the quantitative law of electrolysis, the magnetization of light, and dia-magnetism: not mentioning others of much significance. Next there is the great truth which men still living have finally established—the correlation and equivalence of the physical forces. In the establishment of this truth Englishmen have had a large share—some think the larger share. Remembering that in England the conception of heat as a mode of motion dates from Bacon, by whom it is expressed with an insight that is marvellous considering the knowledge of his time—remembering, too, that "Locke stated a similar view with singular felicity;" we come, among Englishmen of the present century, first to Davy, whose experiments and arguments so conclusively supported those of Rumford; then to the view of Roget and the postulate on which Faraday habitually reasoned, that all force arises only as other force is expended; then to the essay of Grove, in which the origin of the various forms of force out of one another was abundantly exemplified; and finally to the investigations by which Joule established the quantitative relations between heat and motion. Without dwelling on the important deductions from this great truth made by Sir W. Thomson, Rankine, Tyndall, and others, I will merely draw attention to its highly-abstract nature as again showing the baselessness of the above-quoted notion.

Equally conclusive is the evidence when we pass to Chemistry. The cardinal value of the step made by Dalton, in 1808, when the *aperçu* of Higgins was reduced by him to a scientific form, will be seen on glancing into Wurtz's "Introduction to Chemical Philosophy," and observing how the atomic theory underlies all subsequent chemical discovery. Nor, in more recent days, has the development of this theory fallen unduly into foreign hands. Prof. Williamson, by reconciling the theory of radicals with the theory of types, and by introducing the hypothesis of condensed molecular types, has taken a leading part in founding the modern views of chemical combinations. We come next to the cardinal conception of atomicity. In 1851, Prof. Frankland initiated the classification of the elements by their atomicities: his important generalization being now avowedly accepted in Germany by those who originally disputed it; as by Kolbe in his "Moden der Modernen Chemie." On turning from the more general chemical truths to the more special chemical truths, a like history meets us. Davy's discovery of the metallic bases of the alkalies and earths was an all-important step. Passing over many other achievements in special chemistry, I may single out, for their significance, the discoveries of Andrews, Tait, and especially of Brodie, respecting the constitution of ozone as an allotropic form of oxygen; and may join with these Brodie's discoveries respecting the allotropic forms of carbon, as throwing so much light on allotropy at large. And then we come to the all-important discoveries, general and special, of the late Prof. Graham. The truths he established respecting the hydration of compounds, the transpiration and the diffusion of liquids, the transpiration and the diffusion of gases, the dialysis of liquids and the dialysis of gases, and the occlusion of gases by metals, are all of them cardinal truths. And even of still greater value is his luminous generalization respecting the crystalloid colloid states of matter—a generalization which, besides throwing light on many other phenomena, has given us an insight into organic processes previously incomprehensible. These results, reached by his beautifully-coherent series of researches extending over forty years, constitute a new revelation of the properties of matter.

Neither is it true that in advancing the Concrete Sciences we have failed to do our share. Take the first in order—Astronomy. Though, for the long period during which our mathematicians were behind, Planetary Astronomy progressed but little in England, and the development of the Newtonian theory was left chiefly to other nations; yet of late there has been no want of activity. When I have named the inverse problem of perturbations and the discovery of Neptune, the honor of which we share with the French, I have called to mind an achievement sufficiently remarkable. To Sidereal Astronomy we have made great contributions. Though the conception of Wright, of Dur ham, respecting stellar distribution was here so little attended to that, when afterward enunciated by Kant (who knew Wright's views), and by Sir W. Herschel, it was credited to them; yet since Sir W. Herschel's time the researches in Sidereal Astronomy, by Sir John Herschel and others, have done much to further this division of the science. Quite recently the discoveries made by Mr. Huggins respecting the velocities with which certain stars and nebulæ are approaching us and others receding, have opened a new field of inquiry; and the inferences reached by Mr. Proctor respecting the "drifting" of star-groups, now found to harmonize with the results otherwise reached by Mr. Huggins, go far to help us in conceiving the constitution of our galaxy. Nor must we forget how much has been done toward elucidating the physical constitutions of the heavenly bodies as well as their motions: the natures of nebulæ, and the processes going on in sun and stars, have been greatly elucidated by Huggins, Lockyer, and others.

In Geology, the progress made here, and especially the progress in geological theory, is certainly not less—good judges say much greater —than has been made elsewhere. Just noting that English geology goes back to Ray, whose notions were far more philosophical than those set forth long afterward by Werner, we come to Hutton, with whom in fact rational geology commences. For the untenable Neptunist hypothesis, asserting a once-universal aqueous action unlike the present, Hutton substituted an aqueous action, marine and fluviatile, continuously operating as we now see it, antagonized by a periodic igneous action: he recognized denudation as producing mountains and valleys; he denied so-called primitive rocks; he asserted metamorphism; he taught the meaning of unconformity. Since his day rapid advances in the same direction had been made. William Smith, by establishing the order of superposition of strata throughout England, prepared the way for positive generalizations; and, by showing that contained fossils are better tests of correspondence among strata than mineral characters, laid the basis for subsequent classifications. The better data thus obtained, theory quickly turned to account. In his "Principles of Geology," Lyell elaborately worked out the uniformitarian doctrine—the doctrine that the earth's crust has been brought to its present complex structure by the continuous operation of forces like those we see still at work. More recently, Prof. Ramsay's theory of lake-formation by glaciers has helped in the interpretation; and by him, as well as by Prof. Huxley, much has been done toward elucidating past distributions of continents and oceans. Nor must we forget Mallet's "Theory of Earthquakes"—the only scientific explanation of them yet given. And there must be added another fact of moment. Criticism has done far more here than abroad, toward overthrowing the crude hypothesis of universal "systems" of strata, which succeeded the still cruder hypothesis of universal strata, enunciated by Werner.

That our contributions to Biological Science have in these later times not been unimportant, may, I think, be also maintained. Just noting that the "natural system" of plant-classification, though French by development, is English by origin, since Ray made its first great division, and sketched out some of its subdivisions, we come, among English botanists, to Brown. He made a series of investigations in the morphology, classification, and distribution of plants, which in number and importance have never been equalled: the "Prodromus Floræ Novæ-Hollandia" is the greatest achievement in classification since Jussieu's "Natural Orders." Brown, too, it was who solved the mystery of plant-fertilization. Again, there is the conception that existing plant-distribution has been determined by past geological and physical changes—a conception we owe to Dr. Hooker, who has given us sundry wide interpretations in pursuance of it. In Animal-physiology there is Sir Charles Bell's discovery respecting the sensory and motor functions of the nerve-roots in the spinal cord; and this underlies multitudinous interpretations of organic phenomena. More recently we have had Mr. Darwin's great addition to biological science. Following in the steps of his grandfather, who had anticipated Lamarck in enunciating the general conception of the genesis of organic forms by adaptive modifications, but had not worked out the conception as Lamarck did, Mr. Darwin, perceiving that both of them were mistaken in attributing the modifications to causes which, though some of them true, were inadequate to account for all the effects, succeeded, by recognizing the further cause he called Natural Selection, in raising the hypothesis from a form but partially tenable to a quite tenable form. This view of his, so admirably worked out, has been adopted by the great majority of naturalists; and, by making the process of organic evolution more comprehensible, it is revolutionizing biological conceptions throughout the world. In the words of Prof. Cohn, "no book of recent times has influenced the conceptions of modern science like the first edition of Charles Darwin's 'Origin of Species.'"[1] Nor should we overlook the various kindred minor discoveries, partly dependent, partly independent: Mr. Darwin's own respecting the dimorphism of flowers; Mr. Bates's beautiful interpretation of mimicry in insects, which led the way to many allied interpretations; Mr. Wallace's explanations of dimorphism and polymorphism in *Lepidoptera*. Finally, Prof. Huxley, besides dissipating some serious biological errors of Continental origin, has made important contributions to morphology and classification.

Nor does the balance turn against us on passing to the next highest concrete science. After those earlier inquiries by which Englishmen so largely advanced the Science of Mind, and set up much of the speculation subsequently active in France and Germany, there came a lull in English thinking; and during this arose the absurd notion that the English are not a philosophical people. But the lull, ending some forty years ago, gave place to an activity which has quickly made up for lost time. On this point I need not rest in assertion, but will quote foreign testimony. The first chapter of Prof. Ribot's work, "*La Psychologie Anglaise Contemporaine*," begins thus:

> "'The sceptre of Psychology,' says Mr. Stuart Mill, 'has been decidedly restored to England.' It might be held that it had never passed out of her hand. Certainly, psychological studies are now pursued in that country by men of the first mark, who, by the solidity of their method, and, what is rarer still, by the precision of their results, have brought about a new era for science; but we might call this a reduplication rather than a renewal of former glory.'"

Similarly, on turning to Ethics considered under its psychological aspect, we find foreign testimony that English thinkers have done most toward the elaboration of a scientific system. In the preface to his late work, "*La Morale nella Filosofia Positiva*" (meaning, by "*Positiva*," simply scientific), Prof. Barzellotti, of Florence, states

[1] "*Die Entwicklung der Naturwissenschaft in den letzten fünfundzwanzig Jahren.*" By Prof. Dr. Ferdinand Cohn. Breslau, 1872.

that for this reason he limits himself to an account of English speculation in this department.[1]

And then, if, instead of Psychology and Ethics, Philosophy at large comes in question, there is independent testimony of kindred nature to be cited. Thus, in the first number of *La Critique Philosophique*, published under the direction of M. Rénouvier, the acting editor, M. Pillon writes:

> "In England a great amount of work is done in the field of thought. . . . Not alone does England surpass France in ardor and in work (for that is not saying much), and in the interest attaching to the researches and discussions of her thinkers: she even surpasses Germany itself in this last point."

And still more recently M. Martis, in the leading French periodical, has been referring to—

> "The new ideas which have sprung up in free England, and which are destined one day to metamorphose the natural sciences."[2]

So that, while Mr. Arnold is lamenting the want of ideas in England, it is discovered abroad that the genesis of ideas here is extremely active. While he thinks our ideas are commonplace, our neighbors find them new, to the extent of being revolutionary. Oddly enough, at the very time when he is reproaching his countrymen with lack of *geist*, Frenchmen are asserting that there is more *geist* here than elsewhere! Nor is there wanting other testimony of kindred nature. In the lecture above cited, Dr. Cohn, while claiming for Germany a superiority in the number of her earnest workers, says that "England especially has always been, and is particularly now, rich in men whose scientific works are remarkable for their astonishing laboriousness, clearness, profundity, and independence of thought"—a further recognition of the truth that the English, instead of drudging along the old ruts of thought, are distinguished by their ability in striking out new tracks of thought.

In his essay on the "Functions of Criticism at the Present Time," Mr. Arnold insists that the thing most needful for us now, in all branches of knowledge, is "to see the object as in itself it really is;" and in "Friendship's Garland," his *alter ego*, Arminius exhorts our Philistinism "to search and not rest till it sees things more as they really are." Above, I have done that which Mr. Arnold urges; not by picking up stray facts, but by a systematic examination. Feeling sure that Mr. Arnold has himself taken the course he advises, and is, therefore, familiar with all this evidence, as well as with the large quantity which might be added, I am somewhat puzzled on finding him draw from it a conclusion so different from that which presents itself to me. Were any one, proceeding on the foregoing data, to assert that, since the beginning of this century, more has been done in Eng-

[1] His reasons for this valuation are more fully given at p. 143.

[2] *Revue des Deux Mondes*, 1 Fevrier, 1873, p. 731.

land to advance scientific knowledge than has ever been done in a like interval, at any time, in any country, I should think his inference less wide of the truth than that which, strange to say, Mr. Arnold draws from the same data.

And now to consider that which more immediately concerns us—the effect produced by the bias of anti-patriotism on sociological speculation. Whether in Mr. Arnold, whom I have ventured to take as a type, the leaning toward national self-depreciation was primary and the overvaluing of foreign institutions secondary, or whether his admiration of foreign institutions was the cause and his tendency to depreciatory estimates of our social state the effect, is a question which may be left open. For present purposes it suffices to observe that the two go together. Mr. Arnold is impatient with the unregulated, and, as he thinks, anarchic state of our society; and everywhere displays a longing for more administrative and controlling agencies. "Force till right is ready," is one of the sayings he emphatically repeats; apparently in the belief that there can be a sudden transition from a coercive system to a non-coercive one—ignoring the truth that there has to be a continually-changing compromise between force and right, during which force decreases step by step, as right increases step by step, and during which every step brings some temporary evil along with its ultimate good. Thinking more force needful for us, and lauding institutions which exercise it, Mr. Arnold holds that even in our literature we should benefit by being under authoritative direction. Though he is not of opinion that an academy would succeed here, he casts longing glances at the French Academy, and wishes we could have had over us an influence like that to which he ascribes certain excellences in French literature.

The French Academy was established, as he points out, "to work, with all the care and all the diligence possible, at giving sure rules to our language, and rendering it pure, eloquent, and capable of treating the arts and sciences." Let us consider whether it has fulfilled this intention, by removing the most conspicuous defects of the language. Down to the present time, there is in daily use the expression *qu'est ce que c'est*, and even *qu'est ce que c'est que cela?* If in some remote corner of England is heard the analogous expression—"What is that there here?" it is held to imply entire absence of culture: the use of two superfluous words proves a want of that close adjustment of language to thought which even partially-educated persons among us have reached. How is it, then, that though in this French there are five superfluous words (or six, if we take *cela* as two), the purifying criticism of the French Academy has not removed it from French speech—not even from the speech of the educated? Or why, again, has the Academy not condemned, forbidden, and so expelled from the language, the double negative? If among ourselves any one lets drop the sentence, "I didn't say nothing," the inevitable inference is that he has lived with the ill-taught; and further, that in his mind words and ideas answer to one another very loosely. How is it, then, that in French, notwithstanding Academic control, this use of superfluous symbols of thought, which, logically considered, actually inverts the intended meaning, has continued—has become a rule instead of a solecism? Once more, why has not the French Academy systematized the genders? No one who considers language as an instrument of thought, which is good in proportion as its special parts are definitely adjusted to special functions, can doubt that a meaningless use of genders is a defect. It is undeniable that to employ marks of gender in ways always suggesting attributes that are possessed, instead of usually suggesting attributes that are not possessed, is an improvement. Having an example of this improvement before them, why did not the Academy introduce it into French? And then—more significant question still—how, without the aid of any Academy, came the genders to be systematized in English? Mr. Arnold, and those who, in common with him, seem to believe only in agencies that have visible organizations, might, perhaps, in seeking the answer to this question, lose faith in artificial appliances and gain faith in natural processes. For, as, on asking the origin of language in general, we are reminded that its complex, marvellously-adjusted structure has been evolved without the aid or oversight of any embodied power, Academic or other, so, on asking the origin of this particular improvement in language, we find that it, too, arose naturally, not artificially. Nay, more, it resulted from one of those unregulated, anarchic states which Mr. Arnold so much dislikes. Out of the conflict of Old-English dialects, sufficiently allied to coöperate, but sufficiently different to have contradictory marks of gender, there came a disuse of meaningless genders and a survival of the genders having meaning—a change which an Academy, had one existed here in those days, would doubtless have done its best to prevent; seeing that during the transition there must have been a disregard of rules, and apparent corruption of speech, out of which no benefit could have been anticipated.

Another fact respecting the French Academy is by no means congruous with Mr. Arnold's conception of its value. The compiling of an authoritative dictionary was a fit undertaking for it. Just recalling the well-known contrast between its dilatory execution of this undertaking, and the active execution of a kindred one by Dr. Johnson, we have more especially to note the recent like contrast between the performances of the Academy and the performances of M. Littré. The Academy has long had in hand two dictionaries—the one a second edition of its original dictionary, the other an historical dictionary. The first is at letter D; and the initial number of the other, containing A—B, issued fifteen years ago, has not yet had a successor. Meanwhile, M. Littré, single-handed, has completed a dictionary which, besides doing all that the two Academy dictionaries propose to do, does much more. With which marvellous contrast we have to join the startling fact, that M. Littré was refused admission to the Academy in 1863, and at length admitted in 1871 only after violent opposition.

Even if we pass over these duties which, in pursuance of its original purpose, the French Academy might have been expected to perform, and limit ourselves to the duty Mr. Arnold especially dwells upon—the duty of keeping "the fine quality of the French spirit unimpaired," and exercising "the authority of a recognized master in matters of tone and taste" (to quote his approving paraphrase of M. Rénan's definition)—it may still, I think, be doubted whether there have been achieved by it the benefits Mr. Arnold alleges, and whether there have not been caused great evils. That its selection of members has tended to encourage bad literature instead of good, seems not improbable when we are reminded of its past acts, as we are in the letter of Paul Louis Courier, in which there occurs this, among other passages similarly damaging:

"A duke and peer confers honor upon the French Academy which will have nothing to do with Boileau, rejects la Bruyère . . . . but readily admits Chapelain and Conrart. In like manner we see a viscount invited to the Acedémie greeque, but Corai repulsed, while Jornard comes in as though it were to work in a mill."

Nor have its verdicts upon great works been such as to encourage confidence: instance the fact that it condemned the "Cid" of Corneille, now one of the glories of French literature. Nor has its theory of art been beyond question. Upholding those canons of dramatic art which so long excluded the romantic drama, and maintained the feeling shown by calling Shakespeare an "inspired barbarian," may possibly have been more detrimental than beneficial. And when we look, not at such select samples of French literary taste as Mr. Arnold quotes, but at samples from the other extreme, we may question whether the total effect has been great. If, as Mr. Arnold thinks, France "is the country in Europe where the *people* is most alive," it clearly is not alive to the teachings of the Academy: witness the recent revival of the "Père Duchêne," the contents of which are no less remarkable for their astounding obscenity than for their utter stupidity. Nay, when we look only where we are told to look—only where the Academy exercises its critical function, we find reason for skepticism. Instance the late award of the Halpin Prize to the author of a series of poems called "L'Invasion," of which M. Patin, a most favorable critic, says:

"Their chief characteristic is a warmth of sentiment and a '*verve*,' which one would wish to see under more restraint, but against which one hesitates to set up, however just might be their application under other circumstances, the cold requirements of taste.'

Thus we have the Academy pandering to the popular feeling. The ebullitions of a patriotic sentiment which it is the misfortune of France to possess, in too great a degree, are not checked by the Academy, but encouraged by it, even at the expense of good taste.

And then, lastly, observe that some of the most cultivated Frenchmen, not so well satisfied with institutions of the Academy-type as Mr. Arnold seems to be, have recently established, on an English model, a French Association for the Advancement of the Sciences. Here are passages from their prospectus, published in *La Revue Scientifique*, 20 Janvier, 1872; commencing with an account of the founding of the Royal Institution:

"There were at this meeting fifty-eight members. Each one of these put down his name without more ado for fifty guineas, or nearly 1,300 francs of our money—equal to 2,000 francs at the present day. On the morrow the Royal Institution of London was established. We know what it came to be afterward.

"What Englishmen did, in 1799, some eminent *savants* of our own country would repeat to-day in France. Like Rumford, in the last century, they thought that the ancient supremacy of the French name in all branches of science was beginning to decay, and threatened one day to fall.

"God forbid that they should charge this decay upon the French Academy, of which they are themselves nearly all members! But the Academy, though it maintains the prestige of its name in Europe, is growing weak in the majesty of its greatness. It neither possesses sufficient means of action, nor is its energy sufficiently active to use those it has. The sinews of war—money—are lacking, but, what the Academy lacks still more, is bold and intelligent enterprise. It has fallen asleep upon the honors secured to it in the traditions of centuries."

Thus, curiously enough, we find another contrast parallel to that noted above. While Mr. Arnold is lauding French institutions, Frenchmen, recognizing their shortcomings, are adopting English institutions. From which we may fairly infer that, great as is Mr. Arnold's desire "to see the object as in itself it really is," he has not in this case succeeded; and that, endeavoring to escape the bias of patriotism, he has been carried too far the other way by the bias of anti-patriotism.

One more illustration of the effect of this bias on Mr. Arnold calls for brief comment. Along with his over-valuation of foreign regulative institutions, there goes an under-valuation of institutions at home which do not exhibit the kind of regulation he thinks desirable, and stand in the way of authoritative control. I refer to those numerous Dissenting organizations characterizing this "anarchy" of ours, which Mr. Arnold curiously makes the antithesis to "culture."

Mr. Arnold thinks that, as a nation, we show undue faith in machinery:

"Faith in machinery is, I said, our besetting danger. . . . What is freedom but machinery? what is population but machinery? what is coal but machinery? what are railroads but machinery? what is wealth but machinery? what are religious organizations but machinery?"[1]

And in pursuance of this conception he instances the desire to get Church-rates abolished and certain restrictions on marriage removed, as proving undue belief in machinery among Dissenters; while his own disbelief in machinery he considers proved by wishing for stronger governmental restraints,[2] by lauding the supervision of an Academy, and by upholding a Church Establishment. I must leave unconsidered the question whether an Academy, if we had one, would authorize this use of language, which makes it seem that voluntary religious agency is machinery and that compulsory religious agency is not machinery. I must pass over, too, Mr. Arnold's comparision of Ecclesiasticism and Nonconformity in respect of the men they have produced. Nor have I space to examine what he says about the mental attitudes of the two. It must suffice to say that, were the occasion fit, it might be shown that his endeavor "to see the object as in itself it really is" has not succeeded much better in this case than in the cases above dealt with. Here I must limit myself to a single criticism.

The trait which in Mr. Arnold's view of Nonconformity seems to me most remarkable is, that in breadth it so little transcends the view of the Nonconformists themselves. The two views greatly differ in one respect—antipathy replaces sympathy; but the two views are not widely unlike in extension. Avoiding that provincialism of thought which he says characterizes Dissenters, I should have expected Mr. Arnold to estimate Dissent, not under its local and temporary aspect, but under its general aspect as a factor in all societies at all times. Though the Nonconformists themselves think of Nonconformity as a phase of Protestantism in England, Mr. Arnold's studies of other nations, other times, and other creeds, would, I should have thought, have led him to regard Nonconformity as a universal power in societies, which has in our time and country its particular embodiment, but which is to be understood only when contemplated in all its other embodiments. The thing is one in spirit and tendency, whether shown among the Jews, or the Greeks—whether in Catholic Europe, or in Protestant England. Wherever there is disagreement with a current belief, no matter what its nature, there is Nonconformity. The open expression of difference, and avowed opposition to that which is authoritatively established, constitutes Dissent, whether the religion be Pagan or Christian, Monotheistic or Polytheistic. The relative attitudes of the dissenter and of those in power are essentially the same in all cases; and in all cases lead to persecution and vituperation. The Greeks who poisoned Socrates were moved by just the same sentiment as the Catholics who burnt Cranmer, and the Protestant Churchmen who imprisoned Bunyan and pelted Wesley. And, while the manifestations of feeling are essentially the same, while the accom-

[1] "Culture and Anarchy," p. 16. [2] Ibid., pp. 130-140.

panying evils are essentially the same, the resulting benefits are essentially the same. Is it not a truism that without divergence from that which exists, whether it be in politics, religion, manners, or any thing else, there can be no progress? And is it not an obvious corollary that the temporary evils accompanying the divergence, are outbalanced by the eventual good? It is certain, as Mr. Arnold holds, that subordination is essential; but it is also certain that insubordination is essential—essential, if there is to be any improvement. There are two extremes in the state of a social aggregate, as of every other aggregate, which are fatal to evolution—rigidity and incoherence. A medium plasticity is the healthful condition. On the one hand, a force of established structures and habits and beliefs, such as offers considerable resistance to change; on the other hand, an originality, an independence, and an opposition to authority, energetic enough to overcome the resistance little by little. And, while the political nonconformity we call Radicalism has the function of thus gradually modifying one set of institutions, the religious nonconformity we call Dissent has the function of thus gradually modifying another set.

That Mr. Arnold does not take this entirely-unprovincial view, which would lead him to look on Dissenters with less aversion, may in part, I think, be ascribed to that over-valuation of foreign restraints and under-valuation of home freedom, which his bias of anti-patriotism fosters; and serves further to illustrate the disturbing effects of this bias on sociological speculation.

And now to sum up this somewhat too elaborate argument. The general truth that, by incorporation in his society, the citizen is in a measure incapacitated for estimating rightly its characters and actions in relation to those of other societies, has been made abundantly manifest. And it has been made manifest also that when he strives to emancipate himself from these influences of race, and country, and locality, which warp his judgment, he is apt to have his judgment warped in the opposite way. From the perihelion of patriotism he is carried to the aphelion of anti-patriotism; and is almost certain to form views that are more or less eccentric, instead of circular, all-sided, balanced views.

Partial escape from this difficulty is promised by basing our sociological conclusions chiefly on comparisons made among other societies—excluding our own. But even then these perverting sentiments are sure to intrude more or less; for we cannot contemplate the institutions of other nations without our sympathies or antipathies being in some degree aroused by consciousness of likeness or unlikeness to our own institutions. Discounting our conclusions as well as we may, to allow for the errors we are thus led into, we must leave the entire elimination of such errors to a future in which the decreasing antagonisms of societies will go along with decreasing intensities of these sentiments.

ENGLISH AND AMERICAN SCIENCE.[1]

By JOHN W. DRAPER, LL. D.

MR. PRESIDENT: When I was in London a year or two ago, I passed some pleasant hours with my friend Prof. Tyndall. Among these, I think that, perhaps, the most pleasant were those of one afternoon that we spent together in the laboratory of the Royal Institution, where Davy discovered potassium and sodium, and decomposed the earths; where Young first announced the grand and fertile principle of interference, and placed on firm foundations the wave-theory of light; where Faraday made his great discoveries in electricity and magnetism. On that occasion Dr. Tyndall was showing me some of his own splendid discoveries—the action of ether-waves of short period upon gaseous matter, clouds formed by actinic decomposition. I saw the superb sky-blue light, and verified its polarized condition. It was like the light of heaven.

Well, as I laid down the Nicol prism we had been using, I could not help thinking that there was an unseen "presence" in the place—a *genius loci*—that inspired men to make such discoveries. Who was it that brought that genius there?

At the time of the American Revolution, there resided in the town of Rumford, N. H., one Benjamin Thompson, who occupied himself in teaching a school. He embraced, as we Americans would say, the wrong side of the question on that occasion—he sided with the king's government. He went to England, became a man of mark, and was knighted. Then he went on the Continent, again distinguished himself by his scientific attainments, again was titled, and this time, in memory of his American home, was called Count Rumford.

On his return to London, Count Rumford founded the Royal Institution, and thus to a native American the world owes that establishment which has been glorified by Davy, and Young, and Faraday, and the lustre of which is now so conspicuously maintained by Tyndall. Had it not been for Rumford, Davy might have spent his life in filling gas-bags for Dr. Beddoes's patients; Faraday might have been a bookbinder, and certainly Tyndall would not have been honoring us with his presence here to-night.

But if Benjamin Thompson, an American, founded the Royal Institution, James Smithson, an Englishman, shortly afterward founded that noble institution in Washington which bears his name, and which, under the enlightened care of Prof. Henry, has so greatly ministered to the advancement and diffusion of science. You, sir, have called on me to respond to your toast, "English and American Science," and I think these facts show you how closely they have been associated.

[1] Address at the Tyndall Banquet.

Now, Prof. Tyndall is on the point of leaving us. When he gets back to Albemarle Street, he will remember Broadway. I am sure that you will all join me in wishing him a pleasant voyage over the Atlantic. But I wish him something better than that, I will add—a safe return to America. There is a great deal for him to do here yet. He may tell his friends that he has been to America, but he must not tell them that he has seen the Americans. We who are living on the Atlantic verge of the continent are only modified Europeans—very slightly modified, indeed. One must go beyond the Alleghanies—yes, and over to the Pacific coast, before he can say he has seen what the American really is. I suppose that Dr. Tyndall has finished his glacier expeditions to Switzerland. Is there nothing here that can tempt him? He and other members of the Alpine Club need not go about the streets of London weeping, like so many broken-hearted Alexanders, that there are no more worlds to conquer. Let them take a look at the Rocky Mountains, and tell us what they think of them. Dr. Tyndall is a lover of Nature. Well! we can show him all kinds of scenery, from where the half-frozen Mackenzie is lazily flowing through a waste of snows on its way toward the Arctic Ocean, to where oranges are growing on the Gulf. Or, if he is tired of inanimate Nature, and is in the mood of Dr. Johnson—you know the story. Boswell said to Johnson one day: "See! What a beautiful afternoon; let us take a walk in the green fields." "No, I won't," replied the grim and gruff lexicographer. "I've seen green fields; one green field is like another green field. They are all alike. No, sir! I'll walk down Cheapside. I like to look at men"—if Dr. Tyndall is in that mood, can we not satisfy his curiosity? Another friend of mine, Mr. Froude, has set us all talking about Ireland. We can show Dr. Tyndall how we take the Irish immigrant, in his corduroy knee-breeches, his smashed-down hat, and his shillalah in his fist, and, in a generation or so, turn him into an ornament of professional life, make him a successful merchant, or familiarize him with all the amenities of elegant society. If that's not enough, we will show him how we take the German, and, wonderful to be said, make him half forget his fatherland and half his mother-tongue, and become an English-speaking American citizen. If that's not enough, we will show him how we have purged the African, the woolly-headed black man, of the paganism of his forefathers, and are now trying our hand at Darwinizing him into a respectable voter. If that's not enough, we will show him how, in the trans-Mississippi plains, we are improving the red Indian—alas! I fear my friend will say, improving him off the face of the earth! If that's not enough, we will show him where we have got tens of thousands of Chinese, with picks and shovels, digging Pacific railways. We are mixing European and Asiatic, red Indians and black Africans, together, and I suppose certain English naturalists will tell us that the upshot of the thing will be a survival of the fittest. In San Francisco, we can show Dr. Tyndall the church, the chapel, the joss-house, all in a row, and, perhaps, considering his forlorn, celibate condition, he may be conscience-stricken when we display before his astonished eyes the much-married men of Mormondom.

Nowhere in the world are to be found more imposing political problems than those to be settled here; nowhere a greater need of scientific knowledge. I am not speaking of ourselves alone, but also of our Canadian friends, on the other side of the St. Lawrence. We must join together in generous emulation of the best that is done in Europe. In her Majesty's representative, Lord Dufferin, they will find an eager appreciation of all that they may do. Together we must try to refute what De Tocqueville has said about us: that communities such as ours can never have a love of pure science. But, whatever may be the glory of our future intellectual life, let us both never forget what we owe to England. Hers is the language that we speak; hers are all our ideas of liberty and law. To her literature, as to a fountain of light, we repair. The torch of science that is shining here was kindled at her midnight lamp.

SCIENCE AND PUBLIC AFFAIRS.[1]

By President ANDREW D. WHITE,
OF CORNELL UNIVERSITY.

MR. CHAIRMAN: There is a legend well known to most of us—and which has an advantage over most legends in that it is substantially true—that a very distinguished man of science in this country was once approached by an eminent practical man, and urged to turn his great powers in scientific investigation and exposition to effect in making a fortune.

And, to the great surprise of that man of business, the man of science responded, "But, my dear sir, *I have no time to waste in making money*."

Of all the recent great results of science, I think, sir, that those words have struck deepest and sped farthest in the average carnal mind on our side the Atlantic.

"No time to waste in making money!" I have stood sir, in the presence of a very eminent man of affairs—one whose word is a power in the great marts of the world, and watched him as he heard for the first time this astonishing *dictum*. He stood silent—apparently in awe. The words seemed to reverberate among the convolutions of his brain, and to be reëchoed far away, back, from depth to depth, among the deepest recesses of his consciousness—"No time to waste in making money!"

[1] Address at the Farewell Banquet to Professor Tyndall.

The honored guest of this evening comes among us as another of those men who, in following a very high vocation, have given no thought to money-getting.

Of course, indirectly, his brilliant discoveries have, in many cases, aided to heap up gold in the world's coffers, but that has not been the direct object of his life-work. As to the money value of most of his discoveries, you might as well try to fix the worth of a fixed star, or a baby. His career has been that of a seeker for new truth—and an eloquent proclaimer of it; and it is in this apostolate that he has been so warmly welcomed in this great metropolis of money-making.

The toast, sir, to which you ask me to speak is, "The Relation of Science to Political Progress."

Now, sir, I maintain that the true spirit of scientific research—incarnate before us in our honored guest—embracing as it does zeal in search for truth, devotion to duty which such a search imposes, faith in good as the normal and necessary result of such a search—that such a spirit is, at this moment, one of the most needed elements in the political progress of our country.

I might go on to show how usefully certain scientific methods might be brought to bear on the formation of political judgments, and in determining courses of political action. I might show how even a very moderate application of scientific principles would save us from what is constantly going on in municipal, State, or national legislation—the basing of important statutes to-day, on the supposition that two and two make four, and to-morrow on the theory that two and two make forty; but the hour is late, and I spare you; I will confine myself simply to the value, in our political progress, of the spirit and example of our honored friend, and of those like him.

What is the example which reveals that spirit? It is an example of *zeal*—zeal in search for the truth, *sought for truth's sake*—and not for the sake of material advantage; it is an example of *thoroughness*—of the truth sought in its wholeness, not in dilutions or adaptations, or suppressions, supposed to be healthy for this man's mind, or that man's soul; it is an example of *bravery*—the fearlessness that leads a truth-seeker to brave all outcry and menace; it is an example of *devotion to duty;* without which, for a steady force, as Prof. Tyndall just now observed, no worthy scientific work can be accomplished; and, finally, an example of *faith*—of a high and holy faith that the results of earnest truth-seeking cannot be other than good—faith that truth and goodness are inseparable—faith that there is a Power in the universe which forbids any honest truth-seeking to lead to lasting evil. A faith, this is, which has had its "noble army of martyrs" from long before Roger Bacon down to this present—martyrs not less real than that devoted saint, from whom, as I understand, our guest takes his name, who perished in the flames as a martyr to religious duty.

What I maintain then, is, that this zeal for truth as truth, this faith in the good as forever allied to the true, this devotion to duty as the result of such faith and zeal, constitute probably the most needed element at this moment in the political regeneration of this country, and that, therefore, the example of our little army of true devotees of science has an exceeding preciousness.

Said a justly-distinguished senator to me yesterday, in Washington: "The true American idea of education is to give all children a good and even start; then to hold up the prizes of life before them; then to say to them: 'Go in and win; let the smartest have the prizes.'"

Who of the common herd shall dispute the conclusions of a senator beneath the great cast-iron dome at Washington?—But here, in this presence, I may venture to say that such a theory of education is one of the main causes of our greatest national danger and disgrace. No theory can be more false, or, in the long-run, more fatal. Look at it for a moment:

We are greatly stirred, at times, as this fraud or that scoundrel is dragged to light, and there rise cries and moans over the corruption of the times; but, my friends, these frauds and these scoundrels are not the "corruption of the times." They are the mere pustules which the body politic throws to the service. Thank God, that there is vitality enough left to throw them to the surface! The disease is below all this; infinitely more wide-spread.

What is that disease? I believe that it is, first of all, *indifference*—indifference to truth as truth; next, *skepticism*, by which I do not mean inability to believe this or that dogma, but the skepticism which refuses to believe that there is any power in the universe strong enough, large enough, good enough, to make the thorough search for truth safe in every line of investigation; next, *infidelity*, by which I do not mean want of fidelity to this or that dominant creed, but want of fidelity to that which underlies all creeds, the idea that the true and the good are one; and, finally, *materialism*, by which I do not mean this or that scientific theory of the universe, but that devotion to the mere husks and rinds of good, that struggle for place and pelf, that faith in mere material comfort and wealth, which eats out of human hearts all patriotism, and which is the very opposite of the spirit that gives energy to scientific achievement.

The education which our senatorial friend approved leads naturally to just this array of curses.

On the other hand, I believe that the little army of scientific men furnish a very precious germ from which better ideas may spring.

And we should strengthen them. We have already multitudes of foundations and appliances for the dilution of truth—for the stunting of truth—for the promotion of half-truths—for the development of this or that side of truth.

We have no end of intellectual hot-house arrangements for the cultivation of the plausible rather than the true; and therefore it is that we ought to attach vast value to the men who with calmness and determination seek THE TRUTH, in its wholeness, on whatever line of investigation, not diluting it or masking it.

Their zeal, their devotion, their faith, furnish one of those very protests which are most needed against that low tone of political ideas which in its lower strata is political corruption. Their life gives that very example of a high spirit, aim, and work, which the time so greatly needs.

In this view, then, sir, do I most heartily welcome our friend as a strong leader—not only in scientific, but in political and general progress. His influence has spread far beyond his lecture-room; nay, it shall spread far beyond those who have read or shall read his lectures.

I might speak of his quickening influence on one body of men—five hundred strong—assembled in one of our newer institutions of learning. But that influence extends far beyond those who stand in institutions of learning. The reverence for scientific achievement, the revelation of the high honors which are in store for those who seek for truth in science—the inevitable comparison between a life devoted to that great pure search, on one hand, and a life devoted to place-hunting or pelf-grasping on the other—all these shall come to the minds of thoughtful men in lonely garrets of our cities, in remote cabins on our prairies, and thereby shall come strength and hope for higher endeavor.

And, Mr. Chairman, as this influence for good spreads and strengthens, I have faith that gratitude will bring in results for political good of yet another kind.

Many predecessors of our friend have, as literary men, strengthened the ties that bind together the old land and the new; and I trust that love, admiration, and gratitude, between men of science on both sides the Atlantic, which our guest has done so much to arouse, may add new cords and give strength to old cords which unite the hearts of the two great English-speaking nations.

DISCOVERY OF MOUNT TYNDALL.[1]

By Prof. WILLIAM H. BREWER,
OF THE YALE SCIENTIFIC SCHOOL.

MY DEAR SIR: In answer to yours of the 6th, I may say that, being familiar with all the circumstances relating to the discovery and naming of *Mount Tyndall*, I was asked to respond to a toast alluding to this, at the dinner given in honor of Prof. Tyndall on the 4th, but which want of time prevented being called for. You now ask me for an abstract of what I intended to say. I will give it (as nearly as I can), and this the more willingly, as his success, as a

[1] Letter to Prof. Mayer, Secretary to Committee of the Tyndall Banquet.

mountaineer was not even alluded to by any of the speakers, nor was the fact that, in recognition of his discoveries in the Alps, one of the highest peaks in our country has been named for him.

In 1864 I had charge of a party exploring the group of highest peaks of the Sierra Nevada, in California—the highest, in fact, in the United States. For several years I had been familiar with its distant aspects, as seen from nearly every side. The group was entirely unknown, however, so far as any accurate knowledge of its height, topography, or interior scenery, was concerned. Previous attempts to reach it had failed. Once we had been prevented by floods, and once turned from its flanks by hostile Indians. But this time we were more successful. Our camp was at 10,000 feet elevation, the deep, blue-black canopy of sky our only shelter. From this point our first attempt failed. Two of us reached an altitude of nearly 14,000 feet, only to find the crest nearly five miles beyond, and separated from us by a cañon 3,000 or more feet deep, with vertical precipices of perhaps 1,000 feet below us, and, still farther below, frozen lakes of vivid blue. We turned back, weary and dispirited.

That night, the intrepid Clarence King earnestly begged that he be permitted to try, with Cotter, to reach the summit. I hesitated. We were short of provisions, and far from supplies. Moreover, I had seen the difficulties, and he had not, but he had read Tyndall's "Glaciers of the Alps," and thought no place inaccessible. Permission was at length given, but this meant partial starvation to those of us remaining, that they might have the necessary food, and to those who went it meant fatigue, sleeping among the rocks at 11,000 or 12,000 feet, hard climbing, and doubtful success.

Early dawn of July 4th found us on the way, with instruments and six days' provisions. We carried their packs up to 13,000 feet, to lighten their labors, then pointed out the way they must take, and, after a hearty shake of the hand, saw them descend into the cañon and disappear. The evening of the fifth day saw their return; they had reached the summit, and were back in safety. By the light of the camp-fire that night I calculated the height as well as I could from their observations. It was the highest unnamed peak that had yet been measured in the country, so we called it Mount Tyndall.

This peak now finds a place on our maps. Its position is about latitude 36° 39′ north, longitude 118° 19′ west, and its height 14,386 feet. It is one of a group of peaks, several of which are above 14,000 feet, amid the most sublime surroundings. The peaks are buttressed with ridges of granite, streaked with the snows of ages, and furrowed with cañons, the desolation of the scene increased rather than relieved by the many little blue lakes that repose in the ancient glacier-beds. This group is a part of that chain which stretches from Cape Horn to Behring's Straits, the grandest mountain-system on our planet. Here is the monument bearing the name of our honored guest.

PROFESSOR JOSEPH HENRY.

Prof. Tyndall's books are now so widely read that the name is almost a household word where our common language is spoken. We cannot hope that it will be so a hundred years hence; with the advance of scientific knowledge, the new generations will read new books, and ours be buried or partially hidden in the great ocean of scientific literature. But I look forward in imagination, and see that the man will not be forgotten; he will be remembered as one who loved and advanced science. This peak will perhaps still more keep his memory green, and the coming generations of school-children conning their lessons in geography, and philosophers studying the grander features of our globe, will learn to pronounce the name of one who loved mountains even as he loved science.

SKETCH OF PROFESSOR HENRY.

PROF. JOSEPH HENRY, who is widely known throughout the scientific world for his various original investigations, and as the organizer and Permanent Secretary of the Smithsonian Institution, is of Scotch descent, and was born in Albany, in the State of New York. Having lost his father in early childhood, he was sent at the age of seven years to live with his grandmother, and to attend school at Galway, in Saratoga County, where he remained until he was fourteen. Having accidentally and secretly obtained access to the village library, he became fascinated with books of fiction, and devoted much of his time to reading. Returning to Albany, he was apprenticed to the trade of a jeweller, with which he was occupied two years. He afterward developed a passion for serious study, and became teacher of a country district school. He studied for a time in the Albany Academy, and, through the recommendation of its principal, Dr. T. Romeyn Beck, was appointed private tutor in the family of General Stephen Van Rensselaer, the patroon of Rensselaerwyck. There his duties occupied him three hours a day, and the rest of his time was spent as an assistant to Dr. Beck, in his chemical investigations; but he also studied anatomy and physiology, with a view to graduating in medicine. He, however, obtained a position as an engineer to survey a route for a State road from the Hudson River to Lake Erie, through the southern tier of counties. Having finished this arduous and responsible labor, he was elected to fill the vacant chair of Mathematics in the Albany Academy. As the duties did not begin immediately, he spent several months exploring the geology of New York State with Prof. Eaton, of the Rensselaer Institute of Troy. He entered upon his work at the academy in 1826, and then commenced a course of original investigations on electricity and magnetism, the first regular series on Natural Philosophy which had been prosecuted in this country since the days of Franklin. These researches made him favorably known not only in this country, but in Europe, and led to his call in 1832 to the chair of Natural Philosophy in the College of New Jersey, at Princeton.

In the first year of his course in this institution, during the absence of the Professor of Chemistry, Dr. Torrey, in Europe, he gave lectures in Natural Philosophy, Chemistry, Mineralogy, Geology, Astronomy, and Architecture. This work interrupted his original investigations, but he soon commenced anew where he had left off at Albany, and devoted himself to a work of research, until he was called to his present position in Washington. In 1835 he was granted by the trustees of the college a year's absence in Europe, nine months of which he spent principally in Paris, London, and Edinburgh, in intercourse with the *savants* of these cities, and procuring more efficient apparatus to prosecute his investigations.

Meantime Mr. John Smithson, of England had left a large sum of money to the Government of the United States, to be devoted "to the increase and diffusion of knowledge among men." An institution was projected to carry out this purpose, and in 1846 Prof. Henry was requested by some of the members of the Board of Regents to give his views as to the best methods of realizing the intentions of its founder. In compliance with this request he gave an exposition of the will, and of the method by which it might most efficiently be realized. On account of this exposition and his scientific reputation, he was called to the office of Secretary or Director of the establishment. Unfortunately, Congress had attempted to organize the institution without a due appreciation of the terms of the will. This gave rise to difficulties and expenditures on local objects, particularly to the commencement of a very expensive building, which have much retarded the full realization of what might have been produced by the plan originally proposed by Prof. Henry.

At the time of the organization of the Light-House Board of the United States, Prof. Henry was appointed by President Fillmore one of its members, and he still continues in the position. During the war he was appointed one of a commission, together with Prof. Bache and Admiral Davis, to examine and report upon various inventions, intended to facilitate the operations against the enemy, and to improve the art of navigation. On the death of Prof. Bache, he was elected President of the National Academy of Sciences, established by an act of Congress in 1863, to advance science, and to report upon such questions of a scientific character as might be connected with the operations of the Government. He is a member of various societies in this country and abroad, and has several times received the degree of LL. D., the last time from Cambridge, Massachusetts.

Prof. Henry was married in May, 1830, to Miss Alexander, of Schenectady, the sister of Prof. Alexander, of Princeton, and from the ardent devotion of his wife, and the fraternal sympathy of her brother in his pursuits, he has received assistance and support beyond that which usually fall to the lot of men. The most peaceful, and to himself the most profitable, part of his life was that spent in Princeton, for which place, and the college connected with it, he retains the warmest attachment.

The following is a brief enumeration of his scientific investigations and discoveries:

1. A sketch of the topography of the State of New York, embodying the results of the survey before mentioned.

2. In connection with Dr. Beck and the Hon. Simeon De Witt, the organization of the meteorological system of the State of New York.

3. The development, for the first time, of magnetic power, sufficient to sustain tons in weight, in soft iron, by a comparatively feeble galvanic current.

4. The first application of electro-magnetism as a power, to produce continued motion in a machine.

5. An exposition of the method by which electro-magnetism might be employed in transmitting power to a distance, and the demonstration of the practicability of an electro-magnetic telegraph, which, without these discoveries, was impossible.

6. The discovery of the induction of an electrical current in a long wire upon itself, or the means of increasing the intensity of a current by the use of a spiral conductor.

7. The method of inducing a current of quantity from one of intensity, and *vice versa*.

8. The discovery of currents of induction of different orders, and of the neutralization of the induction by the interposition of plates of metal.

The discovery that the discharge of a Leyden jar consists of a series of oscillations backward and forward until equilibrium is restored.

10. The induction of a current of electricity from lightning at a great distance, and proof that the discharge from a thunder-cloud also consists of a series of oscillations.

11. The oscillating condition of a lightning-rod while transmitting a discharge of electricity from the clouds causing it, though in perfect connection with the earth, to emit sparks of sufficient intensity to ignite combustible substances.

12. Investigations on molecular attraction, as exhibited in liquids, and in yielding and rigid solids, and an exposition of the theory of soap-bubbles. (These originated from his being called upon to investigate the causes of the bursting of the great gun on the United States steamer Princeton.)

13. Original experiments on, and exposition of, the principles of acoustics, as applied to churches and other public buildings.

14. Experiments on various instruments to be used as fog-signals.

15. A series of experiments on various illuminating materials for light-house use, and the introduction of lard-oil for lighting the coasts of the United States. This and the preceding in his office of chairman of the Committee on Experiments of the Light-House Board.

16. Experiments on heat, in which the radiation from clouds and animals in distant fields was indicated by the thermo-electrical apparatus applied to a reflecting telescope.

17. Observations on the comparative temperature of the sun-spots, and also of different portions of the sun's disk. In these experiments he was assisted by Prof. Alexander.

18. Proof that the radiant heat from a feebly luminous flame is also feeble, and that the increase of radiant light, by the introduction of a solid substance into the flame of the compound blow-pipe, is accompanied with an equivalent radiation of heat, and also that the increase of light, and radiant heat in a flame of hydrogen, by the introduction of a solid substance, is attended with a diminution in the heating power of the flame itself.

19. The reflection of heat from concave mirrors of ice, and its application to the source of the heat derived from the moon.

20. Observations, in connection with Prof. Alexander, on the red flames on the border of the sun, as observed in the annular eclipse of 1838.

21. Experiments on the phosphorogenic ray of the sun, from which it is shown that this emanation is polarizable and refrangible, according to the same laws which govern light.

22. On the penetration of the more fusible metals into those less readily melted, while in a solid state.

Besides these experimental additions to physical science, Prof. Henry is the author of twenty-five (1846–'71) reports, giving an exposition of the annual operations of the Smithsonian Institution. He has also published a series of essays on meteorology in the Patent-Office Reports, which, besides an exposition of established principles, contain many new suggestions; and, among others, the origin of the development of electricity, as exhibited in the thunder-storm; and an essay on the principal source of the power which does the work of developing the plant in the bud, and the animal in the egg.

He has also published a theory of elementary education, in his address as President of the American Association for the Advancement of Education, the principle of which is, that in instruction the order of Nature should be followed; that we should begin with the concrete and end with the abstract, the one gradually shading into the other; also the importance of early impressions, and the tendency in old age to relapse into the vices of early youth.

EDITOR'S TABLE.

OUR FIRST YEAR'S WORK.

WHEN THE POPULAR SCIENCE MONTHLY started, the public were informed that it would be published a year at any rate, and go on if fairly sustained; our second volume is now completed, and we are happy to announce that the enterprise will be continued, and gives promise of permanence. It was entered upon as an experiment, and generally thought to be a hopeless one. The quality of those periodicals which reach great circulation was pointed out as evidence of what the people demand, and we had the most discouraging assurances that they will not sustain a solid and really instructive magazine, which requires them to think. Believing, however, that there are large numbers who would gladly support such a monthly if they could get it, we determined to give them the chance, and have been justified in the result. Our MONTHLY is not only a success, but it has succeeded on its own merits alone. All the clap-trap artifices for rushing into a big circulation have been avoided: the public have neither been bribed by premiums, nor tempted by cheapness, nor lured by large promises, nor stunned by pictorial display, nor deafened by the trumpetings of self-praise, such as usually accompany the advent of new periodicals. We entered quietly upon the undertaking, and with its announcement the first number was ready, so that people might judge of it themselves. In our prospectus we said: "THE POPULAR SCIENCE MONTHLY will contain instructive and attractive articles and abstracts of articles, original, selected, and illustrated, from the leading scientific men of different countries, giving the latest interpretations of natural phenomena, explaining the applications of science to the practical arts, and to the operations of domestic life.

"It is designed to give especial prominence to those branches of science which help to a better understanding of the nature of man; to present the claims of scientific education, and the bearings of science upon questions of society and government; how the various subjects of current opinion are affected by the advance of scientific inquiry will also be considered." We appeal to the two volumes of the MONTHLY now completed in proof that these pledges have been fairly redeemed.

In stating that our enterprise is an undoubted success, it will, of course, not be understood that we have a circulation at all comparable with that of the leading periodicals devoted to light literature, but it is greater than was anticipated, and is steadily increasing. The undertaking has, moreover, met with wide sympathy and warm encouragement from the most intelligent class of readers throughout the country. There has been an almost unanimous expression of opinion on the part of individuals and the press that THE POPULAR SCIENCE MONTHLY has met an urgent public need, that it is the most valuable magazine now before the American public, and deserves an extensive patronage. For all these kind expressions, and for the substantial support which has accompanied them, we return to our friends the most cordial thanks.

But, while our work has been thus far approved, we are far from claiming that it has been perfect. It has the imperfections which are incident to a new project in a new field, and which it will require time and experience to remove. We intend to improve it in several important features. While pursuing the general plan now entered upon, we expect to enlarge its resources, to make more prominent the applications of science to common life, to give a more popular form to its discussions, and, in short, to make it a magazine that no family with brains in it can afford to do without.

Our object will continue to be to furnish a higher grade of reading for purposes of public instruction. In this matter the press of the country has been false to its trust. We have an educational system that brings the whole mass of the people up to the reading-point, and hardly carries them beyond it. The school-master, when he has done with them, hands his pupils over to the editors, and the Dailies, Weeklies, and Monthlies, go on with the work of education. In the school they are taught to worship books, and to consider print and wisdom as synonymous, so that there arises a superstition that mere reading is an intellectual virtue. Were the supreme object of education to make customers for newspapers, our system could hardly be improved. But how does the press meet its responsibilities and use its power? With rare exceptions, it must be said, by ministering to popular weaknesses. Editors fill their pages with worthless gossip, with interminable comment on passing frivolities, with trashy and demoralizing fictions, with the lies, libels, and multitudinous inanities of politics, and with endless, ambitious writing on every empty topic that will serve to make a sensation and beguile the reader without the exertion of thought. It is not in this way that the serious work of public education is to be carried forward. Excess of reading without regard to its quality is a pernicious dissipation, and, besides wasting precious time, it disqualifies those who indulge in it from that serious effort of thought which is the first condition of mental improvement. The main purpose in starting our magazine was to do something to counteract this baneful influence, to contribute something toward elevating the standard of popular reading, and to promote the higher ends of education by diffusing valuable knowledge, and making accessible the productions of the world's ablest thinkers.

A few have criticised the MONTHLY as containing too much foreign matter; but our aim is to get the best, be it foreign or domestic. In the interests of truth we have to guard against the "bias of patriotism," and all who do this will recognize that the leading intellectual work of the world is now done in Europe. A spurious patriotism fosters national jealousies and teaches us that foreigners are our enemies; but, in the sphere of science, the selfish and paltry antagonisms of men can be forgotten, and to talk about "foreigners" is impertinent. Our allegiance is to the age and to the growing spirit of liberality, which is its greatest honor. But we shall guard against undervaluing American scientific thought, and would refer to the present contents of the MONTHLY in attestation of this purpose.

Again thanking our friends for their generous encouragement, we ask for its continuance, and an increase of their efforts to promote the diffusion of our magazine. As it was for the people to decide whether it should be sustained, so it will be for them to enlarge the sphere of its usefulness by extending its circulation, and thus enabling us to carry out our plans for its improvement.

MR. GODWIN ON THE LIMITS OF SCIENCE.

MR. PARKE GODWIN, of the *Evening Post*, was chosen to speak for the press at the Tyndall banquet; but he saw fit to throw his toast behind him, and take up a more ambitious *rôle*. He used the occasion to give a lesson to the scientific gentlemen present as to the proper limit of their inquiries. He staked out the ground within which all is legitimate, and beyond which all is mere fantastic pseudo-science and subversive of religious faith. It has ever been a favorite occupation with outsiders to instruct the investigators of Nature where they must stop, so that scientific progress has largely consisted in levelling barriers and establishing the rights of inquiry in forbidden places. Moreover, at each step of advance the pioneers of research have been bidden to stand, in the name of religion; so that in breaking down these restrictions advancing science has been simply widening the scope and liberty of religion itself.

Mr. Godwin may now speak with safety of the "roaring furnaces of the sun," but, for suggesting that the sun is a mass of incandescent matter Anaxagoras was accused of impiety and banished. Hipparchus, for making a catalogue of the stars, was denounced as impious. Galileo, for inquiring into the celestial motions, was anathematized as a heretic. Newton's theory of gravitation was branded as an atheistic attempt to explain the universe without the intervention of God. The early anatomists were charged with impiety for dissecting the human body. The first geologists incurred theological denunciation, and the abhorrence of the pious, as seeking to undermine the Bible and overthrow Christianity. But in each of these cases it turned out that the alarm of the religious was groundless, and every one of the departments of knowledge that science has created, the theologians, as soon as they got through denouncing it, have turned to account for their own purposes. But it seems that there is a class that cannot even learn in the school of experience. The next great step of progressive thought, the synthesis of the sciences, the unification of their facts and principles by the most comprehensive laws, so as to arrive at the philosophy of Nature on the basis of actual knowledge, is sternly contested, and we are to have the fight over again with the descendants of the old enemies of investigation, and on exactly the same grounds. Again, men of science are bidden to stand lest God be driven from the universe. Mr. Godwin appears as the champion of imperilled faith, and his speech is reëchoed and applauded by the press as a well-timed defence of religion against the inroads of "irreligious science." Let us briefly examine his argument.

After mentioning some examples of spurious science, Mr. Godwin says: "These are conjectures that impose upon us their own fantastic offspring for the legitimate heirs of science. Science is exact and certain and authoritative, because dealing with fact and the systematic coördination of facts only. She does not wander away into the void inane. She has nothing to do with questions of primal origin nor of ultimate destinies; not because they are unimportant questions, or insoluble, but because they transcend her instruments and her methods. She leaves them to philosophy, which proceeds not by demonstration and proof but by insight, by intuition and by moral reasoning; or she leaves them to revelation, in whose supernal light alone they can be properly illuminated and fully seen."

To avoid being misled, a correction or two is here necessary, before considering Mr. Godwin's main position. He says that science is exact, which is quite true of the "exact sciences," but is not true of all science. It is not true of those in which the phenomena do not admit of precise measurement, such as biology, psychology, and sociology, which are nevertheless clear and certain in their truths and as strictly sciences as any other. He says that science deals with "facts and the coördination of facts only." But facts can neither be determined nor coördinated except by the constant use of theories and hypotheses. Science consists in the *interpretation* of facts, and this always begins with hypothetical conjecture; while the progress of science is nothing else than the growth of hypothesis and of theory by which facts are put in their proper relations.

Mr. Godwin avers that science has nothing to do with questions of "primal origin," by which he means, as we gather from a passage to be directly quoted, questions of the origin of the universe, the origin of our earth, the origin of plants and animals, the origin of man and his institutions. This is certainly an extraordinary statement to put forth to the scientific men of the present day. And that a great problem of Nature which is soluble, is yet not a problem of science, but belongs to a method which "proceeds not by demonstration and proof," is a statement that will be equally surprising. As for the method of "insight," "intuition," "moral reasoning," and "revelation," it had been tried on the phenomena of Nature for thousands of years, and it was exactly because it had broken down that the method of science arose. The order of the universe has been discovered by demanding "demonstration and proof;" but on what ground is it assumed that the problem of the *present* operations of the universe is of a different nature from the problem of its *past* operations? The order of Nature is one and continuous, and the same method which has given us a knowledge of its present workings can alone be competent to give us the knowledge of its past workings. Science is the coördination of facts, that is, putting them in order, but they must be coördinated in their sequences as well as in their coexistences—in time as well as in space. Nor is it any more possible to study the present in Nature, without going back to the past which has created it, than it is to do the same thing in political affairs. It is now well recognized that our knowledge of existing things is profoundly dependent upon our knowledge of the way they have been produced. The present phase of astronomical science embraces the problem of the formation of the solar and stellar systems. What is geology but a history of the formation of the earth? Zoology has been revolutionized by modern embryological studies. The psychological point of view is now that of the development of mind. Philology has become a science through the study of lingual origins; and sociological science has at its foundation the problem of the origin and growth of social activities and organizations. Questions of origin, of derivation, and of transformations in time, are, in fact, the supreme characteristics of the science of the nineteenth century.

Mr. Godwin forbids it. He might as well forbid the flow of the Gulf Stream; it cannot be arrested till the study of cause and effect is ruled out of the scientific court as an illegitimate procedure. The study of origins is the highest issue of ages of scientific preparation, and the ripening of science into an authentic philosophy.

Of Mr. Godwin's three or four examples of illegitimate science, here is one. He says: "Then there is another of these outside teachers of science, but this one is entitled to the highest respect—though I think he rides a hobby beyond the capacity of the creature to carry—who contrives a vast process of cosmic evolutions, who tells us that a great while ago—ten thousand years—no, a hundred million of millions of millions of years ago—a nebulous gas was diffused through the immensity of space, which first twisted itself into a solar system, then into a world, then into layers of mineral strata, then into vegetable spirales, into animal motions, into human vortices called societies, into iliads, parthenons, and Shakespeares, and at last into a grand philosophy of evolution—the crown and consummation of the whole; which may all be true, though the birth strikes me as hardly worthy of so long and so tremendous a parturition."

Mr. Godwin declares that the doctrine of Evolution, of which he seems to have a very tortuous conception, is an instance of illegitimate science. The nebular hypothesis is its first and remotest "twist," and so Kant, Laplace, Herschel, Huggins, and a multitude of other astronomers who have contributed to its establishment are to be pitched over the enclosure as pseudo-scientists! If the reader will glance at the excellent paper of Prof. Leconte in the preceding pages, on the Nebular Hypothesis, he will quickly see what Mr. Godwin's opinion in this matter is worth.

But the foregoing passage has a further significance; it gives an interesting clew to Mr. Godwin's estimate of the value of the universe. It is not worth production by so tedious a process as that of Evolution; but, if got up in six days—indefinite periods being excluded—Mr. Godwin would probably allow that it is worth cost. Estimates of the natural world will of course vary with the knowledge of it. The first valuation was made in times of blank ignorance of Nature, and still harmonizes with that state of mind. Yet Mr. Godwin's position evinces progress, because in the pre-scientific ages Nature was not only despised as worthless, but hated as worse than worthless. The whole scheme was regarded as under a divine curse, and its students were put into prison and punished in various ways. We are past all that now, and Nature is considered as of some interest and fit enough to be studied by those who like it—if they will consent to have bits in their mouths and be kept within suitable bounds. There has been progress, because the dispensation of hate has been succeeded by that of indifference; but still the devotion of men of science to the study of Nature is a popular puzzle. It is not yet looked upon as the highest occupation of the human mind to extend our knowledge of the order of things around us. On the part of classes still called educated, there survives an ill-concealed contempt for the mental pursuits of mere collectors, observers, and experimenters. It is not now so bad as when in England Lady Glanville's will was attempted to be set aside on the ground of lunacy, evinced by no other evidence than a fondness for collecting insects; yet enthusiastic naturalists who ransack field and forest, mountain and sea, are still regarded as a class apart—as eccentric objects of curiosity, not to be compared in dignity with the students of art, literature, and metaphysics. So much of the old spirit continues that, as objects of thought and in the education of to-day, the works of man are ranked as superior to the works of God. Nor is it by any means considered so very desirable to know all about Nature. Large numbers of the cultivators of sentimental literature still protest that, if the world were once understood, it would no longer be worth living in. The heads of college-bred people are still filled with old childish fictions which are fondly cherished, and science, because it would clear away the mountains of this rubbish, in which the seekers after a liberal education are still made to delve, is dreaded as a desolating agency that would bereave us of all that is most refining and ennobling in culture. In his speech, Mr. Godwin goes off with double objurgation, as follows: "'Great God!" as Wordsworth says—

> . . . . "'Great God! I'd rather be
> A pagan suckled on a creed outworn;
> So might I, standing on this pleasant lea,
> Have glimpses that would make me less forlorn.
> Have sight of Proteus rising from the sea,
> Or hear old Triton blow his wreathèd horn.'"

Now, this may be all very well for callow sophomores; but when old fellows, who ought to have been weaned from this pagan nonsense long ago, take to whining about their forlornness, with nothing remaining but God's universe, the case becomes pitiable. This is the second time that Prof. Tyndall has been gravely told across the table in New York by after-dinner orators that they would go back to heathenism rather than accept the science that his presence suggested—a striking comment on the value which these defenders of the faith attach to the religion of civilization. But let people be suckled where they please; as for our own spiritual lactation we prefer to get it from the revelations of modern science rather than from the Jack-and-a-Beanstalk tomfooleries of pagan mythology.

No! the alarm-bell is rung at the progress of science in the present age to but little purpose. The worth of the universe must rise as its grandeurs are comprehended, and our joy in its harmony and beauty will be heightened the more deeply it is understood.

"I grieve not that ripe knowledge takes away
The charm that Nature to my childhood wore,
For with the insight cometh day by day
A greater bliss than wonder was before."

Nor are religious considerations to be invoked to deter men of science from their exalted work, for the single-minded pursuit of truth is an intrinsically religious act. No limits are to be tolerated but those imposed by Nature herself, and up to those limits the work must be pressed as a sacred duty. For, if, as we believe, science is but a record of the Divine operations in matter, there is devoutness in scientific investigation, and to push it to the farthest possible boundaries becomes a matter of clear religious obligation.

The article of Dr. Barnard, characterizing our educational system, and the brief statement of Prof. Agassiz's opinion in regard to New-England education, both of which will be found elsewhere in our pages, are commended to the very special attention of the burning advocates of compulsory education. According to these, all that our educational system lacks of perfection is a suitable appendage of policemen and constables to drive everybody into the school-houses, that they may be compelled to participate in its blessings. In their view, the only difficulty remaining is a defective will, and a perverse and contumacious spirit, which can only be dealt with by law-warrants and bludgeons. In so far as compulsory education is merely a kind of street-cleaning, a scraping together of refuse and vagabond children in places where something can be done to humanize them, it may be admissible; but there are very serious grounds of protest against coercion being carried farther. If our so-called educational system be defective to its very roots, a total inversion of the method of Nature, and a violation of the constitution of the mind, as Dr. Barnard declares, or if it be a crude vestige of old mediæval ignorance and stupidity, as Prof. Agassiz maintains, there is evidently a good deal to do before police-officers can be properly invoked to force it down people's throats. The logic, of course, is short from the establishment of State education, and its maintenance by compulsory taxation, to its enforcement upon everybody by legal coercion. But State education has its evils, and not the least of them is that it gets the benefit of our idolatry of government and the blind admiration of the "institutions of our country," which are believed to be the most perfect under the sun. But "first be sure you are right, and *then* go ahead" is a golden motto, and, if applied in this case, will postpone for some time the crusade of the coercionists. As long as our school-system is open to such indictments as those of Messrs.

Barnard and Agassiz, which will be sustained by every intelligent critic who looks into it, we submit that the question of compulsion is premature; if any system is to be enforced, let it be a rational one.

LITERARY NOTICES.

KEY TO NORTH AMERICAN BIRDS, containing a Concise Account of every Species of Living and Fossil Bird at present known upon the Continent north of the Mexican and United States Boundary. Illustrated by Six Steel Plates and upward of 250 Woodcuts. By ELLIOTT COUES, Assistant Surgeon United States Army. Boston: Estes & Lauriat. New York: Dodd & Mead, 1872.

THIS exhaustive and beautifully-executed folio comes to us as an exponent of the present state of American ornithological science. The position of Dr. Coues as a naturalist is a guarantee of the character of his work. He lays under contribution the latest results, having been assisted by various eminent gentlemen, while a large part of the volume consists of his own original observations. While the work is attractive to all who care for this fascinating subject, the author has nevertheless aimed at strict scientific accuracy in his statements. At the outset he puts the question, "What is a bird?" and most people would think the answer very simple, but in such matters most people are apt, unhappily, to be mistaken. How loose and insufficient the common notion would be as compared with the conception of science, may be shown by quoting the answer that Dr. Coues gives to his own question: "A bird is an air-breathing, egg-laying, warm-blooded, feathered vertebrate, with two limbs (legs) for walking or swimming, two limbs (wings) for flying or swimming, fixed lungs in a cavity communicating with other air-cavities, and one outlet of genito-urinary and digestive organs; with (*negative characters*) no teats, no teeth, no fleshy lips, no external fleshy ears, no (perfect) epiglottis nor diaphragm; no bladder, no scrotum, no corpus callosum; and with the following collateral characters, mostly shared by more or fewer other animals: under jaw hinged with the rest of the skull by means of an interposed movable bone, that is also movably jointed with two bones of the upper jaw; head jointed with neck by only one hinge; shoulder-joints connected with each other by a curved bone, the clavicle (with rare exceptions), and with the breast-bone by a straight, stout bone, the coracoid; ribs all bony, most of them jointed in the middle as well as with back-bone and breast-bone, and having offsets; less than three *separate* wrist and hand bones; two fingers, of one or two bones; head of thigh-bone hinged in a ring, not in a cup; one of the two leg-bones not forming the ankle-joint; no *separate* ankle-bones; less than three *separate* foot-bones; two to four toes, of two to five bones, always ending in claws; both jaws horny-sheathed and nostrils in the upper one; feet and toes (when not feathered) horny-sheathed; three eyelids; eyeball with hard plates in it, eight muscles on it, and a peculiar vascular organ inside; two larynges, or 'Adam's apples;' two bronchi; two lungs, perforated to send air into various air-sacs and even the inside of bones; four-chambered heart, with perfect double-blood circulation; tongue with several bones; two or three stomachs; one liver, forked to receive the heart in its cleft; gall-bladder or none; more or less diffuse pancreas or 'sweet-bread;' a spleen; intestines of much the same size throughout; cæca or none; two lobulated, fixed kidneys; two testicles fixed in the small of the back, and subject to periodical enlargement and decrease; one functional ovary and oviduct; outlets of these last three organs in an enlargement at end of intestine, and their products, with refuse of digestion, all discharged through a common orifice. But of all these, and other characters that come under the head of description rather than of definition, one is peculiarly characteristic of birds; for every bird has FEATHERS, and no other animal has feathers"

MYSTERIES OF THE VOICE AND EAR. By Prof. O. N. ROOD, of Columbia College. Chatfield & Co., New Haven. University Series.

THIS pamphlet is one of the most admirable expositions of its subject that we have ever read. Prof. Rood is one of our first physicists, the author of many valuable researches, and his essay is thoroughly up in the latest results of acoustics and the physiology of sound, while his lecture is not only crowded with interesting scientific facts, but it is written in a remarkably clear and familiar style; the only difficulty being, that there is not half enough of it. He closes with the following suggestive passage: "If you were to tell a thoughtful man, who happened to be quite ignorant of the mechanism and action of the voice, that there were living beings who endeavored to express their wishes, thoughts, and feelings, merely by the aid of mechanical vibrations, thus causing the particles of air to swing like invisible pendulums backward and forward in certain ways, your listener would be impressed by the poverty of the device, and would too hastily conclude that only a few of the simplest and rudest ideas could possibly find expression by the aid of a contrivance so clumsy. He would tell you it was conceivable, perhaps, that, by appropriate use of vibrations, the idea of joy, or rage, or fear, or possibly of hunger, might be imperfectly expressed, with a few others of like character, but that to expect more would be visionary. He would urge that all vibrations were necessarily so similar in general character, that it would be impossible to communicate to them the stamp of thought or feeling. And yet how wonderfully each one of us employs just such vibrations, and, with a skill which seems truly superhuman, impresses upon and commits to them an infinite variety of thoughts, feelings, and ideas, which at times we pour forth in torrents that seem inexhaustible; the vastness of the result attained, the poverty of the means, are utterly overwhelming!

"Think, also, for a moment, of that gift by which we read the stories written on the invisible waves of the air; how we instantly interpret and disentangle their complexities, as they roll in toward us, thousands in a second, with the velocity of rifle-bullets. The powers to hear and speak are gifts which, from purely physical and mathematical stand-points, are absolutely magnificent! And we the possessors of such powers! Is it conceivable that they have been bestowed on us only to be used as at present? Do they not point to a future for our race when they will be employed in a manner which better accords with their inexpressible richness and grandeur?"

Myths and Myth-Makers. Old Tales and Superstitions interpreted by Comparative Mythology. By John Fiske, M. A., of Harvard University. Boston: J. R. Osgood & Co.

Mr. Fiske has given us a book, which is at once sensible and attractive, on a subject about which much is written that is crotchety or tedious. He has devoted himself to the study of myths without allowing them to impair his judgment on matters of fact, and he has become familiar with myth-makers without adopting their hazy views and ambiguous expressions; and so, although we may not entirely agree with him on every point, yet we can heartily recommend his unpretending but instructive volume to the large class of readers who are interested in the subjects with which he deals. It does not claim to be a work of scientific arrangement and close reasoning. Its author, indeed, speaks of it, in his modest preface, as a "somewhat rambling and unsystematic series of papers;" but to the general public it will not, on that account, prove less agreeable.

Mr. Fiske disclaims any attempt "to review, otherwise than incidentally, the works of Grimm, Müller, Kuhn, Bréal, Dasent, and Tylor," nor does he claim "to have added any thing of consequence, save now and then some bit of explanatory comment, to the results obtained by the labor of these scholars;" but it has been his aim, he says, "to present these results in such a way as to awaken general interest in them." This aim he seems to us to have fully attained; and we shall be surprised if his book does not do good service in enlisting the sympathies of a large number of readers in behalf of a science which some critics find it more easy to deride than to comprehend. Mr. Fiske's volume comprises seven chapters, which seem to have been originally as many reviews of various works on mythology and animism. Beginning with "The Origins of Folk-lore," he traces home some of the most widely-spread of the pseudo-historic stories, such as those of William Tell, and of Llewellyn and Gellert, as well as a few of the Popular Tales which have caught the fancy of most nations, such as that of "The Master Thief," or "The Giant who had no Heart in his Body." His conclusions, which we are not altogether inclined to accept, are, "that the Tell myth was known, in its general features, to our Aryan ancestors before ever they left their primitive dwelling-place in Central Asia;" and that the Popular Tales

"have been handed down from parent to child for more than a hundred generations; that the primitive Aryan cottager, as he took his evening meal of *yava* and sipped his fermented mead, listened with his children to the stories of Boots, and Cinderella, and the Master Thief, in the days when the squat Laplander was master of Europe, and the dark-skinned Sudra was as yet unmolested in the Punjab."

This is Dr. Dasent's view, and, to a certain extent, that of a still greater authority, Prof. Max Müller. For our part, we are rather of the opinion of Prof. Benfy and his school, and are inclined to recognize, in at least most of the longer and more dramatic of our fireside and nursery romances, mere echoes of tales told long ago by Indian story-tellers. But Mr. Fiske's creed is likely to be the more popular of the two, and he has defined and justified it in a manner which all must praise. His remarks on the vexed question of the Homeric poems can scarcely offend even those critics who are least inclined to identify Athênê and Helen with the dawn or any other atmospheric phenomenon; for he is fully conscious of a truth which has been overlooked by the more enthusiastic writers on the subject—that tales and traditions in their present forms are seldom capable of being straightway resolved into perfect Nature-myths, and that in many cases they have been moulded into their present forms by composers or adapters who were perfectly innocent of mythical meaning—that, as he justly remarks:

"The primitive meaning of a myth fades away as inevitably as the primitive meaning of a word or phrase; and the rabbins who told of a worm which shatters rocks no more thought of the writhing thunder-bolts, than the modern reader thinks of oyster-shells when he sees the word *ostracism*, or consciously breathes a prayer as he writes the phrase *good-by*."

The second chapter of Mr. Fiske's book is devoted to "The Descent of Fire," and seems to have been originally intended as a review of Prof. Kuhn's admirable essay on that subject, or of Mr. Kelly's "Indo-European Folk-lore," a book based upon the works of Kuhn, Grimm, and Mannhardt. The third chapter is to a great extent borrowed from Mr. Baring-Gould's writings on "Werewolves and Swan-Maidens," and is rather inferior to the rest of the book in the matter of critical rejection. It is followed by a chapter on "Light and Darkness," which contains several interesting studies of the numerous evil spirits to which the fancy of different peoples has given rise, and especially of "the mediæval conception of the devil." The fifth chapter, on "The Myths of the Barbaric World," will probably prove the most novel and amusing of all to the general reader, but it makes no pretence of offering any thing that is new to students who are acquainted with Mr. Tylor's works, and with those less known, but valuable books, Brinton's "Myths of the New World," Callaway's "Zulu Nursery Tales," and Bleek's "Hottentot Fables."—*Athenæum.*

Coffee: Its History, Cultivation, and Uses. By Robert Hewitt, Jr. New York: D. Appleton & Co., 1872.

This claims to be the first book in the language exclusively on the subject of coffee, of the history, cultivation, and uses, of which it gives much information. The introduction of coffee into the great capitals of Europe, and the history of their *cafés*, as well as the old coffee-houses in New York, are described in several entertaining pages. Java and South America are the two principal coffee-producing countries, the former furnishing the most highly-prized bean, which is unequalled for delicacy of aroma and the mild oily richness of the beverage. The latter, however, furnishes the most important staple, and its influence as a branch of industry and an element of commerce is shown by the fact that no less than 244,000,000 pounds of Rio coffee were consumed in the United States in a single year, which makes us the largest coffee-consuming nation in the world. Numerous methods of preparing coffee are mentioned in the volume, the best contrivance being stated as the following: It consists of a double coffee-pot, the inner one, containing the coffee and water, being completely surrounded by steam which is generated in a pan or receiver, over which is placed the coffee-pot. In this way all the rich, oily aromas are thoroughly extracted by the action of steam-heat surrounding all parts of the inner vessel. The coffee can never boil, and the result is a beverage more perfect than any percolating, boiling, or straining process has ever produced.

A chapter is devoted to the analysis and adulterations of coffee, and the volume contains a beautiful colored frontispiece representing the coffee-plant, and a map showing its geographical distribution. The work is very neatly gotten up.

The Ten Laws of Health; or, How Disease is produced and can be prevented. By J. R. Black, M. D. Philadelphia: J. B. Lippincott & Co., 1872.

In another part of this number of the Monthly, the reader will find an interesting paper from Dr. Black, on "Applied Sanitary Science," in which, after pointing out some of the more formidable difficulties obstructing a general application of sanitary rules, he urges, as the only effective means of making these rules universally available, that every intelligent member of the community master the leading facts and principles of the subject. In this way his eyes will be opened to the dangers which surround him, and the knowledge necessary to their avoidance or removal will also be at hand for practical use. To this important educational work the book before us is a valuable contribution. The author begins by enforcing the proposition, with which most intelligent physicians will doubtless agree, that diseases are, as a rule, preventible; that man brings them upon himself through ignorance and carelessness, and that most of them may be avoided by conforming to certain well-ascertained laws of health. These laws he ranges under ten heads, in the order of their importance, and then considers each in a threefold manner: the various ways in which it is commonly violated are first pointed out; the results which follow are next indicated; and, lastly, comes a description of the ways and means necessary to its proper observance. With some slight exceptions, the matter of the book is eminently sound, and its precepts safe to follow, while the style is clear and vigorous, qualities which, united with the excellence of its mechanical get-up, admirably fit it for popular reading.

Administration of Justice under Military and Martial Law. By Charles M. Clode. London: Murray. New York: Scribner, 1872.

A royal commission in England, some time since, expressed a desire for some such work as the present, and the British War Department have made an acquaintance with military law an essential condition of promotion in the army. It is therefore plain that this work meets a want in England; and, as the United States Army is governed by a code remodelled on the basis of the British Mutiny Act, military men on this side of the Atlantic will probably find these pages valuable for reference.

Lectures on Light. Delivered in the United States, in the Winter of 1872–'73. By Prof. John Tyndall, LL. D., F. R. S. 196 pages. D. Appleton & Co.

In his address at the farewell banquet, Prof. Tyndall said: "On quitting England, I had no intention of publishing the lectures I have given here, and, except a fragment or two, they were wholly unwritten when I arrived in this city. Since that time, besides lecturing in New York, Brooklyn, and New Haven, the lectures have been written out. No doubt many evidences of the rapidity of their production will appear; but I thought it due to those who listened to them with such unwavering attention, as also to those who wished to hear them, but were unable to do so, to leave them behind me in an authentic form." Many thousands who listened to these lectures, and many more thousands who did not, will be grateful to Prof. Tyndall for having written them out so fully for general perusal. Accompanied as they are with numerous illustrations of apparatus and experiments, and written in the author's vivid and graphic way, they will interest the reader almost as much as they did those who heard them.

These lectures were undoubtedly prepared with rapidity, but the reader, we think, will find few traces of it. They were written out with extreme care, and, in vividness of description, felicity of illustration, and transparent clearness, they fall below nothing that this author has given us before. The text is accompanied with numerous neatly-executed cuts of apparatus and experiments, which will aid the thousands who heard the lectures to recall the scenes and circumstances of their delivery, while other thousands, who saved their time and money by absence, will get the result of the professor's teachings in a form by no means unsatisfactory.

Prof. Tyndall came to this country, not to have a "good time," but to do hard work; and he worked hard, not to profit himself, but to promote the interests of science, which he has most at heart. And he not only gave his talent, his exertion, and six months of his precious time, to this object, but he left all the profits of the enterprise to be used for promoting scientific education.

Prof. Tyndall's receipts from his lectures in the several cities were as follows:

Boston, six lectures	$1,500
Philadelphia, six lectures	3,000
Baltimore, three lectures	1,000
Washington, six lectures	2,000
New York, six lectures	8,500
Brooklyn, six lectures	6,100
New Haven, two lectures	1,000
Total	$23,100

Of this amount, the surplus above expenses, amounting to upward of $13,000, was conveyed, by an article of trust, to the charge of a committee, of which Prof. Joseph Henry is chairman, and which is authorized to expend the interest in aid of students who devote themselves to original researches. This is certainly a noble example, and deserves to be emulated.

The "Proceedings of the Farewell Banquet to Prof. Tyndall" are now in press, and are soon to be published in a pamphlet. It will contain letters from the scientific men throughout the country, and all the speeches delivered on the occasion, revised by their authors.

Arrangements have been made by the firm of Holt & Williams to furnish the *Fortnightly Review* to American subscribers at the reduced price of $6.00 a year, or 50 cents a number. This able periodical was projected and established by Mr. George H. Lewes, some ten years ago, and was at first, as its name implies, published once a fortnight. It was modelled on the plan of the *Revue des Deux Mondes*, the leading French periodical, which is issued every two weeks. After three or four years, however, Mr. Lewes withdrew from his management, and it was changed to a monthly, under the editorship of Mr. Morley, author of the excellent papers on Voltaire and Rousseau. The *Fortnightly* is the chief organ of the Positivist writers in England, such as Mill, Harrison, Brydges, and contains much able discussion of radical politics and advanced philosophy.

Annals of Bee Culture, for 1872, D. L. Adair, Editor (published by John P. Morton, Louisville, Ky.), contains twenty-two papers by well-known authorities on matters relating to the apiary. The opening article, "The Genesis of the Honey-Bee," by the editor, will well repay an attentive perusal.

BOOKS RECEIVED.

Manual of Paleontology. By Henry Alleyne Nicholson. Edinburgh, 1872. Blackwood.

Caliban: the Missing Link. By Daniel Wilson, LL. D. London and New York: Macmillan.

Modern Diabolism; Commonly called Modern Spiritualism. With New Theories of Light, Heat, etc. By M. J. Williamson. New York, 1873. James Miller. (Not worth reading.)

Arrangement of the Families of Fishes (Smithsonian Miscellaneous Collections, 247). By Theodore Gill, M. D., Ph. D. Washington, 1872.

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MISCELLANY.

The Selective Power of Plants.

Sheffield Scientific School,
New Haven, Conn., *Feb.* 25, 1873.

Editor Popular Science Monthly.

Dear Sir: In his interesting article on "Spontaneous Movements in Plants," printed in your January number, Dr. A. W. Bennett remarks, page 284, that "the selective power of plants, in absorbing from the soil a larger portion of those ingredients which are required for the formation or healthy life of their tissues, is an absolutely unexplained phenomenon." Dr. Bennett says further, "A striking instance of the liability to consider a mere statement of an obscure law in other terms as an explanation of that law, occurs in an admirable treatise on the growth of plants—Johnson's 'How Crops Grow.'" Then follows the subjoined quotation from my book (the italics are Dr. Bennett's): "The cereals *are able to dispose* of silica by giving it a place in the cuticular cells: the leguminous crops, on the other hand, *cannot remove it* from their juices; the latter remain saturated, and thus further diffusion of silica from without becomes impossible, except as room is made by new growth. It is in this way that we have *a rational and adequate* explanation of the selective power of the plant." Dr. Bennett adds: "The 'rational and adequate explanation' seems to me, on the contrary, to be merely a restatement of the selective power of the tissues in other terms. Because the tissues want the silica, is no explanation of how they get it."

Very possibly, Dr. Bennett holds me at a disadvantage as the matter thus stands, but I am, in fact, very seriously misrepresented in the last sentence of his quotation from "How Crops Grow." On page 363 of the American edition, the reader may see that the period which concludes Dr. Bennett's quotation should be a comma, and that the sentence, as I wrote it, first comes to a conclusion after an important qualifying clause, and reads, entire, as follows: "It is in this way that we have a rational and adequate explanation of the selective power of the plant *as manifested in its deportment toward the medium that invests its roots.*"

It appears that Dr. Bennett has inadvertently confused two quite distinct things. He asserts, at first, that "the absolutely unexplained phenomenon" is "the selective power of plants in absorbing from the soil those ingredients which are required for their tissues." But, afterward, he declares my "explanation" to be "merely a restatement of the selective power *of the tissues.*" Obviously, the selective power of the plant, as manifested toward the medium that invests its roots, is one thing, and the selective power of the tissues toward the substances dissolved in the cell-juices is, or in many cases may be, another. The former is what I offered a rational and adequate explanation of. The latter I have not ventured to attempt to explain. The former is explained by being coördinated with the well-ascertained facts of "diffusion" and "osmose," and referred to established, if not fully-developed, physical laws. The latter belongs to the yet very obscure phenomena of chemism, which are only known to us imperfectly in some of their results, and whose inner nature the recent amazing progress of organic chemistry has hardly begun to enable us to speculate upon with any satisfactory degree of probability.

Dr. Bennett writes of silica as one "of

those ingredients which are required for the formation or healthy life" of the plant-tissues. In "How Crops Grow," the evidence is given which forces us to the conclusion that silica is unessential to the growth and perfect development not only of leguminous plants, but of all the various cereals, although the latter, when they grow in the soil, do contain 2.5 per cent., more or less, of this substance in their foliage. If silica be taken up by legumes and by corn-crops which are able to grow to perfection of parts and fulness of dimensions in its absence, then, certainly, "because the tissues *want* silica is no explanation of how they get it;" but saturation of the cell-juices does explain how a limit is put to the influx of this body into the plant from the soil.

S. W. Johnson.

Probable Cause of Boiler-Explosions.—Some six years ago, Mr. W. F. Barrett, F. C. S., observed that a red-hot ball of copper, on being immersed in a light solution of soap in water, entered the liquid without hissing or visible generation of steam. In a paper read before the British Association, he tells of sundry experiments made with a view to investigate this phenomenon, and thinks that it probably accounts for many otherwise unaccountable explosions of steam-boilers. After experimenting with sundry red-hot metals in soap-water, he tried water without soap; but then the hissing was loud, and the evolution of steam copious. He next dissolved in water several soluble substances, and found that albumen, glycerine, and organic liquids in general, facilitate the acquisition by water of the spheroidal shape, probably by increasing its cohesion, while bodies such as ammonia, which yield vapor readily, have the same effect, though in not so marked a degree. Oil, whether shaken up or floating on the water, has the same effect as soap. When the red-hot ball is lowered into the liquid, to a depth of a foot or more, it is seen to be surrounded by a shell of vapor, bounded by an envelop resembling burnished silver. As the ball cools, the shell grows thinner, and finally collapses. This is followed by a report, and volumes of steam are emitted. The author adds: "I have heard that traces of oil get into the boilers of steam-engines, and there can be no doubt that dissolved organic matter often finds its way in. If in any way we increase the intensity of the water, we render it possible for a corroded boiler to give way under the pressure of the steam suddenly generated in the way I have indicated."

Practical Application of Singing Flames.—The "singing flame," which at first view might seem to be merely a curious phenomenon, is found to be, in fact, a discovery of very high importance for science and the useful arts. One of the latest applications of this principle is that made by Dr. A. K. Irvine, of the British Iron and Steel Institute, who makes use of the singing flame in the construction of a safety-lamp for mines. If an explosive mixture of inflammable gas and air be passed through and ignited on the surface of a disk of wire gauze too fine to suffer the flame to traverse it, and then surrounded by a chimney, to prevent air from entering, save through the gauze, the flame vibrates, and, the vibration being communicated to the ascending gases, produces a sound varying in pitch and intensity according to the height and calibre of the chimney. A lamp constructed on this principle will give timely warning to the miner whenever the atmosphere and the fire-damp are coming together in the proportions requisite for an explosion.

Science in the Household.—The application of science to the affairs of the household, both in the shape of improved processes and the introduction of labor-saving appliances, has already gone sufficiently far to warrant the expectation that from this quarter there will eventually come a solution of the problem of rational house-keeping, when the family will be largely rid of the annoyances incident to a state of dependence on incompetent and wasteful hirelings, and master of its own internal economy. Already the sewing-machine has wrought a revolution in the clothing department, which leaves scarcely a trace of its former wearisome tasks. The washing-machine and wringer, aided by various detergent preparations, have in like manner greatly lightened the work of the laundry, making the destructive and exhausting labor of rubbing a useless waste of power. And now, as the latest and most important addition to the resources of the house-keeper, we have a device which, going under the name of the "Warren Cooker," accomplishes an even greater reduction in the labor, expense, and care of the culinary department of the household.

This implement was but recently introduced into this country, and, though widely commended, is comparatively unknown; we cannot, therefore, do our readers a better service than to give them a brief account of its advantages. The article is an application of the principle that cooking is best done at a low, uniform heat, or a heat that, in the case of meats, will neither coagulate their juices nor harden their fibre. By Warren's plan both meat and vegetables are cooked at the same time, though in separate compartments and in different ways. When the "Cooker" is in operation, the meat is enclosed in a tight chamber, the bottom of which rests in boiling water, while a large portion of the sides is surrounded by steam, the remaining or upper portion of the sides being exposed to the outer air. No water or steam is permitted to enter the chamber, which, by the above-described arrangement, is kept at a uniform temperature of about 210° Fahr. The juices of the meat, and consequently its flavor, are thus wholly retained without dilution or impairment, and at the end of the process both fibre and juices are left in a condition most favorable to the work of digestion, none of the hardness or stringiness of baked or roasted meats being in the least degree perceptible.

Vegetables are cooked by steam, which in its exit is made to traverse a chamber divided into compartments for the reception of different sorts. Dumplings, or any thing else permitting the direct contact of steam, may also be cooked in this part of the apparatus.

We have had the implement in almost daily use for upward of six months, cooking with it the meat, fish, and poultry, ordinarily employed for the table, and its general performance has been in the highest degree satisfactory. It saves all round, and might very appropriately have been named the "Economical Cooker." Compact and simple in arrangement, it is easily and quickly got into operation. Unable to go wrong when once properly started, it does away with the worry and care incident to ordinary cooking. Run by any contrivance that will boil water, it makes possible a great saving of fuel. Cooking the meat in a closed pot, without access of either water or steam, it saves over the old way a large percentage of material; and, always turning out an evenly-cooked, juicy, and never overdone joint, it above all saves the feelings of the entire family.

To this strong indorsement of the implement, it is our duty to add a word of caution, for the benefit of those who are just commencing its use. The circulars of the manufacturer state the time per pound required for cooking various meats. Rigidly adhering to these directions when we first began to use the "Cooker," underdone dinners were the frequent result; and it was soon learned that from three to five minutes additional per pound were required to make the process complete.

Not the least of the advantages that will follow the general adoption of this mode of cooking will be, the encouragement of simplicity in the preparation of food; for, inasmuch as the contrivance preseves the natural flavor of the articles cooked in it, there will be no need of adding all sorts of rich and indigestible sauces to replace the losses which occur in cooking by the methods now commonly employed.

Venomous Spiders in New Zealand.—Until recently it was supposed that New Zealand contained no venomous reptiles or noxious animals of any kind, and it was only so late as the year 1856 that the first scientific notice appeared of a poisonous spider, a native of that country. This notice was communicated to the British Linnæan society by Dr. Ralph, and contained a brief description of the katipo (*night-stinger*), giving an account of its nesting habits and of the potency of its sting. A writer in the *Field*, who has closely studied this animal in its native habitat, cites numerous instances showing that the katipo's bite is occasionally fatal, and invariably very painful. Like many other venomous creatures, the katipo is not aggressive, and stings only when he is molested and greatly irritated; but, if merely touched with the finger, he will fold up his legs, and feign death. If again molested, the animal will try to escape, and will employ his sting only when driven to the wall. The katipo's nest is a perfect sphere, and the eggs about the size of mustard-seed. The changes undergone by this animal in its progress toward maturity are as follows: In the very young state its body is white, with two linear series of connected black spots, and an intermediate line of pale red; under parts brown; legs light brown, with black joints. In the next stage, the fore-part of the body is yellow, with two black "eye-spots," sides black, with transverse marks of yellowish white; dorsal stripe bright red, commencing higher up than in the adult, and with the edges serrated. At a more advanced age the stripe on the back is brighter, with a narrow border of yellow, and the thorax and legs are nearly black. In the fully adult condition, the female is very handsome in form and color. The body varies in size from that of a pigeon-shot to that of a small green pea; and the outspread legs even of the largest of these animals cover only a space of three-quarters of an inch. The thorax and body are black and shining, with a stripe of bright orange-red down the centre of the body. The male is considerably smaller, having the body blackish brown, with a faint-yellow line down the back.

Prof. Agassiz's Estimate of New-England Education.—The following significant paragraph is from the *Tribune:*

"Prof. Agassiz's speech before the Committee on Education at Boston, last week, was practical, impetuous, and a little impatient. His demand for a State appropriation for the benefit of the Cambridge Museum served as a text from which he drew a sermon, unpleasant, but not untrue nor unnecessary. He warmly expressed his disapproval of the existing system of popular education in America. Instead of using the rich and growing intellectual material of later years, he declared that our colleges teach chiefly the traditional learning of the middle ages. 'Harvard,' said the fiery professor, 'is not a university; it is only a tolerably well-organized high-school.' Nor is even this learning, in his eyes, the best of its kind; it is merely the dregs of scholarship. He brought up our grammar as an example, referring to it as no longer a living matter, but a reduction to formulas from which all the living spirit has fled. As for his darling, Natural Science, he contemplates mournfully the want of thoroughness with which its phenomena are taught in the common schools. The fault, he asserts, is that of the teachers, who have no sort of thorough knowledge in this direction, and who cannot get it from the normal schools, where instruction is given from text-books alone, and in the poorest possible manner. The schools of Massachusetts had round censure from the good professor, and very much it must have astonished the authorities of that great State, who are incessantly ready to fold their hands and go to heaven when they think of their 'superior' school system. Owing to the misplaced confidence which they have in it, the professor thinks that it might be easier to push a new course of education in a new State earlier than in New England."

Ancient Bavarian Agriculture.—The Historical Society of Munich has recently set on foot an investigation of the remains of ancient agriculture to be found in the neighborhood of that city, and in other parts of Bavaria. Garden-plots of an unknown antiquity have been discovered, many of them assuming the form of a parallelogram, with beds of equal length, breadth, and height; while others are in the form of a trapeze, with beds of very unequal length. Oftentimes wide and narrow beds alternate; and again beds are found side by side, the one being ten times the length of the other.

In height they vary from $1\frac{1}{4}$ to 3 feet or over, and the soil is scooped up out of the furrow and thrown up on the bed, uncovering the gravel. There is no trace of drains or water-courses dating from the period of these gardens, though water-courses of a later time are to be seen. In the middle of one of these agricultural districts is always found a free space where in all probability the people had their dwellings, although we find no trace of their abodes. If there ever were houses there, they must have been built of light material. Horseshoes are found at various depths in the soil. These are of small dimensions, and so eaten away by rust that they evidently belong to a very remote period. A writer in the *Presse* is of opinion that these little farms date back some 2,000 years, and that then the climate of Bavaria was very moist; for such treatment of the soil in the present comparatively dry climate of that country would lead to the destruction of the crops by drought. It is a little curious that the writer makes no mention of any agricultural or other implements being found; but perhaps closer investigation will bring such objects to light.

Recent Meteorites in France and Italy.—Several members of the French Academy of Sciences have written for that body accounts of two or three meteoric masses lately seen to fall in France and Italy. On July 23d, at about half-past five, on a still afternoon, with clear sky, and the sun shining brightly, there was heard at Lancé (Loir-et-Cher) a violent report, succeeded by a rumbling. A "fiery lance" was observed by a land-owner of Lile-Bouchard to shoot across the sky with great swiftness. *En route* it divided into two meteors, which continued for some time to move parallel. At Tours they were also observed, and described as bottle-shaped, and of an orange color. One of these meteorites was found near Lancé by M. de Tastes. It weighed about 103 lbs., and had penetrated into the earth to a depth of 5 feet 9 inches. It broke to pieces on removal. The other meteorite was soon after found, some 7½ miles south of the first. It was of the same character as the first, but weighed only a few ounces and had penetrated about 20 inches. The large piece is of an unequal spheroidal shape, with rounded surface, and covered with a crust as if by fusion. The fracture is black, showing globular structure, and numerous small spheroidal grains. Here and there are small metallic grains, yellow in color. Specific gravity 3 80. In water it yielded a very small quantity of chloride of sodium. There is not a trace of salts of potash, nor any sulphates or hyposulphates. Dissolved in nitric acid, a silicate was found, consisting chiefly of magnesium and protoxide of iron. Spectrum analysis seemed to indicate the presence of copper; but there was no calcium, barium, or strontium. Carbon was absent, but, as usual, cobalt and nickel accompanied the iron. On the evening of August 8th, at 8 minutes past 11, a meteorite was seen at Rome, Velletri, and other places. But a more interesting one was observed by Padre Secchi at Rome, August 31st, at 5.15 A. M., mean time. A globe of fire was observed, well marked and a little red in color. Its progress was at first slow, but it gained speed, and left behind it a luminous train like a cloud lit up by the sun. On reaching its highest point, it suddenly expanded, and finally disappeared. Three or four minutes afterward a tremendous detonation was heard. It was like a mine-explosion, and was followed by a rolling sound, as of file-firing. A fragment of this meteor was picked up and found to be very ferruginous, hard, and covered with a crust. The extreme distances at which the meteorite was seen are 93 miles apart.

An Efficacious Disinfectant.—A writer in the *Chemical News* offers some useful hints on disinfectants, which may be of interest. After a long-continued series of experiments, he pronounces sulphate of aluminium and hydrochlorate of alumina very powerful disinfectants and antiseptics. Their solubility and harmlessness render their use admissible under all ordinary circumstances. The chloride and sulphate of iron have the same action as the above, and, further, they absorb the sulphuretted products of decomposition. For this reason these salts are the most efficacious of disinfectants. But there is one objection to their use, viz., that the iron would injure any vegetation with which the disinfected matter might come in contact. The writer recommends, as the best of all disinfectants, for general use, a solution containing hydrochlorate of alumina, with a small quantity of chloride of iron. The hydrochlorate will do all the work of a disinfectant and antiseptic, while the chloride will absorb the sulphuretted compounds.

Atmospheric Pressure and Vegetable Growth.—M. Bert, whose observations upon atmospheric pressure and animal life we have already noted, has been making experiments upon the influence of pressure on vegetation. From these it would appear that temperature is not the only condition modifying vegetal growth at varying altitudes, but that varying degrees of atmospheric pressure have also a controlling influence in this respect. Some grains of wheat were sown in bell-glasses with all the conditions identical, save that the contents of one glass were subjected to the normal pressure of the atmosphere, those of another to two-thirds the ordinary atmospheric pressure, and those of a third to one third the ordinary atmospheric pressure. The first grains sent forth shoots 20 centimetres (7 inches) long, the second 5 inches, and the third did not come up at all. Again, with a pressure of 5 atmospheres, the plants did not come up, the radicles only having been sent out, and on opening the vase a strong alcoholic oder was perceived, in place of the ordinary acetic odor of putrefying wheat. After a few days a mould made its appearance.

Electric Detonators for exploding Mines.—Two new electric detonators, for exploding mines, one for land and the other for marine service, have been introduced in England. The former consists of a tin tube filled with fulminating mercury, and having a head of beech-wood. The electric wires run through this head, being insulated by gutta-percha, and their extremities held apart. In the space between the ends of the wires, and in contact with the fulminating mercury, is loosely packed a little gun-cotton, which is ignited by an electric current. The marine detonator has also a tube of tin filled with fulminating mercury, as also a beech-wood head. From tip to tip of the wires extends a platinum wire $\frac{3}{10}$ inch long, and 0.003 inch thick, in a bed of loose gun-cotton. The electric current heats the platinum, thus igniting the gun-cotton and exploding the fulminant, which in turn explodes the powder.

Development of Vibrio-Life.—In the course of his very interesting experiments on protoplasmic life, Dr. Grace Calvert shows that a solution of albumen from a new-laid egg, in pure distilled water, does not develop protoplasmic life, when the atmosphere is shut out. If, however, it be exposed to the atmosphere for from 15 to 45 minutes, minute globular bodies will appear, which have an independent motion. The time required for these bodies to develop is proportioned to the surface exposed, as was shown by Dr. Calvert, who experimented with two portions of albumen, 400 grains each, one in a test-tube of three-fourths inch diameter, and the other in a test-glass showing a surface of liquid two inches in diameter to the atmosphere. In the tube, vibrios appeared after twelve days, but in the glass after five. With undistilled water, they appeared in the test-tube within 24 hours. Further, M. Pasteur having shown oxygen to be necessary to the life of the mucedines, Dr. Calvert shows that it is no less necessary to the existence of vibrios. To confirm this, he put into each of five glass bulbs a solution of albumen in water, the first being left in contact with the atmosphere 24 hours, and the ends of the tube then hermetically sealed about two inches on each side of the bulb. The other tubes were similarly closed, after passing oxygen, hydrogen, nitrogen, and carbonic acid, over the solutions. The tubes remained closed for 27 days, during which period the albumen in contact with oxygen was seen speedily to become turbid, and then that in contact with air, while the other three remained clear. The tubes were then broken, and it was found that those containing oxygen and common air held a large amount of vibrio-life, while those containing nitrogen, carbonic acid, and hydrogen, held but very small quantities; hydrogen least of all. Thus it was proved that oxygen is an essential element to the production of putrefactive vibrios. The transition from globular protoplasms, or monads, as he calls them, into vibrios, and their ultimate transformation into microzyma, is then described by Dr. Calvert. "A few hours after impregnation," says he, "the monads appear in the albumen, having a diameter of about $\frac{1}{128000}$ of an inch, and appear to form masses. Next, some of the monads are lengthened into vibrios, which have an independent motion, though still attached to the mass. As this motion prevails in this or in that direction, the mass is moved over the microscope-field. At last it is broken up, and soon each individual vibrio is seen rolling or swimming about. Their size is now $\frac{1}{20000}$ of an inch, and they finally attain a length of $\frac{1}{6400}$ of an inch." These long vibrios are gradually changed into cells, which Dr. Calvert calls microzyms, the first step in transformation being their division into two independent bodies. An extremely faint line appears across the animalcule's centre, increasing in distinctness until the vibrio looks like two individuals joined together. Then they separate, acquiring each an independent existence. The parts again divide and subdivide, until they appear to be no more than cells endowed with great natatory power. In twelve months or so the vibrios disappear, being succeeded by microzyms, either in motion or at rest. If these latter be placed in a solution of fresh albumen, vibrios are abundantly developed, apparently because they have now all the circumstances favorable to their growth and reproduction.

Experiments on the Circulation of the Frog. — Certain drugs, such as digitalis, veratrum, and ergot, when taken into the system, are known to exert a powerful influence on the apparatus of circulation, and, on this account, are largely employed by physicians as medicinal agents. In order to learn something further of the manner in which they act, Dr. Boldt has been studying the effects produced by their active principles when thrown into the circulation of the frog. Curarized frogs had the intestines and mesentery exposed, so that the movement of the blood in these parts could be readily watched through the microscope. Twelve experiments with digitalin, injected hypodermically, showed that it produces a strong contraction of the peripheral vessels, which is followed by a marked slowing of the pulse, and this, if the dose be large enough, by laming of the heart, as shown by smallness, irregularity, and rapidity of the pulse, with a vibrating or undulating blood-stream; finally, after a short increase in rapidity, the pulse falls with great suddenness, and then, with general vaso-motor paralysis, the animal dies. Eleven experiments with veratrin showed that it directly paralyzes heart and arterial muscles, there being an immediate lowering of the pulse-frequency, the size and force of its wave, and an increase in the lumen of the vessels. Twelve experiments with ergotin resulted in a constant lowering of the pulse-rapidity, by both large and small doses, accompanied by peristaltic or wave-like contractions and expansions of the artery.

Paper Car-Wheels.—Car-wheels of paper, though universally admitted to be superior to those of iron or steel, have not been much used hitherto, owing to their high price. If, however, as is claimed, paper wheels are more durable than those of other materials, and if they do less injury to the tracks, besides being safer and more noiseless, it may in the end be found economical to employ them. The Connecticut River Railroad, as we learn from the *Iron Age*, is about to give these wheels a practical trial, having ordered a set of them for the forward truck of a locomotive. The process of manufacturing wheels of paper is as follows: A number of sheets of common straw-paper are compacted together under a pressure of 350 tons. The mass is then turned perfectly round, and the hub forced into a hole in the centre. The tire, which is of steel, has a bevel of one-quarter of an inch on the inside edge, and the paper filling is forced in under a pressure of 250 tons. Two iron disks, one on either side, and bolted together, keep the filling from coming out; but, as the tire bears on the paper and not on the disks, the wheel partakes of the elasticity of the former.

Biela's Comet.—Arago, to quiet all apprehensions of a collision of the earth with Biela's comet, made an accurate calculation of its orbit and periods, and so showed that such a catastrophe could not occur for thousands or even millions of years. But, as Prof. Daniel Kirkwood shows, in the *Journal of the Franklin Institute*, the break-up of that comet, which was observed in January, 1846, very materially alters the conditions of the problem, and now Prof. Kirkwood announces the latter end of November, 1892, as the time when, in all probability the earth and the comet will come in collision. The comet's period is about six years and eight months. After the break-up of January, 1846, it reappearance in

1852 was looked for with great interest, and it was then seen that its two fragments had not only remained apart, during the interval, but that the distance between them had increased. In 1859 no observation could be taken, and in 1866, though the circumstances were eminently favorable, no comet was seen. The same thing occurred again in September, 1872. But, when the earth's orbit, on November 29th, intersected that of the comet a few weeks later, after the passage of the latter, it was expected that we should have a view of the meteors forming its dispersed train. And such was the fact, as the records of astronomical observation all over the world show. "As the meteors of this cluster," concludes Prof. Kirkwood, "are doubtless the *débris* of Biela's comet, if we find the epoch at which the original body would have crossed the earth's orbit *near* the 29th of November, we may regard the collision of our planet with some of the large fragments — and hence a grand meteoric display—as highly probable at the same period. An easy calculation, which need not here be repeated, gives the last of November, 1892, as such an epoch."

Temperature in Disease.—In health the temperature of the human body is but slightly variable, rarely oscillating beyond one or two degrees on either side of 99° Fahr. In disease, however, the variations are greater, and in the disorders of young children wider even than in those of the adult. The temperature in grown persons has been observed to fall to 95° Fahr., and to rise as high as 107° Fahr., giving a range of 12°; and these are regarded as the extreme limits of variation in the ailments of adult age. In the sickness of children, according to M. Roger, the temperature sometimes falls to 74.3° Fahr., and may rise to 108.5° Fahr., which is equivalent to a range of 33.2°. In the typhoid fever of infants, the temperature in the majority of cases attains or passes 104° Fahr. Of the eruptive fevers, it rises highest in scarlatina, sometimes reaching 105.8° Fahr., next highest in small-pox, and in measles the least of all.

Among the diseases characterized by a fall of temperature below the normal standard, Roger observed in six cases that the mercury sank to 78.8°; in other cases the depression reached respectively 77°, 73.4°, 72.5°, and in one instance to 71.6°, or 27.4° below the temperature of health.

Hansen's Writing-Ball.—Under the title of "A New Writing-Machine," we alluded in a former number to the character of this invention, which during the past season has elicited a great deal of admiration both in the Copenhagen Exhibition and in London. Since first introduced to the public, it has been very materially improved, and now not only furnishes superior facilities for writing, but is admirably adapted to the purposes of copying as well. In the improved machine, the paper rests on a level surface, so that the operator is at all times able to see what he writes, and less time is lost in adjusting and removing the sheet. By interposing carbonized paper between the sheets, and making all move together, several copies may be written or printed off at a single operation. It will thus perform the duty of several copying-clerks, and has also been found admirably suited to the work of writing out telegraphic dispatches.

Mental Labor and Health.—The *Lancet* reverts to the question of mental labor and longevity, in order to correct some misapprehensions of its recent articles on that topic. "Intellectual activity," persists the *Lancet*, "is a preserver rather than a destroyer of nervous health: but this holds true only when the conditions of ordinary hygiene are not outrageously violated." If, coupled with the intellectual strain, we have harassing anxiety, sleeplessness will result, and this is fatal. But suppose there is no such anxiety, but merely ardor for work, then a man might easily transgress the plainest laws of health. The minimum of sleep required by the adult male in twenty-four hours, according to the *Lancet*, is six hours, and by the adult female, seven. As for night-work, the *Lancet* does not think it injurious *per se*. The light should be very white, powerful, and steady, otherwise there will be brain-irritation. The intellectual worker must obey implicitly the reversed scriptural law: "If a man will not eat, neither shall he work." He must take abundant nutriment, at proper times, together with a "moderate amount of stimulants," says the *Lancet*. But any excess of alcohol or tobacco will produce insomnia: indeed, hundreds of cases where insomnia is charged to the account of "overwork" are best explained by excess in stimulation.

Dredging on the New-England Coast.—Prof. Verrill has a very interesting article in the January number of the *American Journal of Science* on the "Results of recent dredging expeditions on the coast of New England." In the summer of 1872 the headquarters of Prof. Baird, United States Fish Commissioner, were at Eastport, on the coast of Maine, and he invited the coöperation of Prof. Verrill and others in the work of making a thorough zoological survey of the waters of that region. Prof. Verrill had already devoted portions of six summers to the same work. The survey of 1872 not only carefully explored all the bays and estuaries, but also the deeper waters in their vicinity, more especially places known to be the haunts of valuable fishes; and the alcoholic collection of specimens obtained filled 2,000 bottles and jars, and several large cases.

Whenever animals were found to change in form or appearance on being preserved in alcohol, drawings were carefully made from life by Mr. J. H. Emerton, of Salem. The surveying party also studied and ascertained as far as possible the haunts and habits of such animals as form the natural food of fishes. The abundance and variety of living forms in the localities explored will be obvious from the statement that, besides *Foraminifera*, *Entomostraca*, and other minute creatures, the results of this and of previous dredgings, which have not been reported, add 350 species to the already known fauna of the region. Of these species some are undescribed, but the majority occur in the fauna of Northern Europe.

Marine plants were found growing at depths varying from shore-line to 80 fathoms: thus *Ptilota serrata* occurred at a depth of 75 fathoms. On St. George's Bank, in 430 fathoms water, 44 species of animals were obtained, not reckoning foraminifera. This is the deepest dredging yet done on our coasts north of Florida. The following were the temperatures here observed:

Air	66° Fahr.
Surface water	65° "
Bottom water	51° "

Prof. Verrill, however, thinks there may have been an error in the statement of the deep-sea temperature here, owing to defects in the instruments employed. He notes, at no great distance from St. George's Bank, the following temperatures for 50 fathoms water:

Surface water	62° Fahr.
Bottom water	45° "

And off Cape Sable a still greater coldness of the bottom was observed in 45 fathoms water, viz.:

Air	58° Fahr.
Surface water	56° "
Bottom water	35° "

In these cold waters the animal life found was more arctic in its character

Between St. George's Bank and Nova Scotia the bottom was found to consist of fine soft, sandy mud. This, according to Prof. Verrill, may be owing to a depression of the area between the bank and the coast. This depression would withdraw the bottom out of the reach of the powerful currents which sweep over and outside the banks. Where these currents have full play, nothing but coarse sand and gravel is found even at a depth of 430 fathoms—nearly half a mile.

So strong are the currents, and so enormous their volume, in this part of the ocean, that to the east of St. George's Bank, where no bottom was found at 1,800 fathoms (rather more than two miles) depth, their mutual collision sufficed to produce a roar like breakers on a beach. The report is to be continued, and a complete list published of all the species of animals obtained.

Ostracism of a French Savant.—The new edition of Robin and Littré's great "Dictionary of Medicine" was lately presented to the French Academy of Sciences. Pathology is there regarded as a branch of biology, levying contributions on mathematics, chemistry, physics, and even social science and history. The Bishop of Orleans says that this dictionary lowers man to the level of the brutes; and the conservative justices of the peace of the sixth arrondissement of Paris take up the strain.

These wise judges declare M. Robin to be incapacitated, by his religious belief, from serving on a jury. They used to order such things better than this in France, but just at present there is an effervescence of emotional religionism in that country, and, as M. Robin is not in sympathy with it, he must be put down. The disqualified doctor is one of the foremost medico-legal authorities in Europe, and can well smile at the pettishness of the justices and their backers.

Causes of Horse-Influenza.—Prof. James Law contributes to the *Lens* a highly-important paper on "The Causes of Influenza in Horses." This is by far the ablest study on the subject which has yet been published, and we earnestly advise those of our readers who take an interest in the matter to procure the January number of the *Lens*, and peruse the discussion in full. We have space only for a brief summary. The author considers, one by one, the various causes assigned both by men of science and by empirics, for the outbreak and propagation of the disease. As regards the influence of *soil* and *elevation*, he finds that these cannot be proved factors in the problem, since the mountains of Vermont and New Hampshire were visited by the epizoötic no less than the flat and malarious sea-coast of New Jersey, Maryland, and Virginia. Again, it has been supposed that a low temperature is an active agent in aggravating the disorder; but Fulton County, Ga., showed a mortality threefold greater than that of Dodge County, Wis. And yet, after the outbreak of the disorder, in the last-named locality, there occurred a great and sudden fall of the thermometer. The author shows very clearly indeed that sudden changes of weather are not the cause of the outbreak, from the meteorological tables of Toronto, where the equine influenza first appeared. These tables show that during September, 1872 (the month of the outbreak), there was the average barometer and thermometer, and that the relative humidity of the atmosphere and the direction and velocity of the wind were normal.

Another cause often assigned is *acrid or fetid fogs*. But, in this respect, the month of September, 1872, showed nothing peculiar. With regard to the amount of *ozone* in the air, the author had no estimates; but he shows that, even were that gas proved to be in excess in September, it cannot be regarded as the cause of the rise or spread of the disease. His facts on this point are entirely conclusive.

He next considers what influence is to be attributed to the action of electrical disturbance. It is certain that September, 1872, was, at Toronto, marked by a high degree of electrical disturbance. But then was that the cause of the outbreak? That is by no means proved. If it *were* the cause, then we should have influenza at all periods of great electrical disturbance, which is not the case. The author is, however, disposed to allow that this disturbance may have "predisposed the system to the attack of a poison which existed previously."

There remains the theory of contagion, and this the author adopts. The contagion in this case is *specific*, confined to one species. Breaking out first in Toronto, it radiated in all directions, following the great routes of travel, and its progress is in nearly every instance traceable to the importation of animals from infected districts. But what is the nature of the *contagium* here—of the diseased or morbific matter transmitted from one animal to another? On this point there are two theories. One of these holds that the specific poison consists of fungi or the like. The other, which is that of our author, sees in the granules, existing abundantly in the diseased organs, the morbific agent. These multiply very rapidly, and are conveyed to a considerable distance through the atmosphere, in the clothing of human beings, etc.

The first-named theory, that which attributes the origin and propagation of influenza to vegetal organisms, is adopted by Mr. G. W. Morehouse, in the *American Naturalist*. He found in the matter from a diseased horse's nostrils, and also in the air, the spores of three different cryptogamous plants, of which he gives engravings. But he fails to tell us whether or no these same spores were in the air long before or after the disorder, as well as during its prevalence. Also whether these vegetal organisms are not equally to be found in the mucous discharges of sound horses. On this point, however, we are not left to conjecture, for we have the authority of Prof. Law, corroborated by the observations of Dr. Woodward, for the statement that no "*specific* vegetal germs have been found in the air, blood, or nasal discharges, during the prevalence of the influenza."

Elevation and Subsidence of the Earth's Surface.—The *Philosophical Magazine* for December, 1872, contains an interesting paper by Captain F. W. Hutton, F. G. S., "On the Phenomena of Elevation and Subsidence of the Surface of the Earth," from which we condense the following: Assuming the increase of heat of the earth's interior to be 1° Fahr. to every 50 feet of descent, there occurs at a depth of about 23 miles an isogeothermal line or surface where cohesion of the rocks is overcome by heat, or rather would be so overcome at the ordinary atmospheric pressure. But the expansive force of the heat is balanced by the pressure of 23 miles of superincumbent rock, and thus a general equilibrium is maintained. The position of the earth's surface is due to three causes: 1. Its own weight; 2. Support of the interior mass; and, 3. Lateral thrust of the various portions against one another.

Whatever disturbs this adjustment must produce change of surface. If any elevation takes place in one section, there must follow subsidence in another. A great decrease of pressure is, doubtless, brought about by the radiation of heat into space, but this the author insists does not account for all the phenomena. There are two and only two agencies constantly at work, adequate to the production of this rise and fall of surface, and these are denudation and deposition, the latter being of greatest importance. The isogeothermal line will conform itself to undulations of the surface; so that, if a deposition of 100 feet of sand or rock occur, the line of heat will rise 100 feet, and the heat of the former line will correspondingly increase. Citing experiments of Colonel Totten and Mr. Adie illustrating the expansion of rocks by heat, the author says: "If the overlying mass be of loose particles, or sand, there could only be such elevation as would arise from increase of volume; but in case of solid rock, as limestone, there would be not only the increase of volume, but an arch-like elevation arising from lateral thrust. From this cause would arise ridges of elevation."

In illustration of this, he refers to the well-known elevation of the Wealden and Chalk of England. Here, with a thickness of the Cretaceous of 2,100 feet and of the Wealden of 1,300 feet, making in all 3,400 feet, we have a total rise of the arch of about 4,100 feet, the total breadth being about 100 miles. The elevation of the nummulitic limestone of the Eocene is also cited. This formation, 8,000 feet thick, is an ocean-deposit extending from Spain and Morocco to China and India, and has been elevated into enormous ridges, as the Atlas, Pyrenees, Apennines, and Himalayas. The author suggests that the cooling of mountain elevations as they rise above the snow-line may reduce the temperature of the surface, so that the rise of the isogeothermal is arrested, and further elevation ceases. On this point tables are given, showing the rise due to certain depths and areas of deposit.

Denudation, like cooling of surface, is supposed to induce subsidence in a given area by causing the line of heat to recede. But what could have disturbed the original equilibrium? "There can, I think, be but one answer to this question, viz., the origin of life on the globe. This life, by abstracting the carbonate of lime from solution in the sea, and depositing it on the bottom, first disturbed the equilibrium." The writer quotes freely from the statements of Babbage, Herschel, Croll, Hopkins, and others, to fortify points of this ingenious but perhaps in some respects fanciful hypothesis.

A Poison-Proof Bird.—A correspondent of *Science Gossip* tells of an attempt to capture a specimen of the scavenger-bird, or "adjutant," of India, in which he failed in a most unexpected way. On account of its valuable services in clearing the streets of decaying and putrid matter, the bird is held in high esteem by the natives, who take every precaution to protect it from harm. This prevented an open attack, and poison was the only alternative. The carcass of a partially-dissected bat was stuffed with enough arsenical paste and corrosive sublimate to kill twenty men, and the titbit thrown to a flock of the birds near by. One of them swallowed the whole of it at a gulp, and our student in comparative anatomy thought his game secure. But, though closely watched for three hours, not the slightest sign of uneasiness was manifested, and at the end of this time the creature flew away with its fellows, apparently as well as the best of them. The accustomed haunts of the flock were afterward carefully searched, but no trace could be found of the dead body wanted; and it was concluded that, unlike other gormands, this one was not to be easily got at through his stomach.

Purpose of the Rattlesnake's Rattle.—In the *American Naturalist*, for February, Prof. Samuel Aughey gives the results of his observations upon the use made of their rattles by the rattlesnake. It is the vulgar opinion that the reptile sounds his rattle for the purpose of enticing birds, and some naturalists even are disposed to find here a mimicry of the sound made by the so-called locust, or cicada. Prof. Aughey does not undertake to explain all the purposes served by the rattle, but he fully agrees with Mr. F. W. Putnam in rejecting this mimetic theory. Does the rattle, then, serve any useful purpose? In reply to this question, the author tells us what he has himself observed. In July, 1869, he was in Wayne County, Nebraska, and, as he was one day investigating the natural history of that district, he heard the familiar rattle of the snake. The sound was repeated at intervals, and proceeded from a rattlesnake that was calling its mate, which soon came in answer to the summons. Prof. Aughey had a similar experience the following year, and from these facts he is disposed to think that the purpose served by the rattle is to call the sexes together.

Another purpose may be to paralyze its victims with fright, and to inspire its natural enemies with terror. As an illustration of the use of the rattle for the former purpose, the author says that, as he followed through the woods of Dakota County, Nebraska, a Baltimore oriole, he heard a rattle, and at once saw the bird as it were paralyzed with fear, and ready to fall a prey to the serpent. The writer shot the rattlesnake. He adds that he once witnessed an attack of seven hogs on a rattlesnake. Soon after the battle opened, the snake rattled, and three others came to his aid. But the hogs were victorious in a few minutes.

OBITUARY.

Professor Matthew Fontaine Maury, whose scientific labors in the Hydrographical Office, Washington, earned for him eminent rank among *savants*, and were of inestimable benefit to the commerce of the world, died at Lexington, Va., February 1st, aged 67 years. At the time of his death he was Professor of Physics in the Virginia Military Institute. He was author of a "Treatise on Navigation," of a "Physical Geography of the Seas," of "Letters on the Amazon and Atlantic Slopes of South America," and other works.

The eminent French naturalist Felix Archimède Pouchet died December 6, 1872, at Rouen, in the 73d year of his age. He is best known to fame by his researches into the question of spontaneous generation, on which he held the affirmative side. He was a very voluminous writer, his principal works being on "Spontaneous Ovulation," and "The Organs of Digestion, Circulation, and Respiration." He was educated for a physician, and was for a long time professor in the Rouen School of Medicine.

The Rev. Adam Sedgwick, LL. D., F. R. S., F. G. S., Professor of Geology in the University of Cambridge, England, died January 27th, aged about 90 years. He long stood in the foremost rank of men of science in England, and was, both alone and with the assistance of Sir R. Murchison, the author of several works on geology. His first acknowledged publication appeared in 1822, and treated of the physical structure of the Devonshire and Cornish formations. In 1851 he was awarded the Wollaston Palladium Medal for researches into the geological structure of the British Isles, the Alps, and the Rhenish provinces. Two years before his death he resigned his professorship at Cambridge, but to the last took a warm interest in the progress of science.

NOTES.

The Mont Cenis Tunnel labors under a very serious defect—that of insufficient ventilation. Under ordinary circumstances the difference of temperature at the opposite sides of the Alps is such as to keep up a steady current of air through the tunnel. But it may happen that the temperature at both ends shall be the same, and then the air within will be stationary. A freight-train recently came to a stand-still, all hands on board having become half asphyxiated by foul air. Another train came to the rescue in time to save their lives. The tunnel, therefore, cannot be relied upon at all times to ventilate itself, and some artificial mode of ventilation must be applied without delay.

A comparison made between smokers and non-smokers belonging to the Polytechnic School of Paris shows that the non-smokers take the highest rank in every grade. Further, it is found that the smokers lost grade constantly. In 1861 the Minister of Public Instruction accordingly issued a circular forbidding the use of tobacco by pupils in public schools.

The *Food-Journal* quotes from the *Swiss Times* the statement that the sale of horse-meat has been authorized by the authorities in Geneva, the price per pound for the choice morsel being regulated by law.

A searcher of ancient records has exhumed the following weather statistics for Germany: In 1241 the trees bloomed in March, and in May cherries were ripe. In 1289 there was no winter, and young girls wore wreaths of violets at Christmas. In December, 1538, the gardens were green, and in full bloom the following month. The years 1572, 1588, 1607, 1609, and 1617, were similarly abnormal. There was neither snow nor frost in 1659. The trees bloomed in February, 1722. The year 1807 was extremely mild, as also 1834 and 1846.

One of the newest uses of paper is to employ it as *skins* for sausages. This is of course a German notion, and Würtemburg is its birthplace. Unlike the *skins* commonly used, the paper envelop is not subject to fermentation, and is cleanliness itself.

In spite of the heavy fines imposed upon milk adulterations in the cities of Ireland and England, the fraudulent practice still goes on; the fines being paid by societies organized in the interest of the fraud. To meet this difficulty, milk-consumers are urging the authorities to add, to the imposition of fines, the punishment of imprisonment, as the only effective deterrent that can be brought against this class of swindlers.

A report on the average life of academicians, addressed to the French Academy of Science, by M. Potiquet, shows that the mean age of members of the French Institute, from its foundation in 1795 down to November, 1869, is 51 years and 10 months at the time of their election, and 71 years and 5 months at the time of their decease. The latter figure shows an uncommonly high average of life, and will doubtless cause some surprise; and yet, as the author has bestowed great pains on his tables, and taken every precaution to avoid error, his results may be confidently accepted as entirely trustworthy.

A writer in the *Medical Record* commends the use of borax, as a remedy for the hoarseness or loss of voice common among public speakers and singers. A few minutes before any continuous exercise of the vocal organs, a small lump, three or four grains, of borax is to be slowly dissolved in the mouth and gradually swallowed. The solution acts upon the orifice of the glottis and the vocal cords precisely as "wetting" acts upon the notes of the flute. It is also stated that five grains of nitre taken in a glass of water, the body being wrapped in extra clothing, will excite a gentle perspiration for an entire night; and this treatment will break up a cold if employed at its first onset.—*Detroit Review of Medicine.*

A careful estimate gives the population of the globe as follows: Europe, 301,600,000; Asia, 794,000,000; Australia and Polynesia, 4,365,000; Africa, 192,520,000; America, 84,524,000; total, 1,377,000,000. London has 3,251,000, ranking first among cities in point of population. Next comes Su-choo, China, with 2,000,000. Five cities in China have an aggregate population of 6,884,000 inhabitants.

A man in Brussels, while under the influence of intoxicating liquor, fell into the Canal Charleroi. After some trouble and considerable loss of time his body was recovered and taken in charge by Dr. Joux, police-surgeon. After trying all the usual remedies for three hours, Dr. Joux applied iron, at a white heat, to the upper part of the body, near the vital organs. In half an hour the man awoke to life.

To obviate the slipperiness of asphalt pavements, it is proposed to mould the asphalt into blocks about the size of the ordinary granite blocks, and in the centre of each to fix a piece of stone or of wood.

Owing to the prevailing floods, salmon were to be found throughout the whole winter in all the rivers of Ireland. In the streets of Bandon, seven salmon were killed in one day, some of them in the very houses.

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