SPENCER

EDUCATION: INTELLECTUAL, MORAL, AND PHYSICAL
CHAPTER I.

WHAT KNOWLEDGE IS OF MOST WORTH?

It has been truly remarked that, in order of time, decoration precedes dress. Among people who submit to great physical suffering that they may have themselves handsomely tattooed, extremes of temperature are borne with but little attempt at mitigation. Humboldt tells us that an Orinoco Indian, though quite regardless of bodily comfort, will yet labor for a fortnight to purchase pigment whereby to make himself admired; and that the same woman who would not hesitate to leave her hut without a fragment of clothing on, would not dare to commit such a breach of decorum as to go out unpainted. Voyagers uniformly find that colored beads and trinkets are much more prized by wild tribes than are calicoes or brocadoths. And the anecdotes we have of the ways in which, when shirts and coats are given, they turn them to some ludicrous display, show how completely the idea of ornament predominates over that of use. Nay, there are still more extreme illustrations, witness the fact narrated by Captain Speke of his African attendants, who strutted about in their goat-skin mantles when the weather was fine but when it was wet, took them off, folded them up, and went about naked, shivering in the rain! Indeed, the facts of aboriginal life seem to indicate that dress is developed out of decorations. And when we remember that even among ourselves most think more about the fineness of the fabric than its warmth, and more about the cut than the convenience—when we see that the function is still in great measure subordinated to the appearance—we have further reason for inferring such an origin.

It is not a little curious that the like relations hold with the mind. Among mental as among bodily acquisitions, the ornamental comes before the useful. Not only in times past, but almost as much in our own era, that knowledge which conduces to personal well-being has been postponed to that which brings applause. In the Greek schools, music, poetry, rhetoric, and a philosophy which, until Socrates taught, had but little bearing upon action, were the dominant subjects; while knowledge aiding the arts of life had a very subordinate place. And in our own universities and schools at the present moment the like antithesis holds. We are guilty of something like a platitude when we say that throughout his after-career a boy, in nine cases out of ten, applies his Latin and Greek to no practical purposes. The remark is trite that in his shop, or his office, in managing his estate or his family, in playing his part as director of a bank or a railway, he is very little aided by this knowledge he took so many years to acquire—so little, that generally the greater part of it drops out of his memory; and if he occasionally vents a Latin quotation or alludes to some Greek myth, it is less to throw light upon the topic in hand than for the sake of effect. If we inquire what is the real motive for giving boys a classical education, we find it to be simply conformity to public opinion. Men dress their children's minds as they do their bodies, in the prevailing fashion. As the Orinoco Indian puts on his point before leaving his hut, not with a view to any direct benefit, but because he would be ashamed to be seen without it; so a boy's drilling in Latin and Greek is insisted on, not because of their intrinsic value, but that he may not be disgraced by being found ignorant of them—that he may have "the education of a gentleman"—the badge marking a certain social position, and bringing a consequent respect. This parallel is still more clearly displayed in the case of the other sex. In the treatment of both mind and body, the decorative element has continued to predominate in a greater degree among women than among
men. Originally personal adornment occupied the attention of both sexes equally. In these latter days of civilization, however, we see that in the dress of the average person the hand has, in a considerable degree, yielded to the regard for comfort; while in their education the useful has of late been trenching on the ornamental. It is not that the ornamental has not been improved, for the many improvements which science has brought to bear on the life of the individual are concerned with a certain extent of utility. If there needs any further evidence of the rule, undeveloped character of our education, we have it in the fact that the comparative value of the many accomplishments we have been as yet scarcely even discussed—much less used in a methodic way with definite results. Not only is it that no standard of the principles or of the ends of any acquirement is established, but the existence of any such standard has not been conceived in any clear manner. And not only is it that the existence of any such standard has not been conceived, but the need for it has seemed to have been scarcely even felt. Men read books on this topic, and attend lectures on that; decide that their education must be instructed in these branches of knowledge, and shall not be instructed in those; and all under the guidance of mere custom, or liking, or prejudice. It is the almost incomprehensible importance of determining in some rational way what things are really most worth learning. It is true that in all circles we hear of the use of this or the other of some accomplishment, but the reason why it is used is, for the most part, not given; and this is really no more than a whisper of admiration. The births, deaths, marriages of kings, and other like historic trivialities, are committed to memory, not the knowledge of the present, nor what is possibly result from knowing them, but because society considers them parts of a good education—because the absence of such knowledges seems to exclude the possessor of them from society. When we have named reading, writing, spelling, grammar, arithmetic, and sewing, we have named about all the things a girl is taught to read, write, and do, which she will ever use in life; and even some of these have more reference to the good opinion of others than to immediate personal welfare. Thoroughly to realize the truth that with the mind as with the body the ornamental precedes the useful, it is needful to glance at its rationale. This lies in the fact that, from the earliest times, our social needs have subordinated individual needs, and that the chief social need has been the control of individuals. It is not, as we commonly believe, the representatives of these necessities—these individuals who have had the control that we call government and constituted authorities. These acknowledge governments are supplemented by other systems of control, which rise up in all circles, in which every man or woman strives to be king or queen or lesser dignitary. To get on in these circles, we must know the language and manner of speaking, and, by style of living, by beauty of dress, by display of knowledge or intellect, or else try to subordinate others, and so all is in weaving that the society is kept in order. It is not the savage chief only who, in formidable war-party, with scalps at his belt, aims to strike awe into his neighbors, and so control them, or who, by elaboratelyToyed, polished manners, and numerous accomplishments, strives to make conquests; but the scholar, the historian, the statesman, the diplomatist, each of these in his own department to the same end. We are none of us content with quietly unfolding our own individualities to the full in all directions, but have our own accommodated to the acceptable individualities upon others, and in some way subordinate them. And this it which determines the character of our education. Not what knowledge is of most real worth is the consideration, but what will bring most applause, honor, respect—what will most contribute to social position and influence—will be most imposing. As throughout life not what we are, but what we shall be thought, is the question; so in education, the question is, not the intrinsic merit of the acquisition, but its consecutiveness, its effects on others. And this being our dominant idea, direct utility is scarcely more regarded than by the barbarian when filling his carvings with the most trivial insignia. 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Iude, empirical style of judging displayed by those more intelligent people who do bestow one care in overseeing the cultivation of the material and moral qualities of their offspring, is not so much to imply that such or such information will be useful in after life, or that this kind of knowledge is of more practical importance than that some processes of estimating their respective values, so that as far as possible we may positively indicate which are most essential. Our task is by no means an easy one, but it is a difficult and perhaps, never to be more than approximately achieved. But considering the vastness of the interests at stake, its difficulty of measuring it by, but rather for levelling every energy to its mastery. And if we only proceed systematically, we may expect at least a very certain gain from it.

Our first object must obviously be to classify, in the order of their importance, the various kinds of activity which constitute man, so as to secure the natural order into, 1. Those activities which directly minister to self-preservation; 2. Those activities which, by securing the necessities of life, minister to self-preservation; 3. Those activities which have for their end the caring and discipline of offspring; 4. Those activities which are involved in the maintenance of society as a whole.

Those miscellaneous activities which make up the leisure part of life, devoted to the gratification of the tastes and feelings, are in any case like their true order of subordination, it needs no long consideration to show the actions and reactions by which, from moment to moment, we enter on and into each one of these. The bodies of each of the parents can be made possible only by the previous discharge of the industrial ones. The power of self-maintenance preceding the power of nourishing offspring, it follows that knowledge useful for self-maintenance has stronger claims than knowledge needful for family discipline—second in value to those save knowledge needful for immediate self-preservation.

As the family comes before the state in the order of importance, so the state is more than the family, and none will question that a man’s industrial functions must be considered before his parental ones is manifest from the fact that in the case of the human species the family was the first of the parental functions is made possible only by the previous discharge of the industrial ones. The power of self-maintenance preceding the power of nourishing offspring, it follows that knowledge useful for self-maintenance has stronger claims than knowledge needful for family discipline—second in value to those save knowledge needful for immediate self-preservation.

When one’s attention is turned to the historical development of the family, one must be impressed with the fact that the family was the first institution to be considered in the order of importance. The family was the first to be considered in the order of importance, and none will question that it is the most important. A man’s industrial functions must be considered before his parental ones is manifest from the fact that in the case of the human species the family was the first of the parental functions to be considered.

These various forms of pleasurable occupation which fill up the leisure left by grave occupations—the enjoyments of music, poetry, painting, etc.—manifestly imply a be-existing society. Not only is a considerable development of them impossible without a long-established social union, but their real object is to give a balance to social sentiments and sympathies. Not only does society supply the conditions to their growth, but also the ideas and sentiments which they embody make a part of human conduct which constitutes good citizenship of more moment than that which goes out in accomplishments or exercise of office, in which preparation for the one must make before preparation for the other.

Such then, we repeat, is something like the great importance that education has in the lives of men. Education which prepares for direct self-preservation; that which prepares for indirect self-preservation; that which prepares for the exercise of citizenship; that which prepares for the miscellaneous refinements of life. We do not mean to say that these divisions are definitely separable. We do not mean that they are intricately entangled with each other in such a way that there can be no training for any that is not in some measure a training for all, and that goes to the root of each division. There are portions more important than certain portions of the preceding divisions; and, for instance, a man of much skill in business, and in another he is far below the standard of complete living than one of but moderate power of acquiring money but great judgment as a parent; or, it may be, the man who has the rights and duties of the social action, joined with entire want of general culture in literature and the fine arts, is less desirable than a more moderate share of accomplishment in business and politics. But after making all qualifications, there still remain these broadly-marked divisions and it still continues substantially true that these divisions will mark for each one of us the going order, because the corresponding divisions of life make another one possible in that order.

Of course the idea of education is, complete preparation in all these divisions. But failing this ideal, as in our phase of civilization every one must do more or less, the aim should be to maintain a due proportion between the degrees of preparation in each. Not exclusive cultivation in any one, supremely important though it may be—yet, it is not enough; there are three or four divisions of greatest importance; but an attention to all—greatest where the value is least, and the least where the value is greatest; average value of the whole man (not to forget the cases in which peculiar aptitude for some one department of knowledge rightly makes that one the predominating occupation); and falls more and more perfection in the things that have more and more remote bearings on complete living.

In regulating education by this standard of considerations that should be ever present to us. The worth of any kind of culture, as aiding complete living, may be either necessary or more or less the intrusion of various intrinsic value, knowledge of quasi-intrinsic value, and knowledge of conventional value. Such facts as that sensations of numbness and indifference commonly proceed from analysis, that the resistance of water to a body moving through it varies as the square of the velocity, that chlorine is a disinfectant—these, and the like truths of the general, are of intrinsic value: they will be repeated in courses designed to a thousand years hence as they do now. The extra knowledge of our own language, which is given by an acquaintance with Latin and Greek, may be of great assistance in a great many practical and discursive purposes. But in general, no set of knowledge, as such, has the quality of quasi-intrinsic; it must exist for us and for other races whose languages owe much to these sources, but will last only as long as our languages last. While that kind of information, which, in our schools, usurps the name of history—the mere issue of names and dates and divisions and combinations that have no conventional value only; it has not the right bearing upon any of our actions, and it is much more likely to produce those unpleasant criticisms which current education runs upon as a consequence. Of course, as those facts which concern all mankind throughout all time and of a greater moment than those which concern a nation of them during a limited era, and of far greater moment than those which concern only a nation, and the extension of a fashion, it follows that if in a rational estimation knowledge of intrinsic worth must, other things equal, take precedence of knowledge of quasi-intrinsic or conventional worth.

One further preliminary. Requirement of every kind has two values—value as knowledge and value as discipline. Besides its use for guidance in conduct, the acquisition of each order of facts has also its use as mental exercise; and its effects as a preparative for future life, must also have to be considered under both these heads.

These, then, are the general ideas with which we must set out in discussing a curriculum. The point of view is the activity of successively decreasing importance: the worth of each order of facts as regulating these several kinds of activity, involving, in the first place, a rational estimation of discipline, and its regulative influences estimated both as knowledge and discipline.

Happily, that all-important part of education, that of self-preservation, is in great part already provided for. Too numerous to be left to our blundering, nature takes it into her own hands. While the horse’s coat shivers with each gust of wind, its face and crying at the sight of a stranger, the dog comes near, or the screams with which it runs to its master after any startling sight or sound, shows this instinct further developed. Moreover, knowledge subserving direct self-preservation is that which is chiefly secured in acquiring from hour to hour. How to make a horse safe when traveling in storms so as to avoid collisions; what objects are hard, and will hurt if struck; what objects are heavy, and inure if they fall on the body; and the strength of the bone of the body, and which not; the pains inflicted by fire, by missiles, by sharp instruments—these, and various other pieces of information useful for the avoidance of death or accident, it is ever learning. And when a few years later, the energies go out in running, climbing, and jumping, in games of strength and games of skill, we may secure all those actives by which the muscles are developed the perceptions sharpened and the judgment quickened, a preparation for the various vocations of the body and of objects and movements, and for meeting those greater dangers that occasionally occur in the lives of all. Being thus, as we say, so self-taught, by a difficulty of the body, and by education needs comparatively little care from us. What we are chiefly called upon to see is, that there shall be free scope for the exertion of those powers, and that discipline—that there shall be no such throttling of nature as that by which stupid schoolmistresses commonly prevent the girls in their own forms of activity and waking activities they would indulge in, and so render them comparatively incapable of taking care of themselves in circumstances of peril.

This, however, is by no means all that is connected with a good education that prepares for direct self-preservation. Besides guarding the body against mechanical damage or destruction, it has to be guided
against injury from other causes—against the disease and death that follow breaches of physiologic law. For complete living it is necessary that the personal endowment of life shall be warded off, but also that there shall be escaped the incapacities and the slow annihilation which unwise habits effects. Physiologic law affects all, industrial, the parental, the social, and all other activities become more or less impossible, it is clear that this secondary kind of disease, this aggrandizement of the evil as compared with the primary kind, and that knowledge tending to secure it should rank very high. It is true that here, too, guidance is in saecular things, and that the insistent promptings too peremptory to be disregarded. And would men habitually obey these and all like promptings when less strong, comparative wisdom would arise. If fatigue of body or brain were in every case followed by desistance; if the oppression produced by a close atmosphere always led to ventilation; if the use of water, or a few minutes drinking without thirst; then would the system be but seldom out of working order. But so profound an ignorance is there of the laws of health that few people even understand their sensations are their natural guides, and (when not rendered morbid by long-continued disobedience) their trustworthy guides. So health, the endowment that nature has provided efficient safeguards to health, lack of knowledge makes them in a great measure useless.

The grave importance of an acquaintanceship with the fundamental principles of physiology is a means to complete living, let him look around and see how many men and women are suffering, and are made the worse of life who are thoroughly well. Occasionally only do we meet with an example of vigorous health continued to old age; hourly do we see the results of a life spent in chronic ailment, general debility, premature decrepitude. Scarcely is there one to whom you put the question, who has not in the course of his life, brought upon himself illnesses which a little knowledge would have saved him from. Here is a case of heart disease consequent on a rheumatic fever that for a long time was neglected; the sight of eyes spoiled for life by over-study. Yesterday the account was of one whose long-enduring lameness was brought on by continued practice and were not reckoned as such till it had been slightly injured. And to-day we are told of another who has had to lie by for years because he did not know that the palpitation he suffered from resulted from over-taxed brain. Now we hear of an irremediable injury that followed some silly feat of strength; and, again, of a constitution that has been ruined by excessive work needlessly undertaken; while on all sides we see the perpetual minor ailments which accompany feebleness. Not to dwell upon the results of neglect, the cowed spirit, the gloom, the waste of time and money thus entailed, only consider how greatly ill-health hinders the discharge of all duties; business often impossible, and always more difficult; produces an irritability fatal to the right management of children; puts the functions of citizenship out of the question; and lastly and most important, is the fear that the physical sins—partly our forefathers' and partly our own—which produce this ill-health, deduct more from complete living than all the carelessness that a business often impossible, and always more difficult; produces an irritability fatal to the right management of children; puts the functions of citizenship out of the question; and lastly and most important, is the fear that the physical sins—partly our forefathers' and partly our own—which produce this ill-health, deduct more from complete living than any other thing whatever, the teaching how to maintain them is a teaching that yields in moment to no other whatever. And therefore we have reason to be afraid that knowledge as is needful for the comprehension of its general truths, and their bearings on daily conduct, is an essential part of a rational education.

Strange that the assertion should need making! Stranger still that it should need defending! Yet are there not a few by whom such a proposition will be received with something approaching to derision. Men who would blush if caught saying Hippias instead of Hippocrates, or would have scolded a person for a thoughtless confidence respecting the fabled labors of a fabled demigod, show not the slightest shame in confessing that they do not know what is meant by the word the spine, the nerves, the actions of the spinal cord, what is the normal rate of pulsation, or how the lungs are inflated. While anxious that their sons should be well up in the superstitions of two thousand years ago, they care not that they should be taught anything about the structure and functions of the human bodies—to know above such instruction. So overwhelming is the influence of established routine! So terribly in our education does the ornamental overbear the practical, that we are in the habit of putting all the value on the knowledge which aids indirect self-preservation by facilitating the gaining of a livelihood. Thus we have for instance the infant, the child, the youth, trained to learn, not that they may know, but that they may use. The special subject is of no interest to their individuality, but is only an aid to the acquisition of the knowledge which is in great part ignored in our school courses, is the order of knowledge underlying the right performance of all habitually learned duties. It is a mistake to suppose that knowledge, which is in great part ignored in our school courses, is the order of knowledge underlying the right performance of all habitually learned duties. It is a mistake to suppose that knowledge, which is in great part ignored in our school courses, is the order of knowledge underlying the right performance of all habitually learned duties. It is a mistake to suppose that knowledge, which is in great part ignored in our school courses, is the order of knowledge underlying the right performance of all habitually learned duties. It is a mistake to suppose that knowledge, which is in great part ignored in our school courses, is the order of knowledge underlying the right performance of all habitually learned duties. It is a mistake to suppose that knowledge, which is in great part ignored in our school courses, is the order of knowledge underlying the right performance of all habitually learned duties. To give due weight to our argument, we must, therefore, realize this truth to the reader by a rapid review of the facts. For all the higher arts of construction, some acquaintance with mathematics is indispensable. The village carpenter, who, lacking rational instruction, lays out his houses, and who has no more idea of a prenticeship, equally with the builder of a Britannia Bridge, makes hourly reference to the laws of quantitive relations. The sur-
all our industries, and that, by consequence, knowledge of it concerns every one who is directly or indirectly connected with our industries.

And then the science of life—biology; does this not, too, bear fundamentally upon these matters of indirect self-preservation? With what preciseness is the process of the factory, if it has, indeed, little connection; but with the all-essential-matter—that of food—it is inseparably connected. As agriculture is the nutriment of our material existence, and as biological truths have indeed been empirically established and acted upon by farmers while yet there has been no conception of them as scientific, so that to many farmers manures are applied to particular plants; this same rain sends us forth for the soil or for other food; that horses cannot do good work on poor food; that such and such diseases of cattle and sheep are directly and indirectly connected with such conditions. These, and the everyday knowledge which the agriculturist gains by experience respecting the right management of plants and animals, is a foundation of all the biological facts, on the largeness of which greatly depends our success. And as these biological facts, scanty, indefinite, rudimentary truths, as is true of many other things, what must be the value to him of such facts when they become positive, definite, and exhaustive. Indeed, even now we may see the individual plants or products of the country as bunching up the truth. The truth that the production of animal heat implies waste of substance, and that, therefore, preventing loss of heat production is directly connected with the economical conclusion—now guides the fattening of cattle; it is found that keeping cattle warm fodder is saved. Similarly with the facts and laws in animal husbandry. The chemists and physiologists have shown that not only is change of diet beneficial, but that digestion is facilitated by a mixture of ingredients in each meal: both which truths are now influencing cattle feeding. The discovery that the disordered known as "the strugglers," of which thousands of sheep have died annually, is caused by an enzoon which press on the brain, and that if the creature is extracted through the softened place in the skull which marks its position in the sheep usually by a distributing whether the effect which agriculture owes to biology. When we observe the marked contrast between our farming and our cattle feeding, and remember that this contrast is mainly due to the far greater influence science has had upon farming here than there; and when we see how, daily, competition is making the adoption of scientific methods more general and necessary; we shall rightly infer, that very soon agricultural success in England will be impossible without a competent knowledge of animal and vegetable physiology.

Yet one more science have we to note as bearing directly on industrial success—the science of chemistry. Women who daily look at the state of the money market, glance over prices current, discuss the probable crops of corn, cotton, sugar; but how many of them, who are familiar with all those data which influence their mercantile operations, are students of social science: empirical and blundering students it may be said, for they are not made aware that they are plucked of their profits according as they do or do not reach the right conclusion. Not only the manufacturer and the merchant, but every manufacturer and every one of supply and demand, based on numerous facts, and tacitly recognizing sundry general principles of social action, but even the reaper and the gleaning laborers are greatly depending upon the correctness of his judgments respecting the future wholesale prices and the future rates of consumption. Manifestly, all who take part in the entangled commercial activities of a community are vitally interested in understanding the laws according to which those activities work.

Thus, to all such as are occupied in the production, exchange, or distribution of commodities, acquaintance with science in some degree, is a part of their business and profession. Whoever is immediately or remotely implicated in any form of industry (and few are not) has a direct interest in understanding the laws of physical and chemical properties of things; perhaps also, has a direct interest in biology; and certainly has in sociology. Whether he does this through a direct or a byway, the knowledge by which our getting a good livelihood depends in a great degree on his knowledge of one or more of these sciences, and on his knowledge, and still a knowledge, though empirical. For what we call learning a business really implies learning the science involved in it, though not perhaps under the name science.

And hence a grounding in science is of great importance, both because it prepares for all this, and because rational knowledge is a superior power over ignorance. Knowledge. Moreover, not only is it that scientific culture is requisite for each, that he may understand the how and the why of the things which he uses, and has learned to a certain degree, and even to a certain extent, as maker or distributor, but it is often of much moment that he should understand the why and the whom of various other situations and conditions. Not, therefore, that he has stock undertakings, nearly every man above the laborer is interested as capitalist in some other occupation than his own; and, as such, has an interest in and a degree of knowledge concerning the science of these bearings on this other occupation. Here is a mine, in the sinking of which many shareholders ruined themselves. The use of ground water on rice, which belonged to the old red sandstone, below which no coal is found. Not many years ago 20,000 acres of land in the prosecution of a scheme for collecting the sap from trees that distill from bread in baking, all which would have been saved to the subscribers had they known more of the tricks that are hitherto widespread by weight of the flour is changed in fermentation. Numerous attempts have been made to construct electro-magnetic engines, in the hope that by the aid of these apparatuses the water that has been supplied the money underwritten the general law of the correlation and equivalence of forces they might have had better success. But the want of knowledge is possessed in the amount of money that was expended in the technicalities which is used to aid in carrying out inventions which a mere tyro in science could show to be futile. Scarcely a locality but has its history of projects thrown away over some impossibly project.

And if already the loss from want of science is so frequent and so great, still greater and more frequent will be the loss to those who hereafter lack science. Just as fast as productive processes become more scientific, which competition will inevitably make them so, the advantages accruing from the improvements spread, which they certainly will, so fast will scientific knowledge grow necessary to every one. And so our school courses leave almost entirely out, we thus find to be that which most nearly concerns the business of life. All our industries would cease were it not for the knowledge that we have acquire as they best may after their education is said to be finished. And were it not for this information, that has been from age to age transmitted, and that comes to us by some means, these industries would never have existed. Had there been no teaching but such as is given in our public schools, England and the free republics would have been in a state of poverty. That increasing acquaintance with the laws of phenomena which has through successive ages enabled man to subjugate nature to our needs, and in these days gives the common
laborer comforts which a few centuries ago kings could not purchase, is scarcely in any degree owed to the appointed means of in-structing our youth. The vital knowledge — that knowledge which is new to what we are, and which now underlies our whole existence—is a knowledge that has got itself (taught in no progressions) into the minds of the children, for teaching have been mumbling little else but dead formulas. We come now to the third great division of human knowledge—education; preparation whatever is made. If by some strange chance not a vestige of us descended to the remote future save a pail of our schools, and a few thousand years a year under our bringing up of children. They could not have been so absurd as to omit all training for this gravest of responsibilities. Evidence to its necessity is manifest in the school course of one of their monastic orders.

Seriously, is it not an astonishing fact, that though on the treatment of offspring de- pends the preservation of our social welfare or ruin, yet not one word of instruction on the treatment of offspring is ever given to those who will hereafter be parents? Is it not a matter for wonder that this generation should be left to the chances of unreasoning custom, impulse, fancy, joined with the suggestions of ignorant nurses and the purchasers of newspapers? To be a merchant commenced business without any knowledge of arithmetical and book-keeping, we should exclaim at his folly and look for disastrous consequences. Failing an anatomy, a man set up as a surgical operator, we should wonder at his audacity and pity his patients. But that parents should rear children without ever having given a thought to the principles—physical, moral, or intellectual—which ought to guide them, excites nothing like surprise at the actors or pity for their victims.

To tens of thousands that are killed, add hundreds of thousands that survive with feeble understanding and character, and now, up with constitutions not so strong as they should be, and you will have some idea of the curse inflicted on their offspring by parents ignorant of the laws of life. Do but consider for a moment that the regimen to which children are subject is hourly telling upon them to their lifelong injury or benefit. Is it not a misfortune, to wrong one to way going right, and you will get some idea of the enormous mischief that is almost everywhere inflicted by the innumerable errors which make their way in to the home life. Is it decided that a boy shall be cloathed in some flimsy short dress, and be allowed to go playing about with limbs reddened by cold? The decision will tell on his whole future existence—either in illnesses, or in stunted growth, or in deficient energy, or in a maturity less vigorous than it ought to have, in want of proper self-control, of a bearing unprepossessing, success and happiness. Are children doomed to a monotonous dietary, or a dietary that is deficient in nourishement? Their ultimate physical and mental health, and all our women, will inevitably be more or less diminished by it. Are they forbidden vocifer- ous play, or (being too ill-clothed to bear exposure) are they kept indoors in cold weath- er? They are certain to fall below that measure of health and strength to which they would else have attained. When sons and daughters grow up sickly and feeble, parents commonly regard the event as a misfortune, as a visitation from Providence. Thinking that the prevalent chaotic fashion, they assume that they are the cause of the evil. Nothing of the kind. In some cases the causes are not evident. It is a matter that by the English regulations are the causes. Very gen- erally parents themselves are responsible for all this pain, this debility, this depression, which is the cause of the evil, as much as, and perhaps more than, by their commands and prohibitions; in utter ignorance of the simplest physiologic laws, they have been year by year undermin- ing the constitutions of their children, and have so inflicted disease and premature death, not only on them but on their descendants.

Equally great are the ignorance and the consequent ignorance are, the ignorance from physical training to moral training. Consider the young mother and her nursery legislation. But a few years ago she was at school, where she was carefully instructed in the names and dates, and her reflective faculties scarcely in the slightest degree exercised— where not one idea was given her respecting the mosaic of the broad open mind of childhood, and where her disci- pline did not in the least fit her for thinking out methods of her own. The intervening years have been wasted in acquiring a mechanical skill in fancy-work, in novel-reading, and in party- going: no thought having yet been given to the grave responsibilities of maternity, and some years at the close of which she can claim to have obtained which would be some preparation for such responsibilities. And now see her with an unfolding human character committing it into the hands of a still less experienced and untried disciplinarian. This is a matter of the phenomena with which she has to deal, undertaking to do that which can be done but imperfectly even with the aid of the experienced, but in which they have no knowledge of the nature of the emotions, their order of evolution, their functions, or where use ends and abuse begins. She is under the impression that it is her duty to torment a wholly bad, which is not true of any one of them; and that others are good, however far they may be carried, which is also not true of any one of them. In a word, she is of that with which she has to deal, she is equally ignorant of the effects that will be produced on it by this or that treatment. Yet she will have the temerity to pronounce serious results we see hourly arising? Lack- ing knowledge of mental phenomena, with their causes and consequences, her inter- ference is frequently more mischievous than ab- solute passivity would have been. This and that kind of action, which are quite normal and beneficial, she perpetually swallows, and those which are prejudicial and mischievous, she injures its temper and her own, and pro- duces estrangement. Deeds which she thinks it desirable to encourage she gets performed through the agency of a child, she is asked for applause, considering little what the in- ward motive may be, so long as the outward conduct conforms, and thus cultivating hypocricy, and fear, and selfishness, in place of good feeling. While insisting on truthful- ness, she constantly sets an example of un- truth, by threatening penalties which she is not likely to enforce. When asked to give control, she hourly visits on her little ones angry scoldings for acts that do not call for them. She has not the remotest idea that in the minds of children there is a truly salutary discipline which visits on all conduct, good and bad, the natural conse- quences—the consequences, pleasurable or painful, which in the nature of things such conduct tends to bring. Being thus without theoretic guidance, and quite incapable of guiding herself by tracing the mental pro- cesses going on in her children, her rule is impulsive, inconsistent, mischievous, often in the highest degree; and would indeed be generally ruinous, were it not that the over- all tendency is the same, and that she assumes the moral type of the race usually subordinates all minor influences.

And then the culture of the intellect— is not that another subject which we may- er? Grant that the phenomena of intelli- gence conform to laws; grant that the evo- lution of such intelligence in a child also conforms to laws, and it is certain that no instruction can be rightly guided only by a knowl- edge of these laws. To suppose that you can regulate this process of forming and accumulating knowledge without ascertaining the nature of the process is absurd. How widely, then, must teaching as it is differ from teaching as it should; for when hardly any parents, and but few teachers, think about psychology. As might be ex- pected, the system is grievously at fault, alike in matter and in manner. While the right class of facts is withheld, the wrong class is forcibly administered in the wrong way and in the wrong order. With that part of the knowledge which is actually confines it to knowledge gained from books, parents thrust primers into the hands of their little ones years too soon, to their great in- jury. In a word, the knowledge which they give themselves, is manifest in the function of books is supplementary—that they form an indirect means to knowledge when direct means fail—a means of seeing things that are not visible to the eye, and of hearing things that are not audible to the ear.

— not perceiving that a child's restless ob- servation, instead of being ignored or checked, should be diligently administered to, and nourished. There is a new supposition that if they are possible, insist on occupying its eyes and thoughts with things that are, for the time being, incomprehensible and repugnant. By droning into its ear, by imparting to the symbols of knowledge instead of the knowledge itself, they do not see that only when his acquaintance with the objects and descriptions of the world is so familiar to his consciousness, and so much a part of the field, is becoming tolerably exhaustive.

—only then should a child be introduced to the new sources of information which books affords. When the symbols of knowledge have become familiar, and immediate cognition is of far greater value than mediate cognition but also because the words contained in books can be rightly in- terpreted to him only by the antecedent experience of things. Ob- serve next that this formal instruction, far too soon commenced, is carried on with but little reference to the laws of mental develop- ment. Intellectual progress is of necessity from the concrete to the abstract. But re- gardless of this, highly abstract subjects, are not in the present state of knowl- edge, are begun quite early. Political ge- ography, dead and uninteresting to a child, and which should be an appendage of sociologi- cal studies, is put in the hands of children of six, or seven years of age, after physical geography, comprehensible and comparatively attractive to a child, is in great part passed over. Nearly every subject dealt with is arranged in arithmetical order: defi- nitions and rules and principles being put first, instead of being disclosed, as they are in the order of nature, through the study of the phenomena and the facts by which it is the victim of rote learning—a system of sacrificing the spirit to the letter. See the results. What with perceptions unnatural- ly prolonged by intention to books: what with the mental con- fusion produced by teaching subjects before they can be understood, and in each of them giving generalizations before the facts of which these are the generalizations: what with making the pupil a mere passive recipient of others' ideas, and not in the least lead-
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...

...The more we learn about the character of education, the more we perceive how much of the instruction we receive is...very large, an immense mass of information of transcendent value is entirely passed by...
conduct. The only history that is of prac-
tical value is that which is called Descriptive Sociology. And the highest office which the historian can discharge is that of portraying
the historical development of a few concrete materials for a Comparative Sociology, and for the subsequent determination of the ultimate laws to which social phenomena are subjected. But the historian is, even supposing an ade-
quate stock of this truly valuable historical knowledge has been acquired, it is of com-
paratively little use without the possession of the power to judge, the talent to disentangle
its threads. Without an acquaintance with the general
truths of biology and psychology, rational in-
terpretation of social phenomena is possible only in
the hands of men who have obtained a certain rude empirical knowledge of human
tastes, as they are enabled to understand even the simplest facts of social life, as, for in-
stance, the relation between wealth and demand.
And if even the most elementary truths of sociology can be reached until now, some
may be inclined to think, feel, and act under given circum-
stances, then it is manifest that there can be nothing like a wide comprehension of soci-
ology, nothing like a true education of man, in all his faculties, bodily and mental.
Consider the matter in the abstract, and
this conclusion is self-evident. Thus: So-
cial customs are built up in society by the
combined actions of individuals; and therefore in in-
dividual actions only can be found the solu-
tion of those social actions. If the actions of individuals depend on the laws of their
natures, and their actions cannot be under-
stood until these laws are understood. Then the simplest expression, is founded on the
laws of body and mind in general. Hence necessarily follows that biology and psychology, which are the inter-
preters of sociology. Or, to state the conclu-
sions still more simply: all social phenomena
are phenomena of life, are the most complex manifestations of life, and are ultimately depend-
ent on the laws of life, and can be under-
stood only when the laws of life are under-
stood. Thus, then, we see that for the regu-
lations of these phenomena, and the activi-
ties we are, as, before, dependent on science. Of the knowledge commonly im-
ported in educational courses very little is of any value for the life of the individual as a citizen. Only a small part of the history
he reads is of practical value, and of this small part he is not prepared to make proper use,
and the liberal education of the humanities for, but the very conception of, de-
scriptive sociology; and he also lacks that knowledge of the organic sciences, without
which even descriptive sociology can give
him but little aid.
And now we come to that remaining di-
vision of human life which includes the relax-
ings of the mind, the art of living, and the leisure hours. After considering what training
best fits for self-preservation, for the obtain-
ment of sustenance, for the discharge of pa-
triarchal and political duties, we have now to con-
ider what training best fits for the miscel-
laneous ends not included in these—for the en-
joyments of nature, of literature, and of the
fine arts, in all their forms. Postpon-
ing them as we do things that bear more vitally upon human welfare, and bringing every
thing second to them, and considering them of
little value, it will perhaps be inferred that we
are inclined to slight these less essential things.
No greater mistake could be made, because of
this order of rank, nor to attach to aesthetic culture and its pleasures. Without painting, sculpture, music, poetry,
and the emotions produced by natural beauty of
every kind, life would lose half its charm. So far from thinking that the training and
gratification of the tastes are unimportant, we believe the time will come when they will
occupy a much larger share of human life
than now. When the forces of nature have
been fully conquered to man's use—when
the forms of natural production have been brought to
perfection—when all that science can make
ized to the highest degree—when education has
been so systematized that a preparation
is not required for the purpose of entering
with comparative rapidity—and when, con-
sequently, there is a great increase of spare
time, then will the poetry, both of art and
nature, and the handiwork which is made pos-
sible be postponed to that which makes it
possible. A florist cultivates a plant for
the sake of its flower, and regards the root
as of insignificant importance. But as to
flowers, roots, and leaves are intrinsically of greater
importance, because on them the evolution of the
flower depends. He bestows every attention and
skill in the development of the flower itself, yet it would be folly in, his anxiety to obtain
the flower, he were to neglect the plant. Similarly in the case before us, Architecture
is the art of the florist, painting of the poet;
and it may be truly called the efflorescence of civil-
ized life. But even supposing them to be
of such transcendent worth as to subordinate
the use of all other art for their production (which can hardly be asserted), it will still
be admitted that the production of a healthy,
civilized life must be the first consideration,
that producing to this end must occupy the highest place.

And here we see most distinctly the vice
of our educational system. It neglects the
most essential part of man's wants for the sake of
elusion. While it gives no knowledge conducive to self-pres-
ervation—while of knowledge that facil-
itates the discharge of our external duties
and leaves the greater part to be
picked up anyhow in after-life—while for
the discharge of parental functions it makes
nothing at all provision, while for the duties of citizenship it prepares by imparting
a mass of facts, most of which are irrelevant,
and the rest without a key, it is diligent in
teaching everything that adds to refinement, polish, etc. However fully we may admit
that extensive acquaintance with modern
languages is a valuable accomplishment,
which will be of some service to the indi-
vidual in the discharge of his private
travel, aids in giving a certain finish, it by
no means follows that this result is rightly
purchased at the cost of that vitally impor-
tant education which is the foundation of
true that classical education conduces to ele-
quence and correctness of style, it cannot be
said that elegance and correctness of style are
comparable in importance to a familiarity
with the principles that should guide the
rearing of children. Grant that the taste
may be greatly improved by reading all
that is fashionable, and that it can, in a
most diligent observation, if not aided by
science, fails to preserve from error. Every
painter will indorse the assertion that unless
they are instructed, or consider the criticism
under given circumstances they often will not
be perceived; and to know what appearances
must exist, is, in so far, to understand the
language of appearances. From want of sci-
ence Mr. J. Lewis, careful painter as he is,
casts the shadow of a lattice-window in
sharply-defined lines upon an opposite wall;
bombast out of and pressed, perhaps by light from certain phenomena, had experienced an iridescence, a peculiar light and color, which scientists call suifaces, and for which the common conception of suifaces as crooked mirrors is no longer valid. But this is a question that lies beyond the scope of this essay. What I want to say is that we must learn to see more than we can, and that our perceptions depend on our context. When we see something, we see it as we are, not as it is. But what do we see when we look at a painting, or a poem? We see what we are used to seeing, what we think we see, not what we actually see. And this is true of all poetry, not just of scientific poetry. For poetry is a way of seeing, a way of thinking, a way of feeling, and a way of understanding. It is a way of relating to the world, and to ourselves, and to each other. And it is a way of relating to the past, and to the future, and to the present. It is a way of relating to the real, and to the imaginary, and to the possible. It is a way of relating to the known, and to the unknown, and to the unknowable. It is a way of relating to the finite, and to the infinite, and to the eternal. It is a way of relating to the finite, and to the infinite, and to the eternal. It is a way of relating to the finite, and to the infinite, and to the eternal.

So when we say that a poem is a way of seeing, or a way of thinking, or a way of feeling, we are not saying that it is a way of seeing, or a way of thinking, or a way of feeling, in the way that a photograph is a way of seeing, or a way of thinking, or a way of feeling, in the way that a painting is a way of seeing, or a way of thinking, or a way of feeling, or a way of understanding. We are saying that it is a way of seeing, or a way of thinking, or a way of feeling, or a way of understanding, in the way that a dream is a way of seeing, or a way of thinking, or a way of feeling, or a way of understanding.

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pursued or fled from, has acquired a quite telescopic range, to the accountant whose daily practice enables him to add up several columns of figures simultaneously, we find that a memory in which the activities of the mind were aimed mainly from the discharge of those duties which the conditions of life require it to discharge. And we may be certain, a priori, that the same laws are in operation here that are in operation in the case of education. The acquisition of most value for guidance must at the same time be the education of most value for discipline. Let us consider the evidence. A peculiarly interesting feature of the present age is the increase of attention to language-learning which forms so prominent a feature in the ordinary curriculum is that the memory is thereby strengthened. And that advantage peculiar to the study of words. But the truth is that the sciences afford far wider fields for the exercise of the memory. It is possible to ascertain respecting our solar system, much more to remember all that is known concerning the structure of our galaxy. The new compounds which chemistry daily accumulates are so numerous that few save professors know the names of them all; and to recollect the atomic constitutions and chemical equations is quite as impossible without making chemistry the occupation of life. In the enormous mass of phenomena presented by the earth's crust, and that is made manifest by the phenomena presented by the fossils it contains, there is matter which it takes the geological student of years of application to master. In exact sciences, the effort to get it up half a dozen times before he can permanently retain it. The number of species of plants which botanists distinguish amounts to several thousand. The number of species of animals, and forms of animal life with which the zoologist deals are estimated at some two millions. So vast is the accumulation of facts which must be learned by the student of science, cultivated even to a very modest extent, affords adequate exercise for memory. To say the very least, it involves quite as much training for this faculty as language does.

But now mark that while for the training of mere memory, science is as good as if not better than language, it has an immense superiority in the kind of memory it cultivates. In the acquirement of a language, the connections of ideas to be established in the mind, are of small moment, and the great measure accidental; whereas in the acquirement of science the connections of ideas to be established in the mind correspond to the actual relations of the objects, so that the relations of words to their meaning is in one sense natural, and that the genesis of these relations may be traced back a certain distance, and reached at the beginning (to which let us add the remark that the laws of this genesis form a branch of mental science—the science of philology). But the acquisition of languages, as ordinarily carried on, these natural relations between words and their meanings are habitually traced, and there the word means what its pronunciation and its form of expression tell it, and must be admitted that they are commonly learned as fortuitous relations. On the other hand, the relations which science presents are causal relations, and, when properly taught, are understood as such. Instead of being practically accidental, they are necessary, and as such give exercise to the reasoning faculties. While language familiarizes with non-rational relations, science familiarizes with rational relations. While the one exercises memory only, the other exercises both memory and intellect.

Observe next that a great superiority of science over language as a means of discipline is that it cultivates the judgment. As, through the different channels delivered out of the Royal Institution, Professor Profary well remarks, the most common intellectual facts are connected with the judgment. He observes that "society, speaking generally, is not only ignorant as respects education of the judgment, but it is also ignorant of its own ignorance." And he adds that which is by far the most important fact is that is want of scientific culture. The truth of his conclusion is obvious. Correct judgment with regard to all surrounding things, means, and consequences, is only through knowledge of the way in which surrounding phenomena depend on each other. No extent of acquaintance with words of science. He can give the power of forming correct inferences respecting causes and effects. The constant habit of drawing conclusions from data, and this is not a mere intellectual habit, but through the pupil these ideas are received as unquestionable. His constant attitude of mind is that it is important to do the pupil. Of the opposite is the attitude of mind generated by the cultivation of science. By science he has not only reason, but reason which is adequate to the truth of its claims. It is not the acceptance of authority alone, but all are libeity to test them—may, in many cases the pupil is required to think, and reason for himself. And the pupil scientific investigation is submitted to his judgment. He is not asked to admit it without seeing it to be true. And the trust in which the pupil is put in the statement of others is increased by the constancy with which nature justifies his conclusions when they are correctly drawn. From all which there flows the habitual and constant mind's element in character. Nor is this the only moral benefit bequeathed by scientific culture. When carried on, it should always be, as much as possible under the form of independent research, it exercises perseverance and sincerity. As says Professor Tyndall of inductive inquiry, "it requires patient inquiry, it teaches us to appreciate the importance of anxiety as an agent of change, it exercises the faculty of faith and the nature of spirit. The first condition of success is an honest receptivity and a willingness to abandon all preconceptions. The second is a willingness to search for the contrary assertion that is found to contradict the truth. Believe me, a self-renunciation which has something in it, and of which the world never ceases to require, is the true vocation of science.

Lastly we have to assert—and the assertion will, we doubt not, cause extreme surprise—that the spirit which animates the sciences is that of our ordinary education because of the religious culture that it gives. Of course we do not here use the words scientific and religious in any sense of the words philosophical, and in their widest and highest acceptations. Doubtless, to the superstitions that pass under the name of religion, science is independent, but not to the essential religion which these superstitions merely hide. Doubtless, too, in much of the science that is current there is a pervading spirit of irre-
of men its attitude may be proud, before the impassable veil which hides the absolute its allusions, and the laborious, all-pervasive, all-humbilizing, silence.

Only the sincerest man of science (and by this title we do not mean the mere calculator of distances, or analyzer of compounds, but the man who, through lower truths sees higher, and eventually the highest)—only the genuine maus of science, we say, can truly know what it is to create. For him, God is, but humankind conception, is the universal pow-

er of which nature and life and thought are manifestations.

Thus, for us, that for discipline as well as for guidance, science is of chiefest value. In all its effects, learning the mean-

ings of things is better than learning the method of forming them; for the social, moral, or religious training, the study of sur-

rounding phenomena is immensely supe-

rior to the study of grammars and lexicons.

To the question with which we set out, What knowledge is of most worth? the uniform reply is—science. This is the

verdict on all the counts. For direct self-pre-

paration for the maintenance of life and health, the all-important knowledge is—science.

For that indirect self-preservation which we call gaining a livelihood, the knowledge is chiefest value in life. For the
due discharge of parental functions, the proper guidance is to be found only in science. For that interpretation of national life which is the end and aim of the very

citizen cannot rightly regulate his conduct, the indispensable key is—science. Like for the most perfect production and highest en-

joyment of the human arts, that process of preparation is still—science. And for pur-

poses of discipline—intellectual, moral, religious—two the most efficient study is, once more, science.

Science is all-seen, and all也被 has become, in the course of our inquiry, comparatively simple. We have not to estimate the
degree of im-

possibility in the combinations of time and place, and, for the time being, the combination which we find to be of most value is, in all other respects is intrinsically most valuable: its worth is not dependent upon any special application of the mem-

ber of man to the surrounding world. Nec-

essary and eternal as are its truths, all sci-

ence concerns all mankind for all time. Equally at present and in the remotest future must it be of incalculable importance for the regulation of their conduct that men should understand the science of life, physical, mental, and social, and that they should understand all other science as a key to the science of life.

And yet the knowledge which is of such transcendent utility is, for the most part, that of boasted education, receives the least at-
tention. While this which we call civilization could never have arisen had it not been for a certain amount of intellectual effort, the co-

siderable element in what men consider civ-

alized training. Though to the progress of science we owe it that millions find support which is only an illusion from the wands, yet of these millions but a few thou-

sands pay any respect to that which has made their existence possible. Though this in-

creasing knowledge and the interpretation of things has not only enabled wan-

dering tribes to grow into populous nations, but has given to the countless members of these populous nations comforts and pleasures which their few naked ancestors never even conceived, or could have believed, yet is this kind of knowledge only now receiving a grudging recognition in our highest educa-

tional institutions. To the slowly growing

acquaintance with the uniform coexistence

of things, and the establishment of uniform laws—we owe the emancipation from the grossest superstitions. But for science we could be still worship-

pious and deluded forms of victims, perpetuating diabolical doleful and unnatural science, which in place of the most degrad-

ing conceptions of things has given us some of the most exalted sentiments of creation, is written against in our theologies and frowned upon from our pulpit.

Paraphrasing an Eastern fable, we may say that in the future the knowledge science is the household drudge, which, in perspective, hides unrecognized perfections. To her has been committed all the work; by her skill, she has converted the conveniences and gratifications been obtainable

and while ceaselessly occupied ministering to the rest, she has been kept in the back-

ground, that her vain pretensions might that their frivories in the eyes of the world. The parallel holds yet further. For we are fast coming to the dénouement, when the positions of the two haughty sisters sink into merited neglect; science proclaimed as highest alike in worth and

value, will reign supreme.

CHAPTER II.

INTELLECTUAL EDUCATION.

There cannot be a relationship be-
tween luxuries and the successful, the effi-

cient, and the successful social states with which they have coexisted. Having a common origi-

n in the national mind, the institutions based on these co-existences, their special func-

tions, must have a family likeness. When men received their creed and its inter-

pretations from an infallible authority degrai-

dingly, it is possible that the teaching of children should be purely dog-

matic. While “believe and ask no ques-
tions” was the maxims of the Church, it was the practice of the State. But now that Protestantism has gained for adults a right of private judgment and established the practice of appealing to reason, there is harmony in the change that has made juve-

nile instruction a process of exposition ad-

ressed to the understanding. Along with political despotism, stern in its commands, and full of tyranny, we have seen, visiting tyrannous

crimes with death, and implacable in its ven-

gence on the disloyal, there necessarily grew up an academic discipline similarly harsh in its repressions, which, like the vio-

lence itself, meted out, was the blow for every breach of them—a discipline of unlimited autocracy upheld by rods, and fers, and the black-hole. On the other hand, the increase of political liberty, the abolition of law restricting individual action, and the amelioration of the criminal code, have been accompanied by a kindred progress toward non-coercive education. Though the child is hampered by fewer restraints, and other

means than punishments are used to govern him. In those ascetic days when men, ac-

countable, had their minds made up to the

truth. But that the more gratifications they denied themselves the more virtuous they were, they, as a matter of course, considered that the more the parents wished to thwart them, the more

ess that the child's education is to be had as an im-


ing aim—now that hours of labor are being shortened and popular recreations pro-

vided—parents and teachers are beginning to plight their fates to each other. They are gratified, that childish sports should be en-

couraged, and that the tendencies of the growing mind are not altogether so diabolical as was supposed. The age in which all

thought that trade must be established by bounties and prohibitions, that manufactur-

ers needed their materials and qualities and prices to be prescribed, and that the value

of money could be determined by law, was

of course, be prejudicial; but the true method having to be found, the efforts of numerous independent seekers, carrying out their own researches, and attempting to estab-

lish a better agency for finding it than that which could be devised. Each of them struck by some new thought which probably contains more or less of basis in facts, group of them zealous on behalf of his plan, fertile in expediens to test its correctness, and un-

tiring in his efforts to make known its suc-

cess—each of them insists in his
on the rest—there cannot fail, by composition of forces, to be a gradual approximation of all toward the right course. Whatever portion of the normal method any one of these systems has in its working, it is an exhibition of its results, force itself into adoption; whatever wrong practices he has joined in with it must, by repeated experiment and constant observation, force out of his mind, and thus the spirit was sacrificed to the letter. It is at length perceived that in this case as in others, such a result is not accidental but intentional, and that we have to give attention to the signs there must be inattention to the things signified; or that, as Montaigne long ago said, Scepteur par cœur n’est pas science.

Along with rote-teaching is declining also the nearly allied teaching by rules. The particulars first, and then the generalization, of the Montaigne School Reports remark, which, though the reverse of the method usually followed, which consists in giving the pupil the rule directly, without experience to be attached to the right one. Rule-teaching is now condemned as imparting a merely empirical knowledge—which producing an appearance of understanding without the reality. To give the net product of inquiry, without the inquiry that leads to it, is found to be both enervating and inefficient. General truths, to be of due effect and utility, must be made familiar to the mind. The sequences in time only; they are sequences in causation. However imputably, therefore, we may witness the present conflict of educational systems and however we may regret its accompanying evils, we must recognize it as a transition stage needful to be passed through, and beneficial in its ultimate effects.

Meanwhile may we not advantageously take stock of our progress? After fifty years of discussion, experiment, and comparison, how far have we approached our steps toward the goal to be already made good? Some old methods must by this time have fallen out of use, some new ones must have got the place of the old. The part that must be in process of general abandonment or adoption. Probably we may see in these various changes, when put side by side, similar to the stepping-stone in the common tendency, and so, by inference, may get a clue to the direction in which experience is leading us, and gather hints how we may continue the course. We do not infer our way into this, by a preliminary to a deeper consideration of the matter, glance at the leading contracts between the education of the past and the future.

The suppression of every error is commonly followed by a temporary ascendency of the contrariety one; and it so happened that during the last fifty years the insistence alone was aimed at, there came an age when culture of the mind was the sole solicitude—when children had lessons-books put before them that were as well adapted to their older,—when school-hours were protracted, and the getting of knowledge was thougfit the one thing needful. As further, it usually happens that when one error is removed a next advance is achieved by co-ordinating the antagonist errors, and perceiving that they are opposite sides of one truth, so are now coming to the conviction that body and mind both must be cared for, and the whole being unfolded. The forcing system has been in great measure given up, and precaution is discouraged. People are beginning to see that the first requisite to success in life is to be a good animal. The best brain is not of much use without the will; and enough vital energy to work it; and hence to obtain the one by sacrificing the source of the other is now considered a folly—a folly which our educational statistics constantly illustrates. Thus we are discovering the wisdom of the saying, that one secret in education is to know how wisely to combine the two.

The once universal practice of learning by rote is daily falling more into discredit. All modern authorities condemn the old mechanical system of teaching, and the multiplication table is now frequently taught experimentally. In the acquisition of languages the grammar-school plan is being supplanting the rote system. The old process followed by the child in gaining the mother tongue. Describing the methods there used, the “Reports on the Training-School at Battersea” say, the instruction in the whole preparatory course is chiefly oral, and is illustrated as much as possible by appeals to nature. And so throughout. The rote-system, like other systems of its age, made more of the forms and symbols than of the things symbolized. To repeat the words correctly was every- thing; the facts were not an end, and thus the spirit was sacrificed to the letter. It is at length perceived that in this case as in others, such a result is not accidental but intentional, and that we have to give attention to the signs there must be inattention to the things signified; or that, as Montaigne long ago said, Scepteur par cœur n’est pas science.

The saying of Bacon, that physics is the mother of sciences, has come to have a new significance. Without an accurate acquaintance with the visible and tangible properties of things, our conceptions must be erroneous, our inferences fallacious, and our conclusions altogether false. The study of the senses neglected, all after-education partakes of a drowsiness, a haziness, an insufficiency which it is impossible to cure. “Nothing requires more to be insisted on than that the eye and ear, the sense of touch, smell, and taste, be employed by the child in the first stages of education for all the aims of reading and writing, as the present mode of teaching now stands, is a little more than a senseless and pernicious evocation of the sibylline and phrenological powers of observation. After long ages of blindness men are at last seeing that the spontaneous activity of the observing faculties in children has a meaning and a use. In the case of the young, the gift of observation, or play, or mischief, as the case might be, is now recognized as the process of acquiring a knowledge on which all after-endowments depend. The children who have received but ill-education system of objectlessons.

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cution interesting. Hence the lectures on the value of play. Hence the defence of nature, the world, and the rights of man. More and more conforma our plans to juvenile opinion. Does the child like this or that kind of teaching? does he take to it? we cannot always answer these questions. But it is deplorable to us if the variety should be indulged," says M. Marcel; "and the gratification of his curiosity should be combined with his improvement.

The mildness and indulgence which we manifest before the child evinces symptoms of weariness. And so with later education. Short breaks during school-hours, excursions into the open air, and the natural sequence of events, which in these and many like traits the change may be discerned. Asceticism is disappearing out of education as out of life, and the usual idea of the individual's duty to society, of the duty to promote happiness—is beginning to be, in a great degree, the test of legislation for the school and the nursery. What now is the common characteristic of these several changes? Is it not an increasing conformity to the methods of nature? The relinquishment of early forcing, against which so many still protest, to the principle that the first years for exercise of the limbs and senses show this. The superseding of roti-learning lessons by lessons orally and experimentally grounded; of a blackboard and play-ground, shows this. The disuse of rule teaching, and the adoption of teaching by principles—that is, the leaving of generalization and abstractions to the pupil during the lesson; and on this—show this. The system of object-lessons shows this. The teaching of the rudiments of science in the concrete instead of the abstruse. Of all the arts, above all, this tendency is shown in the various directed efforts to present knowledge in attractive forms, and so to make the acquirement of it a thing the power of the mind. Nature in all creatures that the gratification accompanying the fulfillment of needful functions serves as a stimulus to their fulfillment—satisfying the child, delighting the child, the delight taken in the blowing of corals and the pulling to pieces of toys becomes the prompter to actions which teach it the properties of matter, it follows that in choosing the succession of subjects and the methods of instruction which most interest the pupil, we are fulfilling nature's behests, and adjusting our proceedings to the laws of life.

Thus, then, we are on the highway toward the doctrine long ago enunciated by Pestalozzi, that education must conform to the natural process of mental evolution—that there is a certain sequence in which the faculties spontaneously develop, and a certain kind of knowledge which each requires during its development, and that it is for us to ascertain this sequence and supply this knowledge. All the improvements above alluded to are applications of this general principle. A nebulous perception of it now prevails among teachers, and it is daily more manifest; the most modern method of nature is the archetype of all methods, says M. Marcel; "the vital principle in the pursuit is to enable the pupil to arrive at his predetermined course of evolution—if it unfolds spontaneously—if its successive desires for this or that kind of information arise when these are severally required for its nutrition—if there thus exists in itself a prompter to the right species of activity at the right time, why interfere in any way? Why not leave children to the spontaneous sequence of natures? why not remain quite passive and let them get knowledge as best they can? why not be consistent throughout?" This is an attempt to make a consistent generalization, intelligently implying as it does that a system of complete laissez-faire is the logical outcome of the doctrines set forth, it seems to furnish a disproof of the contention made in the text, that in reality, however, they do not, when rightly understood, commit us to any such untenable position. A glance at the physical analogies will show that the result of the application of such a system to the life that the more complex the organism to be produced, the longer the period during which it is dependent on a parent organism for essential aid and protection. The interval between the unlife, rapidly-formed, and self-moving spore of a conifer, and the slowly-developed seed of a tree, with its multiplied envelopes and large stock of nutriments laid by to nourish the germ during its first stages of growth, illustrates this law in its application to the vegetable world. Among animal organisms we may trace it in a series of con

tracts from the monad whose spontaneously-divided halves are as self-sufficing the moment after their separation as was the original; then only passes through a protracted gestation, and subsequently long depends on the breast or the milk, but after that must have its food artificially; and man, who has learned to feed itself, continue to have bread, clothing and shelter provided, and the powers of the letters of instead of their names, or to instruct us numerically or by experimental synthesis, a medium of understanding is as the evolving a like rational course throughout the entire
The true education is practicable only to the true philosopher. Judge, then, what a prospect a philosopher is in the world! Knowledge so little as we yet do of psychology, and ignorant as our teachers are of that little, what chance has a system which requires their most minute attention and protection? Further hindrance and discouragement has arisen from confusing the Pestalozzian principle with the forms in which it has been presented to our view. Our system of education has not answered expectation, discretion has been cast upon the doctrine associated with them, no inquiry being made whether it is true or false. Judging as usual by the concrete rather than the abstract, men have blamed the theory for the bunglings of the practice. It is as though Pestalozzi’s first attempt to construct a steam engine had been held to prove that steam could not be used as a motive power. Let it be constantly borne in mind that the name Pestalozzi was not therefore right in all his applications of them; and we believe the fact to be that he was a man of singularly just intuitions, a man who had occasional flashes of insight rather than a man of systematic thought. His ideas were not achieved, as when he had no books or appliances of ordinary teaching, and when the only object of his attention was to find out at each moment what instructive process children stood peculiarly in need of, and what was the best manner of connecting it with the knowledge they already possessed. M. M. Kruesi, M. Niederer, and their admirers, Pestalozzi was a man of partial intuitions, a man who had occasional flashes of insight rather than a man of systematic thought. His ideas were not achieved, as when he had no books or appliances of ordinary teaching, and when the only object of his attention was to find out at each moment what instructive process children stood peculiarly in need of, and what was the best manner of connecting it with the knowledge they already possessed.

The Mother’s Manual,” beginning as it does with a nomenclature of the different parts of the body, and proceeding next to specify things which children should know, does not reason the plans of culture, but to his profound sympathy, which gave him an instinctive perception of childish needs and difficulties, and to his faculty of co-ordinate and develop the truths which he thus from time to time laid hold of, and had in great measure to leave this to his assistants, Kruesi, Tobler, Buss, Niederer, and Schmid. The result is that in its details his own plans, and those variously devised, contain numerous crudities and inconsistencies.

To M. Comte we believe society owes the emanation of this doctrine—a doctrine which we may accept without committing ourselves to a theory of the genesis of knowledge, either in its case, because of the generalization, the doctrine two more or may be, rather than insufficient to establish it. One is devoted to the hereditary transmission as considered in its generalities. For it be that true men exhibit likeness to ancestry both in aspect and character—if it be true that even the most beneficent human manifestations, as insularity, will occur also in the same family at the same age—If, passing from individual cases in which the trait of few living ones greatly obscure the law, we turn to national types, and since the various facts thus illustrated is true of the whole nation, Intellectually and morally, that every nation has a nature of the human race has mastered its various kinds of knowledge, there will arise in every child an aptitude to acquire knowledge of the nature of the human race. So that even were the order intellectually indifferent, it would facilitate education to lead the individual mind through the steps traversed by the general mind. But the order is not intellectually indifferent, and hence the fundamental reason why education should be a repetition of civilization in little. It is almost as if education was in its main outlines a necessary one, and that the causes which determined it apply to the child as to the race. Not to specify these or the reasons why the order was not that as the mind of humanity placed in the midst of phenomena, and striving to comprehend them has, after endless comparisons, reached its present knowledge of each subject by a specific route, it may reasonably be inferred that the relationship between mind and the phenomena, as between human mind and the data. Hence in deciding upon the right method of education, an inquiry into the method of civilization will help to guide us.

One of the conclusions to which such an inquiry leads, is that in each branch of instruction we should proceed from the concrete to the abstract. As a case before the prophet, and swear by his every word—their proneness to mistake the clothing of the idea for the idea itself, renders it necessary to insist a little further on the distinction between the fundamental principle of the Pestalozzian system, and the set of expedients devised for its practice; and to suggest that while the one may be considered as established, the other is probably nothing but an adumbration of the normal course. Indeed, on looking at the state of our knowledge, one may be quite sure that this is the case. Before our educational methods can be made to harmonize in character and arrangement with the faculties in their modern modifications, the one great point that must be developed in detail—must be transformed into a multitude of specific propositions—must be, if the art of education is to be based.

And then we have necessarily made out in what succession and in what combination of pupils should become active, it remains to choose one of the many possible ways of exercising each of them which best conforms to its natural mode of development. Therefore, it is not to be supposed that even our modern theories of teaching are the right ones, or nearly the right ones.

3. The education of the child must accord both in mode and arrangement with the educational System to which he belongs, or, in other words, the genesis of knowledge in the individual must follow the same course as the genesis of knowledge in the race. To M. Comte we believe society owes the emanation of this doctrine—a doctrine which we may accept without committing ourselves to a theory of the genesis of knowledge, either in its case, because of the generalization, the doctrine two more or may be, rather than insufficient to establish it. One is devoted to the hereditary transmission as considered in its generalities. For it be that true men exhibit likeness to ancestry both in aspect and character—if it be true that even the most beneficent human manifestations, as insularity, will occur also in the same family at the same age—If, passing from individual cases in which the trait of few living ones greatly obscure the law, we turn to national types, and since the various facts thus illustrated is true of the whole nation, Intellectually and morally, that every nation has a nature of the human race has mastered its various kinds of knowledge, there will arise in every child an aptitude to acquire knowledge of the nature of the human race. So that even were the order intellectually indifferent, it would facilitate education to lead the individual mind through the steps traversed by the general mind. But the order is not intellectually indifferent, and hence the fundamental reason why education should be a repetition of civilization in little. It is almost as if education was in its main outlines a necessary one, and that the causes which determined it apply to the child as to the race. Not to specify these or the reasons why the order was not that as the mind of humanity placed in the midst of phenomena, and striving to comprehend them has, after endless comparisons, reached its present knowledge of each subject by a specific route, it may reasonably be inferred that the relationship between mind and the phenomena, as between human mind and the data. Hence in deciding upon the right method of education, an inquiry into the method of civilization will help to guide us.

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1. That in education we should proceed from the simple to the complex is a truth which has always been to some extent acted upon; not professed, indeed, nor by any means consistently. The mind grows. Like all things that grow, it progresses from the homogeneous to the heterogeneous; and a nor-
out of its corresponding art. It results from the necessity we are under, both individually and as a race, of reaching the abstract by way of the concrete, that there must be practice and an accruing experience, and it is in the practice of these things that there can be science. Science is organized knowledge; and before knowledge can be organized, some of it may flow from experiment, but the rest must come from experience. You would have a purely experimental introduction; and only after an ample fund of observations has been accumulated shall you attempt to systematize them and to establish the true laws of the phenomena. By the practical applications of this rule, we may instance the modern course of placing grammar, not before language but after it; or, rather, language is taught by practical drawing. By and by and farther applications of it will be indicated.

A second corollary from the foregoing general principle, and one which cannot be too strenuously insisted upon, is, that in education the process of self-development should be encouraged to the fullest extent. Children should be led to make their own investigations, and to draw their own inferences. They should be told as little as possible, and induced to discover as much as possible. It is not the function of instruction; and that to achieve the best results each mind must progress somewhat after the same fashion is continually proved by the facts. Those who have been brought up under the ordinary school-drill, and have carried away with them the idea that education is practicable, and can be handed to them, are not likely to make children their own teachers. If, however, they will call to mind that the all-important knowledge of surrounding objects which is derived from experience can be gained in a sort of direct way, without help—if they will remember that the child is self-taught in the use of its mother-tongue—if they will estimate the amount of that knowledge which comes only from the observation of the one whom every boy gathers for himself—if they will mark the unusual intelligence of the uncared-for London gamin, as shown in all his afterwards performances and inferences—then, if ever a subject has been tried—if, further, they will think how many minds have struggled and vainly, not only through the mysteries of our irrationality, but also through the various obstacles besides, they will find it a not unreasonable conclusion, that if the subjects be put before him in right order and right time, this diligence will surmount his difficulties with but little assistance. Who indeed can watch the ceaseless observation and inquiry and inference of a child, what with its thoughts as to its acute remarks on matters within the range of its faculties, without perceiving that these powers which it manifests, if brought to bear systematically upon any studies whatsoever, in the same range, would readily master them without help? This need for perpetual telling is the result of our stupidity, not of the child’s; we do not plant the trees and then neglect them, not nor do we plant the trees and then expect to get them because they are planted. If we do not voluntarily acquire these facts, we thrust them into its mind by force of threats and punishment; but by denying the knowledge it craves, and cramping it with knowledge it cannot digest, we produce a morbid state of its faculties, and a consequent disgust for knowledge in general; and when, as a result, parents and teachers say nothing, and, on, and partly of still continued unfitness in its studies, the child can understand nothing without explanation, and becomes a mere passive listener to what is said to him, we infer that education must necessarily be carried on thus. Having by our method induced helpfulness, we straightway make the helplessness a reason for our method. Clearly then the experience of pedagogues cannot rationally be quoted against the doctrine we are defending. And whoever sees this will see that we may safely follow the method of nature throughout—may, by a skilful ministration, make the mind as self-developing in its later stages as it was in its earlier ones; and that only by doing this can we produce the highest power and activity.

6. As a final test by which to judge any scheme of education, and any question, Does it create a pleasurable excitement in the mind of the pupil? When in doubt whether a particular mode or arrangement is or is not in motion, we may try it, as with other things, on some one else, and thereby may safely stifle by this criterion. Even when, as considered theoretically, the proposed course seems the best, yet this is not a satisfactory test. In another course, we should relinquish it; for a child’s intellectual instincts are more trustworthy than our reasonings. In respect to the knowing faculties we may confidently trust in the general law, that under normal conditions healthful action is pleasurable, while action which gives pain is unhealthful. Though at present very incompletely conforming to the emotional nature, yet by the intellectual nature, or at least by those parts of it which the child exhibits, this law will become more and more evident as we go on in our study of this and that study which vex the ordinary teacher are not innate, but result from his unwise system. Fellensay, for instance, that a young boy who has no interest in books is merely opposite to their natural disposition to activity that unless it is the consequence of bad education it is absolutely necessary to那个人's constitutional defect. And the spontaneous activity to which children are thus prone is simply the pursuit of those pleasures which happen to be before them. It is true that some of the higher mental powers as yet but little developed in the race, and congenitally possessed in any considerableness being developed, and are not disposed to the amount of exertion required of them. But these, in virtue of their very complexity, will, in a normal course of cultivation, will, and therefore have no demands made upon them until the pupil has arrived at an age when ulterior motives can be brought into play, and an interest in the immediate business of life is the direct pleasure. With all faculties lower than these, however, the direct gratification consequent on activity is the normal one, and, therefore, it is not an essential one except as a stimulus, and it will be as a stimulus. There are, however, we are obliged to fall back upon some other, we must take the facts as evidence that we are on the wrong track, the whole system is to be reversed. There is greater clarity that there is always a method to be found productive of interest, even of delight; and it ever turns out that this is the method proved by all other tests to be the right one.

With most, these guiding principles will weigh but little if left in this abstract form. It is only the application, and partly with a view of making sundry specific suggestions, we propose now to pass from the theory of education to the practice.

It was the opinion of Pestalozzi that opinion which has ever since his day been gaining ground—that education of some kind should begin from the cradle. Who has not watched, with any discernment, the widespread, the unpossessed infant at surrounding objects knows very well that education does not begin with the knowledge it has not been accustomed to; that it is not. And that these fingerings and suckings of everything it can lay hold of, these open-mouthed listenings to every sound are the true works of mind. The healthful development of the child, the invention of calculating engines, the production of great paintings, or the composition of symphonies and operas. This activity of the faculties from the very first being spontaneous and inevitable, the question is whether we shall supply in due variety the materials on which they may execute their creative powers. And this question so put none but an affirmative answer can be given. As before said, however, agreement with Pestalozzi’s theory does not indicate the details of the practice; and here occurs a case in point. Training of instruction in spelling he says:

"The spelling-book ought, therefore, to contain all those words which are fitted to be taught; and this is taught in every family from the earliest infancy. The method of spelling in the spelling-book ought to repeat them to the infant in such a way as to make the pronunciation even one of them, so that they may be impressed upon its mind by frequent repetition."

Joining this with the suggestions for a nursery method, as set down in his Mother-education, we have here a strong argument for the position, that the states of consciousness out of which they are composed. There can be no idea of form until some familiarity with it in its gradation is acquired; for, as long as the child is small, it receives no knowledge, for instance, of objects presenting different degrees of resistance, a sufficiency of objects reflecting different amounts and qualities of light, and so on. The impressions of sounds contrasted to their loudness, their pitch and their timbre. How fully this á priori conclusion is confirmed by infantile instinct all will see on the face of it. A young child in its infantile stage has in biting its toys, in feeling its brother’s bright jacket-buttons, and pulling papa’s whiskers—how absorbed it is. If we contemplate the infirmities of human nature, the inadequacy of our faculties, the insufficiency of objects to which it applies the word "pretty," when it can pronounce it, wholly in virtue of the bright colors—and how its face expresses its feelings in the presence of a nurse, the snapping of a visitor’s fingers, or any sound which it has not before heard. Fortunately, the ordinary practices of the nursery fulfill these early receptive states of education to a considerable degree. Much, however, remains to be done; and it is of more importance that it should be done than how far we may have accomplished it. And if we have rendered it a period of its greatest activity—the period in which it is spontaneously evolving itself—is capable of receiving more vivid impressions and retaining them, the possibility of these simplest elements must eventually be mastered, and as the mastery of them when ever achieved must take time, it becomes an economical time to occupy this first stage of childhood, during which no other intellectual action is possible, in gaining a complete familiarity with them in all their modifications, as well as in assimilating the general health will be improved by the continual gratification resulting from a due supply of these impressions which every child should receive, but which too often are spared, might here be well filled by some suggestions toward a more systematic ministration to these simplest of the perceptions, of which all subsequent ministration ought to be based upon the general truth that in the development of every
faculty markedly contrasted impressions are the first to be distinguished; that hence sounds greatly differing in loudness and pitch are affected differently by the manner and substance widely, in hardness or texture, should be the first supplied; and that in each case the progression must be by slow degrees to impressions more nearly allied.

Passing on to object-lessons, which manifest form a natural continuation of this principle, it is marked that the system commonly pursued is wholly at variance with the method of nature, as alike exhibited in infancy, in adult life, and in the actions which bring a woman to her children. M. Marcell, "must be shown how all the parts of an object are connected, etc.," and the various manuals of these object-lessons, to which the facts which the child is to be told respecting each of the things put before it. Now it needs but a glance at the daily life of the infant to see that all the knowledge of things which is gained before the acquirement of speech is self-gained—that the qualities of hardness and weight associated with objects, the various colors and forms, the particular qualities of each animal and each person, the production of special sounds by animals of special aspects, are phenomena of which the infant is conscious too. For there are no longer teachers at hand, the observations and inferences required for daily guidance are not to be found in books, nor is there any hint of anything which tells the infant that he lives between the facts with which he is made. Is it possible, then, that while the higher knowledge is thus evolved in the evolution of humanity at large is repeated alike by the infant and the man, a reverse process must be followed during the period between infancy and adult life? If so, what are the first among the few things as learning the properties of objects? Is it not obvious, on the contrary, that one method must be pursued throughout by leading the child in the method we are following. If we have but the wit to see it and the humility to adopt it? What can be more manifest than the desire of children for intellectual sympathy? Mark how the infant sitting on your knee thrusts into your face the toy it holds, that you too may look at it. See when it makes a crank with the toy, and then looks at you, and then looks at you, and then looks at you; always seeing as clearly as it can, "Hear this new sound," "Watch how the child isaller, 1, 2, 3," and it is looking, "Mamma, see what a curious thing," "Mamma, look at this," "Mamma, look at this;" and would continue the habit, did not the silly mamma tell them not to these. Observe how, when out with the nurse-maid, each little one runs up to her with the new flower it has gathered, to show her, and press it to the floor, and sit down looking as pretty as it can. Does not the need of being beryuly with which every urchin describes any novelty he has seen, if only he can find someone to whom he will impart his interest. Does not the indication lie on the surface? Is it not clear that we must conform our course to these intellectual instincts—take it, after the pattern of the process—that we must listen to all the child has to tell us about each object, must induce it to say everything it can think of about each object; must not only be content to follow the indications in the very beginning, but must follow them even for a like exhaustive examination? See the way in which, on this method, the intelligent mother conducts her lessons. Step by step she familiarizes her little boy with the names of the simpler attributes, hardness, softness, color, taste, size, etc., in doing which she finds him eagerly help by bringing the flowers to her, and these is red, and the other to make her feel that it is hard, as fast as she gives him words for these properties.

Each additional property, as she draws his attention to another—the blue with which she brings her, she takes care to mention in connection with those he already knows; so that by the natural tendency to imitate he learns to obtain the word for another property in a way that one after another. Gradually, as there occur cases in which he omits to name one or more of the properties he has become acquainted with, and asks whether by the color or the size, or sometimes another one. Hearing that there is nothing more that he can tell her about the thing he has got. Probably he does not understand, but only feels the child say, "Look at that duck," perhaps laughing at him a little for his failure. A few recurrences of this and he perceives what is to be done. When next asked, "What is that?" and told him the object than he has told her, his pride is roused; he looks at it intently he thinks over all that he has heard, and sees the problem being easy, presented to him. He is full of grief at his success, and she sympathizes with him. In common with every child, he delights in the discovery of his powers. He feels, indeed, the keen delight in quick access to knowledge of new and many of things about which to tell her. As his faculties unfold she adds quality after quality—first progress from hardness to softness; then from one color to another, from color to polish, from simple bodies to composite ones—thus constantly complicating the objects and the properties, constantly taxing his attention and multiplying the phenomena, to a greater extent, constantly maintaining his interest by supplying him with new impressions such as his mind can assimilate, and constantly gratifying him by conquests over such small difficulties as he can master. In doing this she is manifestly but following the methods laid down by the philosophers. She has worked before the younger child in a still earlier period—simply aiding self-evolution, and is aiding the method suggested by the boy's instinctive behavior. Her conscious object is teaching; she is pursuing the one best calculated to establish a habit of exhaustive observation, which is the professed aim of these lessons.

To tell a child this and to show it the other, is not to teach it how to observe, but to make it a mere recipient of another's observations: a proceeding which weakens rather than increases the faculty of observation—which deprives it of the pleasures resulting from successful activity—which prevents this all-attractive knowledge under the natural guidance of the natural instinct, which generates that indifferrence and even disgust with which these object-lessons are not unfrequently regarded. On the other hand, to pursue the course above described is simply to guide the intellect to its appropriate food; to join with the intellectual appetites their natural adjuncts—amour propre and the desire for approval by their companions. Under these circumstances all of those an interested attention which insures perceptions alike vivid and complete; and to habituate the mind from the very beginning to gain all the immediate and lasting advantage which it must ultimately follow.

Object-lessons should not only be carried on after quite a different fashion from that which we have described. They must be projected into a range of things far wider, and continue to a period far later, than now. They should be limited to the contents of the objects readily accessible to the child, the flowers and the hedges, the quarry and the seashore. They should not cease with early childhood, but should be so kept up during youth as to be commenced during the adolescent and the naturalist and the man of science. Here again we have but to follow nature's leadings. Where can be seen an intense delight that of children picking up new flowers and watching new insects, or hoarding pebbles and shells? And who is there but perceive that by sympathizing with them they they lay the basis of any taste of inquiry into the qualities and structures of these things? Every botanist that has had children with him in the woods and the lanes must have noticed exactly the same result. As the result, how keenly they searched out plants for him, how intently they watched while he examined them, how they overwhelmed him with water for flowers, the neat little dogs and the patient and considerate patience of Bacon, the "servant and interpreter of nature," will see that we ought modestly to adopt the course of culture thus indicated. When the same method is applied to other kinds of objects, to the principles of the physical properties of inorganic objects, the child should by the same process be led on to a like exhaustive examination of the things it meets with in the most uninteresting and in most complex facts they present being alone noticed at first: in plants, the color, number, and forms of the petals and shapes of the stalks of flowers, the number of bracts and the presence or absence of variegated leaves, the colors, the man, we...
should be continuously employed as the natural stimulus to the mastery of the comparatively difficult and unassertive form—should be the prospective reward for the achievement. But when in the attempt to represent interesting actualities attempts to represent interesting actualities should be all along encouraged, in the conviction that as, by a widening experience, interest is at all events increasing, and in that interest, they too will be attempted, and that so a gradual approximation will be made toward imitations having some resemblance to the realities. No matter how great the shapes produced, no matter how daubed and glaring the colors. The question is not whether the child is producing good drawing, but whether it is developing its faculties. It has first to gain some command over its fingers, some crude notions of likenesses; and this practice is better than none. The spontaneous, from the standpoint of the highest gratifications; and as usual, their strong instinctive tendency presently generates in them the ambition to make pictures that shall resemble in turn or depict the striking things they see is a further instinctive exercise of the perceptions—a means whereby still greater accuracy of vision is induced. And alike by seeking to interest us in their discoveries of the sensible properties of things, and by their endeavors to draw, they project us into just that kind of culture which they most need.

Had teachers been guided by nature's hints not only in the making of a drawing a part, but in the selection of the modes of teaching it, they would have done still better than they have done. What is it that the child first tries to represent? Things that are in the air, in the grass, or in the water,事物 that are round or oval, in color, things round which its pleasurable associations most cluster—human beings from whom it has received so many emotions, cows and dogs which interest it by the many phenomena they present, houses that are hourly visible and strike by their size and contrast of parts. And which of all the colors, if not the red, is the most delightful? Coloring. Paper and pencil are good in default of something better, but a box of palates—in short, colored chalks—are better. The drawing of outlines immediately becomes secondary to coloring—gone through mainly with a view to the coloring; and the practice of dots and lines, how great is the favor! Now, ridiculous as such a position will seem to drawing masters, who postpone coloring and who teach the pupil the system of drawing lines, angles of the several kinds, and the various figures which lines and angles make up. The work is, in short, a grammar of representation. Now, the system of commencing with a dry analysis of elements, which, in the teaching of language, has been exploded, is to be reinstated in drawing and adopted without any consideration. It will be preliminary to the concrete. Scientific conceptions are to precede empirical experiences. That this is an inversion of the normal order of things, it is also well said concerning the custom of pre-facing the art of speaking any tongue by a drilling in the parts of speech and their functions, that it is about as reasonable as prefacing the art of walking by a course of lessons on the bones, muscles, and nerves of the legs; and much the same thing may be said of the presumptuous pretense of representing objects by a enumeration of the lines which they yield on analysis. These technicalities are alike repulsive and non-essential.

They render the study distasteful at the very outset. They do not teach that which, in the course of practice, will be learned unconsciously. Just as the child naturally gathers the meanings of ordinary words by going on around it, without the help of dictionaries, so, from the remarks on objects, through its experience, will it presently acquire, not only with difficulty, but even pleasurably, those same scientific terms which, if presented at first, are a mystery and a hindrance.

If any dependence is to be placed upon the general principles of education that have been laid down, the process of learning to draw must find expression in those efforts of early childhood described above as so worthy of encouragement. By the time that the voluntary practice thus initiated has given some steadiness of hand and some tolerable ideas of proportion, there will have arisen a vague notion of body as presenting its three dimensions in perspective. Chinese-like attempts to render this appearance on paper, there has grown up a pretty clear perception of the thing to be achieved in the formative period of the lesson, which empirical perspective may be given by means of the apparatus occasionally used in explaining perspective as a science. This idea of perspective, like that of the accidents of sight, is both comprehensive and interesting to any boy or girl of ordinary intelligence. A plate of glass so framed as to stand vertically on the table and to present reflections of parallel lines, will, when held before the object, make it appear to be a book, or like simple object laid on the other side of it, he is requested, while keeping the eye in one position, to make ink dots on the surface, and, if possible, to write with or hide the corners of this object. He is then told join these dots by lines; on doing which he perceives that the lines he has made hide coincide with the object, and the object. And then, on being asked to put a sheet of paper on the other side of the glass, he discovers that it also has lines, which it is thus opportunity to represent the object therein. They not only like it, but he perceives that they must be like it, because he made it himself, and he can do it again. As for the paper, in which he has been permitted to write, he is asked if he can draw. The paper he can repeatedly himself that they do agree with its outlines. The fact is new and striking, and serves to make him experience for himself the lines of certain lengths, placed in certain directions on a plane, can represent lines of other lengths, and having other directions in space. Subsequently, by gradually chang-
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A child has been in the habit of using cubes for arithmetic; let him use them also for the elements of geometry. For this purpose the usual plan is to build up models of the usual solids. It saves all the difficulty of absurd definitions and absurd demonstrations of the nature of solids and surfaces, which are nothing but abstractions. It teaches him the names of the several parts of geometry; at once exhibits points, lines, planes, parallel lines, angles, parallelograms, etc., etc. The child will not only learn the form and substance of things, he will already be familiarized with such divisions as the solid angles, the bases of various solids, and the relationships of their several parts, and of the relation of these parts to the whole. The child needs to be exposed to the various to his figures, which furnish him with elementary notions of the circle, of the right triangle, of the regular polygon and solids, to build these figures in a simple way, and he may now substitute planes. The transition may be very easy. He will see as many of these planes on a piece of paper, and pass to the plane and to the line. If the preceding have been introduced, and continually illustrating the difficulty of fulfilling that ambition. There can be little doubt that geometry has its origin (as, indeed, it has been generally admitted) by the methods dis- covered by artisans, and others, of making accurate measurements for the foundations of buildings, areas of enclosures, and the like; and that geometry has not been considered merely with a view to their immediate utility. They should be introduced to the pupil under analogous relationships. In the cutting out of pieces for his card-houses, in the drawing of ornamental diagrams for coloring, and in those various instructive occupations which an inventive teacher will hint him, for the purpose of awakening his mind and continually illustrating that the difficulty of geometry. When, having meanwhile undergone a valuable discipline of the perceptions, he has reached a fit age for using a pair of compasses, he will begin to appreciate these as enabling him to verify his ocular guesses, be still hindered by the difficulties of the approx- imative method. In this stage he may be led to use geometrical instruments, and yet too young for anything higher, partly because it is desirable that he should be made to feel still more strongly the want of accuracy which the eye and ear alone cannot supply; and partly because the fact of knowledge is to be made continuously inter- esting to art, it is manifest that the proper pre- liminary to geometry is a long practice in those inquiries which will facilitate. Observe that here the child's eye points the way. Almost invariably children show a strong propensity to cut out things with geometrical regularity. This propen- sity which, if duly encouraged and directed, will not only prepare the way for scientific conceptions, but will develop those powers of accurate observation in which most people are so deficient.

When the observing and inventive facul- ties have attained the requisite power, the pupil has reached that condition of geomet- ry; that is, geometry dealing with methodical solutions, but not with the demonstra- tions of them. Like all other transitions in education, this should be made not formally but vantageously. The constructive art should still be maintained. To make a tetrahedron in card-board like one given to him is a proper exercise, for which he may serve as a convenient starting-point. In attempting this, he finds it useful to draw four equilateral triangles of the proper size. Then, when he has in the absence of an exact method to do this accurately, he discovers, by putting the tri- angles into their respective positions, that he has not drawn them accurately; and though the angles do not properly meet at the apex. He may now be shown how, by describing a couple of circles, each of these triangles may be accurately drawn, and with the same degree of success, as before, and after his failure he will duly value the information. Having thus helped him to the solution of this first problem, and having explained the principles of geometrical methods, he is in future to be left altogether to his own ingenuity in solv- ing the questions put to him. To bisect a square, to bisect an angle, to draw a line par- allel to a given line, to describe a hexagon, are problems which a little patience will enable him to solve; but these latter problems may be led on by step by step to questions of a more complex kind, all of which, under rigorous management, he will puzzle over. The first two problems of the four brought up under the old regime will look upon this assertion sceptically. We speak from facts, however, and those neither from experience of teaching. He will become so interested in making out solutions to these problems as to look forward to their geometry-lesson as a chief event of the week, and to the realisation of their being more or less a problem of his own. The practical application of this, but in which one of them is begging for problems to find out during the holidays— each of which facts we state on the authority of the teacher. There could indeed be no stronger prows than are thus afforded of the practicability and the immense advantage of self-development. A branch of knowledge which is commonly considered as un- repulsive, may, by following the method of nature, be made extremely interesting and profoundly beneficial. We say profoundly beneficial because it is so well adapted to the gaining of geometrical facts, but often revolutionize the whole state of mind. It has repeatedly occurred that those who have been stupid by the ordinary school- drill—by its abstract formulas, by its weary tasks, by its cramping—have suddenly had their intellects roused, by thus ceasing to make them pawns in the game, and induc- ing them to become active discoverers. The discouragement brought about by bad teach- ing having been diminished by a little sym- pathy, and the budding interest in the subject having been given the opportunity to achieve a first success, there arises a revol- ution of feeling affecting the whole nature. Their longest days have been so filled, so filled gradually, as success follows success, the in- cubus of despair disappears, and they attack the difficulties of their other studies with a genuine. From these the transition may naturally be made to such modified forms of the regular bodies as are met with in crystals and in the vegetable world. Lastly, these forms assumed by different metals and salts, an acquaintance with the leading facts of mechanics will be incidentally gained. Geometry of this kind, rational geometry, as may be supposed, presents no obstacles. It is a bad habit to contemplate relationships of things, of objects. It is a bad habit to frame a rule from time to time the necessity of certain re- sults as reached by certain means, the pupil comes to regard the demonstrations of a much simpler and to be considered the most familiar problems. His well-disciplined facul- ties enable him easily to master its suc- cessive propositions, and to appreciate their logical sequence. The induction of finding some of his own methods proved to be true. Thus he enjoys what is to the unprepared a dreary task. It only re- st to the pupil to arrive at a fit condition for that most valu- able of all exercises for the reflective facul- ties—the making of original demonstrations. The production of original demonstra- tions, the formation of true book learning, and the making of real books, is an in- ceptive business for the pupils of all ages. Chambers' Euclid will soon become practicable to him; in proving them the process of self-education will be intellectual only but moral.

To continue much farther these sugges- tions would be to write a detailed treatise on the subject of the plan of instruction. The following outlines of plans for exercising the per- ceptions in early childhood for conduct- ing object-lessons for teaching drawing and painting, and the sketching of the sketched illustrations of the method dictated by the general principles previously speci- fied. We believe that on examination they will be found so simple to the complex, from the concrete to the abstract, from the empirical to the rational, but to satisfy the further require- ments that education shall be a repetition of civilization in little, that it shall be as much as possible a process of self-evolution, and that it shall be pleasurable. That there should be in the educational plan no efforts to create new habits, but rather that all the conditions should be to the ends, to prove that this type of method shall be the right one. And when we add that this method of instruction is one of the most characterizing all modern systems of in- struction—that it is but an assumption in full of the method of nature which they adopt par- ticularly—that it displays this complete adoption of the method of nature, not only by con- formity to the above principles, but by fol- lowing the suggestions which the unfolding mind itself gives, facilitating its spontaneous activities, and so aiding the developments which nature is busy with; when we add this, there seems abundant reason to con- clude that the attempt will be made and the method emploied closely approximates to the true one.

A few paragraphs must be appended in further inculcation of the two general prin- ciples, alike the most important and the least attended to: we mean the principle that throughout all, as in nothing else, the right method shall be one of self- instruction; and the obverse principle, that the mental action induced by this process shall lead the pupil from the simplest to the progress from simple to complex, and from abstract to concrete, be considered the essen- tial requirements as dictated by abstract psy- chology, that the pupil's knowledge shall be self-mastered, and pleas- unerably mastered, the tests by which we may judge whether the dictates of ab- stract psychology are being fulfilled. If the first embody the leading generalizations of
the science of mental growth, the last are the chief canons of the art of fostering mental growth. For manifestly if it be true that they can be successively ascended by the pupil himself with little or no help, then they must correspond with the stages of the child's mental growth, and equally if the successive achievements of these steps are intrinsically gratifying to him, it follows that they require no more than that they shall be made.

But the making education a process of self-evolution has other advantages than this of keeping our lessons in the right order. In the first place, it is both very easy and the permanency of impression which the usual methods can never produce. Any piece of knowledge which the pupil has himself secured and solved, becomes by virtue of the conquest much more thoroughly his than it could else be. The preliminary activity of mind which his success implies, the concentration of thought necessary to it, and the excitement consequent on his triumph, conspire to register all the facts in his memory in a way that the mere repeating, or re-reading or re-reading or re-reading in a school-book can be registered. Even if he fails, the tension to which his faculties have been wound up insures his remembering what he has failed to do. Also, he has done him, better than half a dozen repetitions would. Observe again, that this discipline necessitates a continuous organization of the knowledge of the world, a study of the relations and nature of facts and inferences, assimilated in this normal manner, that successively become the premises of further conclusions, and constitute the subject of the questions. The solution of yesterday's problem helps the pupil in mastering to-day's. Thus the knowledge is turned into faculty as soon as it is won. The general subject-matter of the general function of thinking—does not lie merely written in the pages of an internal library, as when rote-learned. Mark further that the possession of the knowledge is not this constant self-help involves. Courage in attacking difficulties, patient concentration of the attention, perseverance through failures—these are characteristics which after-life specially requires; and these are characteristics which this system of making the mind work for its food specially produces. The same remark applies to self-instruction after this fashion we can ourselves testify, having been in youth thus led to successively solve the comparatively simple problems, the comparatively simple problems of leading teachers have been gradually tending in this direction is indicated alike in the saying of Fellenberg, that "the individual, independent activity of the pupil is of much greater importance than the ordinary busy-foolishness of many who assume the office of educators;", in the opinion of Horace Mann, that "unfortunately education among us at present consists too much in telling, not in training;", and in the remark of M. Maresch, that "what the learner discovers himself is better known than what is told to him." Similarly with the correlative requirement, that the method of culture pursued shall be one of which the pupil shall be the subject—activity—an activity not happy in virtue of extrinsic rewards to be obtained, but in virtue of its own healthfulness. Conformity to the trend of the child's nature, thwarting the normal process of evolution, but incidentally securing positive benefits of importance. Unless we are to return to an absolutive, but this, may be added, is that of Professor Fillans, who asserts that "where young people are taught as they ought to be, they are quite as happy in the educational age as in all other ages;" and, more often, more, with the well-directed exercise of their muscular energies, than with that of their muscular powers.

The reason for making education a process of self-instruction, and by consequence a process of pleasurable instruction, we may advert to the fact that in such a process the pupil himself must be the master. It is only by the necessity that education will not cease when school days end. As long as the acquisition of knowledge is rendered habitually repugnant, the tendency to discontinue it when free from the coercion of parents and masters. And when the acquisition of knowledge has been rendered habitually gratifying, will there be as prevailing a tendency to continue, without superintendence, that same self-culture previously carried on under superintendence. These results are inevitable. While the laws of mental association remain true—while men dislike the things and places that suggest painful recollections, and delight in the things and places that promise the relief of pain—painless lessons will make knowledge repugnant, and pleasurable lessons will make it attractive. The men to whom in boyhood it was impossible to make the morning come, but who were never led into habits of independent inquiry, are not the only to be students in after years; while those to whom each morning is looked forward to with pleasure, will begin the day in the same frame of mind at the proper times, and who remember its facts as not only interesting in themselves, but as the occasions of a long series of gratifying achievements. The young are the national resource through life that self-instruction commenced in youth.

CHAPTER III.

MORAL EDUCATION.

Strangely enough, the most glaring defect in our programmes of education is entirely overlooked. While much has been done in the detailed improvement of our systems in respect both of matter and manner, the most pressing desideratum has not yet been recognized. The necessity of preparing the young for the duties of life is tacitly admitted by all to be the end which education should aim at. The masters should have it in view: and happily the parents are far more frequently taught, and the goodness of the method followed in teaching them, are now ostensibly recognized. The boy is the day's work, this end. The propriety of substituting for the usual physical training a training in which the moral languages shall have a share, is argued on this ground. The necessity of increasing the amount of science is urged for like reasons. But though some care is taken to fit youth of both sexes for society and citizenship, no care whatever is taken to fit them for the still more important position they will ultimately have to fill—the position of parents. While it is seen that for the purpose of gaining a livelihood, any amount of education is necessary, it appears to be thought that the bringing up of children no preparation whatever is needed. While many years are spent by a boy in gaining knowledge, of which the chief value is that it constitutes the education of a gentleman, and while many years are spent by a girl in those details which prepare her for dancing parties, not an hour is spent by either of them in preparation for that gravest of all responsibilities—the management of a family. There is no more urgent contingency? On the contrary, it is certain to devolve on nine out of ten. Is it that the discharge of it is easy? Certainly not: it is, that all of functions which the adult has to fulfill this is the most difficult. Is it that each may be trusted by self-instruction to fit himself, or herself, for the office of parent? No: not only is this neglected, but we are far from recognizing it. Among our remote descendants, we must admit that a knowledge of the right methods of juvenile culture, physical, intellectual, and moral, is still to be looked for. This topic should occupy the highest and last place in the course of instruction passed through by each man and woman. As physiology will not be included in the teaching of offspring, so mental maturity is marked by the ability to train those offspring. The subject which involves all other subjects, and therefore the subject in which the education of every one should culminate, is the Theory and Practice of Education.

In the absence of this preparation, the management of children, that lunch speaking
EDUCATION.

must have an exaggerated faith in its work. Hence, of those who regard education, intellectual, moral, and social, as a moral education are necessarily of dual or
—necessary result from the combined

This is the plea put in by some for the rough

—such classes of human beings as the Negroes, for instance, and the

one. It is clear that the ardent politi
calion never undertakes the labors and

is sometimes very pleasant, such as the

to reform the children. The children, in

In philanthropy as in other things

table—less subordinated to its function—

the moral management, is lamentably bad. Parents either never think about the matter at all, or think of it as an inconvenience, and are consequently inconsistent. In most cases, and especially

that their unique expectations are not without use;

and that perhaps it is part of the benefi-
cent order of things that their confidence cannot

Even were it true, however, that some

some possible system of moral government

children. We should then be led to see

the parents, and even every parent be duly indo-

which the united budgeting of the

from this system presupposes, on the part of adults,

a degree of intelligence, of goodness, of self-

And if, on the average of cases, this inherit-

possibly the result of these cases, the

children mirror the defects of their parents;

on the average of cases, we say, because,

which the parents have to check in their

Daily life is, in fact, a sort of

good."

as

impossible that the transmission is a law of nature, as every

naturalist knows it to be, and as our daily

and current proverbs admit it to be.

And if, on the average of cases, this inherit-

harmless in itself, and less than that of adult life—much more unjust,

of whatever kind has for its proximate end to prepare a child for the

produce a citizen who, at the same time

on which our whole system of public

or family)—does not this imply a certain fitness

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"But does not this prove too much?" some one will ask. If a system of moral culture, suited to the age, is in existence that agrees in general with what they should be; if, even were there a system that would do this, existing parents are too imperfect to carry it out; and if, further, the leading principles of such a system, if fully carried out, its results would be disastrously incongruent with the present state of society; does it not follow that a reform in the police of our society is necessary, if not desirable? No! It merely follows that a reform in domestic government must go on pari passu, with other reforms. It merely follows that the present system of methods should not be a mere academic ideal, but should be nor should be ameliorated, except by instamments. It merely follows that the dictates of abstract rectitude will, in practice, influence the conduct of individuals, only as far as they are consistent with the good of the state of human nature—by the imperfections alike of children, of parents, and of society; and can only be better fulfilled as the general result of a moral education.

"At any rate, then," may rejoin our critic, it is clearly useless to set up any ideal standard of family discipline. There can be no such a thing; therefore, we have no moral obligations that we must be nor should be ameliorated, except by instamments. On the average the constitutional conservativeness of mankind is always strong enough to prevent a too rapid change. So admirable are the old methods that we have grown up to the level of a higher belief they cannot receive it; nominally, they may hold it, but not virtually. And even when the truth gets recognized, the obstacles to conformity with it are so persistent as to outlive the patience of philanthropists and even philosophers. We may be quite sure, therefore, that the many difficulties standing in the way of a normal government of children, will always put an adequate check upon the efforts to realize it.

Long before any final explanations, let us go on to consider the true aims and methods of moral education—moral education, strictly so-called, we mean; for we do not profess to treat of the general education of children or of the young, which, as the education of the young is the education of the people, is designed to be the education of the whole. But we shall discuss the immediate objects of moral education as an aid to the education exclusively moral. This we omit as a topic better dealt with separately. After a few pages devoted to the settlement of general principles, during the perusal of which we bespeak the reader's patience, we shall aim by illustrations to make clear the right method of parental behavior in the hourly-occurring difficulties of family government.

When a child falls, or runs its head against the edge of the table, or sorry is caught in the网 of the streets, or some membrane of which tends to make it more the future for the child; and by an occasional repetition of like experiences it is eventually discovered that it is in the way of doing harm and of misery. A child that is badly conducted, it is not ordained that it shall suffer in excess of the amount necessary, with the view of making it still more cautious than the necessary suffering will make it. But from its daily experience it is left to learn the greater or less penalties of greater or less errors, and to behave accordingly.

And then mark, lastly, that these natural reactions which follow the child's wrong actions are constant, direct, unhesitating, and general. If we wish to prevent these or to modify them, rigorous performance. If a child runs a pin into its finger, pain follows. If it does it again, there is again the same result; and so on. But with the same regard that we have a surrounding inorganic nature it finds this unsparing persistence, which listens to no excuse, and from which there is no appeal; and we are not surprised that this natural and therefore beneficial discipline, it becomes extremely hard to transgress.

Still more significant will these general principles be if we attempt to hold throughout adult life as well as through outtafe life. It is by an experimentally gained knowledge of the natural consequences that children are or are not corrected when they go wrong. After home education has ceased, and when there are no longer parents and teachers to forbid this or that or to prevent this or that from entering into a discipline like that by which the child has received its first lessons in self-government. If the youth entering upon the business of life is not to have a similar experience, he will not be skilfully the duties intrusted to him, but by and by follows the natural penalty; he is discharged, and left to suffer for a while for the mistakes of the uninitiated man, failing alike his appointments of business and pleasure, there continually fall the consequent inconveniences, losses, and reverses, until the individual finds out the who charges too high a rate of profit loses his customers, and so is checked in his readiness. Diminishing practice teaches us much that we have not learned from the par excellence of the artificial.
EDUCATION.

inquences in place of them? No unprejudiced reader will hesitate in his assent.

But now observe two important facts. In the first place, the parent of the child who will contend that already most parents do this—that the punishments they inflict are, in the majority of cases, the true consequences of ill-conduct—

is, the result of a child's transgression, and that, in the suffering, physical or moral, which the child is subject to, is the true cause of the misbehavior.

Along with much error this assertion doubtless contains some truth. It is unquestionable that the displeasure of fa-
themselves. But, in the second place, the fact that the passionate parent visits on offending little ones are effects actually produced in such a parent by their offenses, and so are, in some sort, is present as an answer to the objections.

The children of barbarous parents are probably only to be restrained by the barbarous methods which such parents spontaneous devolution of the child. The expression of natural rea-

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writes one who has had personal knowledge of the subject. - Let us loose from school, particularly those whose parents have neglected to exert influence, plunging into every description of extravagance, ignorance, and neglect. They are ignorant of the reasons for moral con- duct—they have no foundation to rest upon, and until they have been severely disciplined by the inequalities of life, they are extremely dangerous mem- bers of society.

Another great advantage of this natural system of discipline is, that it is a system of punishment that is easily understood by the child as such. Whose suffers nothing more than the evil which obviously follows naturally from his own misbehavior is much less likely to feel the pain of it than if he suffers an evil artificially inflicted on him; and this will be true of children as of men. Take the case of a boy who is ha- bitually reckless of his clothes—scrambles through hedges without caution, or is utterly regardless of mud. If he is beaten or sent to bed, he is apt to regard himself as ill-used, and his mind is more likely to be oc- cupied by thinking over his injuries than re- penting of his transgressions. But suppose he is required to rectify as far as he can the damage caused to the clothes by his carelessness, which he has covered himself, or to mend the tear as well as he can. Will he not feel that the evil is one of his own producing, will he not be more continuously conscious of the connection be- tween it and its cause? And will he not, despite his irritation, recognize more or less clearly, that he has cost himself several of the lessons of this kind fail to produce amendment; if suits of clothes are premi- umously spoiled; if, pursuing this same system of punishment, the expense of the money for new ones until the ordinary time has elapsed, and if meanwhile there occur occasions on which, having no decent clothes to wear, he is obstacles to the rest of the family on holiday excursions and fete days, it is manifest that while he will keenly feel the punishment he can scarcely fall to trace the chain of causation, and to perceive that his own carelessness is the ori- gin of it; and seeing this, he will not have that same sense of injustice as when there is no connection between the transgres- sion and its penalty.

Again, the tempers both of parents and children are much less liable to be ruffled un- der this system of punishment. Instead of letting children experience the painful results which naturally follow from wrong conduct, the usual course pursued by parents is to inflict themselves certain other painful results. A double mischief arises from this. Making, as they do, multiplied family laws, and identifying their own supremacy and dignity with the maintenance of these laws, it happens that every transgression comes to be regarded as an offence against themselves, and a cause of anger on their part. If they make use of the same means which result from taking upon themselves, in the shape of extra labor or cost, those evil consequences which should have been al- lowed to result from the conduct of the child with the children. Penalties which the necessary reaction of things brings round upon them—penalties which are inflicted by impatience and natural irritation is comparatively slight and transient; whereas, as penalties which are voluntarily inflicted by a parent, and are afterward remembered, they become an occasion of lasting irrita- tion both greater and more continued. Just consider how disastrous would be the result if this empirical method were pursued from the first. The success of the system depends on the parents to take upon themselves the physical sufferings entailed on their children by igno- rance and awkwardness, and that while bearing these evil consequences they visited on their children certain other evil conse- quences, with the view of teaching them the necessity of tempering their conduct. Suppose that, when child, we had been enabled to have put the child to bed, with midnight, and he had become chil- dren—sulkiness, from far more anger than before? Would there not be changed to feelings that the exacti- est of all policies is pursued in after years. A father who punishes his boy for carelessly or wilfully breaking a sister’s toy, does to a certain extent, though hating his wrongs, much the same thing—inflicts an arti- ficial penalty on the transgressor, and takes the natural penalty on himself—his own feel- ings and his own conduct are needlessly irritated. If he simply required restitution to be made, he would produce far less heart-burning. If he told the boy that a new toy must be bought for the girl, the cost, and that his supply of pocket-money must be withheld to the needful extent, there would be much less cause for ebullition of temper on either side; while in the depriva- tion afterward felt the boy would experience the equitable and salutary consequence.

In brief, the system of discipline by natural re- sult is much more likely, and more extensively, to work a cure than the system of man- ifest that is supposed to be conceived on both sides to be no- thing more than pure justice, and because it more or less substitutes the impersonal type of nature for the personal agency of parents.

Whence also follows the manifest corol- lary, that under this system the parental and state system of punishment, and therefore a more influential one. Whether in parent or child, anger, however caused, and to whomsoever directed, is more or less prolonged, its influence is more likely and more powerful in forming character. If in a certain law of association of ideas, it inevitably re- sults, both in young and old, that dislike is contracted toward things which in our experi- ence are habitually connected with disagree- able feelings; or where affection originally existed, it is weakened, or destroyed, or turned into repugnance, according to the quantity of Parental care over their children is itself a kind of wraith, with its accompanying reprimands and castigations, cannot fail, if often repeated, to produce filial alienation; while the re- mend its state by making a public show of anger, or by failing to weaken the affection felt for them, and may even end in destroying it. Hence the numerous cases in which parents (and especi- ally fathers, who are commonly reputed to express the anger and inflict the punishment) are regarded with indifference, if not with aversion, and hence the equally numerous cases in which children are locked upon as in- factionists. Seeing, then, as must do, that estrangement of this kind is fatal to a salutary moral culture, it follows that parents should inflicting this system of punishment, and therefore they cannot too anxiously avail them- selves of the means to prevent it—this system of letters—this system of letting the penalty be inflicted by the laws of things, which, by saving the parent, from the function of a revengeful avenger, enables him to use these mutual exaspera- tions and estrangements.

Thus we see that this method of moral cul- ture by experience of the natural system, which altogether alike for infancy and for adult life, is equally ap- plicable during the intermediate childhood and youth. And among the advantages of the following: that it gives that rational comprehension of right and wrong conduct which results from actual ex- perience of the good which is likely to be the second, that the child, suffering nothing more than the painful effects brought upon it by its own wrong acts, must recognize more or less clearly; and this leads to it recognizing the justice of the penalties, and receiving those penalties through the fear of wronging others, rather than at the hand of an individual, its temper will be less disturbed; while the parent, occupying the comparatively passive position of the teacher, is more likely to realize that the natural penalties are felt, will proceed according to a method which had been missed? or when a lie has been told? or when some younger brother or sis- ter has been ill-used?

To these questions, let us consider the bearings of a few illustrative facts. Living in the family of his brother-in-law, a friend of ours had undertaken the educa- tion of his little nephew and niece. This he had conducted, more perhaps from natural sympathy than from reasoned-out conclu- sions. He had been with them from their birth. The two children were in doors in their rooms when the author, who, for him, looked on while he examined and iden- tified them, and in this and other ways were ever gaining both pleasure and instruction in the manner in which he had been brought up. One evening, having need for some article lying in another part of the house, he asked his nephew to fetch it for him. Deeply im- pressed with the poetic beauty of the moment, he, contrary to his wont, either exhibited great reluctance or refused, we forget which. His uncle, disapproving of a coercive course, fetched it himself, merely exhibiting by his manner the annoy- ance this ill-behavior gave him. And when, later in the evening, the boy made overtures for pardon —the uncle manifested just that coldness of feeling naturally produced in him, and so let the boy experience the necessary conse- quences. The boy was warned that for the usual time for rising, our friend heard a new voice outside the door, and in walked his little nephew with the hot water, and then the boy, peering at the room, asked what else could be done, exclaimed, "Oh, you want your boots," and forthwith rushed downstairs to fetch them. In this manner he showed a true tenderness for his mis- conduct; he endeavored by unusual services to make up for the service he had refused; his higher feelings had been roused, and vociferous approval by the conquest; and he valued more than before the friendship he thus regained. This is a natural example, it is true, but how often, as a father, acts on the same system, and finds it answer- completely. He makes himself thoroughly his child’s friend. The evening is longed for, and the misdoings, growing more frequent, are more and more enjoyed, especially because they enjoy the Sunday because he is with them all day. Thus possessing their perfect confidence and affection, he finds it easy to make them forget what disapprobation gives him abundant power of control. If, on his return home, he hears that one of his boys has been naughty, he is inclined to urge the coldness which the consciousness of the boy’s misconduct naturally produces, and he finds this a most efficient punishment. The mere withholding of the usual caresses is a source of the keekest distress—produces a much more prolonged fit of crying than a beating
would do. And the dread of this purely moral penalty is, he says, ever present during his absence; so much so that frequently during the day his children inquire of their mother how she is doing—whether she will come back that night or not—until at length the fear of her return will be good. Recently, the oldest, an activeurchin of five, in one of those bursts of animal spirits common to children of that age, drew sundry extravagancies during his mamma’s absence—cut off part of his brother’s hair and wounded himself with a razor. The effect was, that when, a few days after, the mamma was about to go out, she was earnestly entreated by the boy not to do so; and, on perceiving that her request was not complied with, he might again transgress in her absence.

We have introduced these facts before re- phrasing the question, “What is to be done with these grave offences?” for the purpose of first exhibiting the relation that may and ought to be established between parents and children; for on the existence of this relation depends the success of the parent in the management of the child. Hitherto we have shown that by letting a child experience simply the painful reactions of its own wrong actions, a parent in great measure avoids the necessity of future interference and escapes being regarded as one; but it still remains to be shown that where this course has been consistently pursued from the beginning, the resultant feeling of active friendship will be generated.

At present mothers and fathers are mostly considered by their offspring as friend-enemies, and the children’s wrongs are avengedly by the treatment they receive, and oscillating as that treatment does between bribery and thwarting, between petting and censure, children naturally acquire conflicting beliefs respecting the parental character. A mother commonly thinks it quite sufficient to tell her little boy that he is her best friend, and, assuming that he is in duty bound to believe her, concludes that he will forthwith do so. It is all for your good.” “I don’t want to do it; you wouldn’t do yourself.” “You are not old enough to understand it now, but when you grow up you will think of me doing what I do to these.” These words are unanswerable.

Meanwhile the boy is daily suffering positive penalties, and is hourly forbidden to do this, that, and the other which he was anxious to do. By words he hears that his happiness is the end in view, but from the accompanying deeds he habitually receives more or less pain. Utterly incompetent as he is to judge it, to tell her little boy as he has no mother in view, or how this treatment conduces to the happiness of that future, he judges by such results as he feels; and finding that by becoming sceptical respecting these professions of friendship, and is it not folly to make this claim? Must not the child judge by such evidence as he has got from her, and does not this evidence seem to warrant his conclusion? The mother would reason in just the same way if similarly placed. If, in the circle of her acquaintance, she should meet some one who was constantly thwarting her wishes, uttering sharp reprimands, and occasionally striking her, she would pay little attention to any professions of anxiety for her welfare which accompanied these acts. Why, then, does she suppose that her boy will comport otherwise?

But now observe how different will be the results if the system we contend for be consistently pursued—if the mother not only avoids becoming the instrument of punish-
In brief, the truth is that savagery begets savagery, and gentleness begets gentleness. Only a gentle nature is likely to become relatively unsym pathetic; whereas treating them with due fellow-feeling is a means of cultivating their fellow-feeling, and a barrier to the political delinquencies it is by no means a mere selection of talent, it is even more or less of sympathy with parental sorrow, a genuine regret for having caused it, and a desire, by some atonement, to re estab lish the attachment. When the feeling of a child has dwindled down to a mere sense of sympathy, it is as if the child had been engendered afresh out of its mother's heart, and not simply adop ted by her. If, therefore, we would make young people worthy of the name of men, we must make them feel that they are. the offspring of genuine regret they feels (of course, leaving worldly considerations out of the question) varies with the degree of sympathy he has for his child. When the affection of a parent is entirely absorbed by the welfare of his child, and no other interest is admitted into the world, the child is likely to be so much the more happy, and to grow up so much the more independent, the child he...
impulsiveness, so general among mothers, which scolds and forges almost in the same breath. On the other hand, do not unduly continue to show estrangement of feeling, lest your child take to heart the loss of friendship, and so lose your influence over him. The moral reactions called forth from you by your child's actions, you should as much as possible prevent, and the cause of those which you conceive would be called forth from a parent of perfect nature.

Be sparing of commands. Command only to do things that are important, or punishable, or have failed. "In frequent orders the parents' advantage is more considered than the child's," says Richter. As in primitive society, so now, there is no word so not so much because it is intrinsically wrong as because it is a disregard of the king's authority—a rebellion against him; so, when the tone is right, the reason will follow. For where the child's mind is composed of the moral good, it is not itself, but the voice of its ruler which constrains the transgressor proceeds less from reprobation of the offense than from anger at the disobedience.

Let the children feel that they are right, and that the wrong is in the act, before you employ the voice of force. The voice of force has no effect on the child's mind. Even when the voice of force, the words, the tone, and the manner imply. A mother, in giving her children commands, is often so audible in the first instances of the instruction that the children feel more conscious in them than an anxiety for the child's welfare. For the time being the attitude of mind differs but little from that of a hour when the voice of force is a sign of the transgressors, which, in all cases where other modes of regulating conduct can be successfully employed; and he will then respect the having recourse to law when it is necessary. As Richter remarks, "The best rule in politics is said to be "nulla trop goveniur;" it is also true in education.

According to this maxim, parents whose lust of dominion is restrained by a true sense of duty will aim to make their children control themselves without taking the subjection of the child, which naturally follows this or that conduct. Aim, therefore, to diminish the company, that you can substitute for it in your child's mind that government arising from a foresight of results. In infancy a considerable amount of instruction in which the intellectual increases, the number of instances calling for peremptory interference may be, and should be, diminished, with the view of giving room to the growth of self-government. All periods of transition are dangerous; and the most dangerous is the transition from the restraint of the family circle to the self-restraint of the adult state. The importance of pursuing the policy we advocate, which, alike by cultivating a child's faculty of self-restraint, by continually increasing the amount of self-government, and by so bringing it, step by step, to a state of unaided self-restraint, obliterates the ordinary sudden and hazardous change from externally-governed youth to internally-governed maturity. Let the history of your domestic rule typify, in little, the history of our political rule: at the outset, autocratic; in the next stage, the immediate influence of education, and by an incipient constitutionalism, in which the liberty of the subject gains some expression recognition; successive extensions of this liberty of the individual subject, gradually ending in parental abdication.

Do not regret the exhibition of considerable self-will on the part of your children, but endeavor to make it appear as the name of the expression so conspicuous in modern education. The general tendency to assert freedom of action on the one side corresponds with our rule of action on the other. They both indicate an approach to the system of discipline we contend for, under which children will be more and more encouraged to reason as individuals, in the exercise of their own reason, and to act on their own judgment, on natural consequences; and they are both the accompaniments of our more advanced social state. The independent English boy is the father of the independent English man; and you cannot have the last without the first.

German teachers say that they had rather manage a dozen German boys than one English one. Shall we, therefore, wish that our boys had the meagreliness of the German ones, and with it the submisiveness and political servility of adult Germans? Or shall we rather desire that they were as bold and enterprising as our boys those feelings which make them free men, and modify our methods accordingly?

Lastly, always remember that to educate your children is the most complex and extremely difficult thing—the hardest task which devolves upon adult life. The rough and ready style of domestic government has often been useful for the gentle and most uncultivated intellects. Slaps and sharp words are penalties that suggest themselves alike to the least reclamed barbarian; but in our education, we can use this method of discipline; as you may see in the growl and half bite with which a bitch will check a too-exagitent puppy. But if this success a rational and civilized system, you must be prepared for considerable mental exertion—for some study, some ingenuity, some patience, some self-control. You will have naturally to trace the consequences of conduct—to consider what are the results which in adult life follow certain kind of discipline; what methods which by parallel results shall be entailed on the parallel acts of your children. You will daily be called upon to analyze the motives of your children; to distinguish between acts that are really good and those which, though externally simulating them, proceed from inferior impulses; to translate natural acts into transgressions, or ascribing wrong feelings than were entertained. You must make your method to suit the disposition of each child, and must be prepared to make further modifications as circumstances may demand. When dealing with children who have been wrongly treated, you must be prepared for a lengthened trial of patience before succeeding; and when, as the case may be, which is not easy even when a right state of feeling has been established from the beginning becomes doubly difficult when a wrong state of feeling has been established, you will have constantly to analyze the motives of your children, but you will have to analyze your own motives—to discriminate between actions that are growing from a true parental solicitude, and those which spring from your own selfishness, from your love of ease, from your lust of dominion. And then, more trying still, you will have not only to detect but to curb these baser impulses.

In brief, you will have to carry on your higher education at the same time as you are making your education. Intellectually you must cultivate to good purpose that most complex of subjects—human nature and its laws, as exhibited in your own children. Morally you must keep in constant exercise your higher feelings and restrain your lower. It is a truth yet remaining to be recognized, that the lower nature is the nature of each man and woman is to be reached only through the proper discharge of the parental duties. And when this truth is recognized, then the notion of despotism will be lost in the illusion in which man is led by his strongest affections to subject themselves to a discipline which they would spurn.

While some will probably regard this conception of education as it should be, with doubt and discouragement, others will, we think, perceive in the exalted ideal which it involves evidence of its truth. That it cannot be realized by the impulsive, the unsympathetic, and the short-sighted, but demand...
the higher attributes of human nature, they will see to be evidence of its fluxes for the more advanced states of humanity. Though it calls for much labor and self-sacrifice, it will see that it promises an abundant return. Indeed, the value of our own experience will see that while in its injurious effects on both parent and child a bad system is twice cursed, a good system is twice blessed—"almost education." It will be seen that we have said nothing in this chapter about the transcendental distinction between right and wrong, of which education is supposed to be the source, and also nothing. All thinkers are agreed that we may find the criticism of right in the effect of actions if we do not find the rule there; but they do not seem to have had in view. Nor have we introduced the religious element. We have confined our inquiries to a nearer, and a much more neg­ligible, though the most insidious, influence—of education, of which we have said nothing. Our readers may supplement our thoughts in any way they please; we are only concerned that they should be accepted as far as they go.

CHAPTER IV.

PHYSICAL EDUCATION.

Equally at the squire's table after the withdrawal of the ladies, at the farmers' market ordinariness, and at the village alehouse, there is a strong feeling today that the very enactment of the day, excites perhaps the most general interest in the management of animals. Riding home from hunting, the conversa­tion is on the question of animal breeding, and pedigrees, and comments on this or that "good point," while a day on the moors is very unlikely to pass without the mention of something seen on the way of dogs. When crossing the fields together from church, the tenants of adjacent farms are apt to pass from criticisms on the surnames of animals to questions on the breed, and the stock; and thence to slide into discus­sions on the various kinds of fodder and their feeding qualities. Hodge and Giles, after comparing notes over their respective pig­styes, show by their remarks that they have been more or less observant of their masters' beasts and sheep, and of the effects produced on them by the various methods of treatment. Nor is it only among the rural population that the regulations of the kennel, the stall, the cow­shed, and the sheep­pen, are favor­able. In fact, the question of animal husbandry is a matter of universal interest, and of universal inquiry. It is the subject of country fairs; it is the theme at Sunday-schools; it is the object of the farmer; it is the theme of the artist who keeps dogs, the young men who are rich enough to own and then indulge their sporting tendencies, and their more sedate seniors who talk over agricultural pro­gress or read Mr. Mechi's annual reports and Mr. Caird's letters to the Times, form, when added together, a large portion of the inhab­itants. Take the adult males throughout the kingdom, and a great majority will be found to show some interest in the breeding, rearing, or training of animals of one kind or another.

But during after-dinner conversations, or at other times of like intercourse, who hears not of this question? Who does not feel the influence of this question? When the country gentleman has paid his daily visit to the stable, and personally in­pected the condition and treatment of his horses; when he has glanced at his minor live-stock, and given directions about them, how often does he go up to the nursery and examine into its dietary, its hours, its ven­tion, and its feeding? And what is the result? We have found White's "Farriery," Stephen's "Book of the Farm," Nimrod on the "Condition of Hunters," and with the contents of these handbooks, some books have he read on the management of in­fantry and childhood? The fattening prop­erties of oillcace, the relative values of hay and clover, are points on which every land­lord, farmer, and peasant has some knowledge; but what proportion of them know much of the advantage that can be derived from children, and its fitness to the constitutional needs of growing boys and girls? Perhaps the business interests of these classes will be benefited in the future by the introduction of animal husbandry. This explanation is inadequate, however, seeing that the same contrast holds more or less among other classes. Of a score of children who might prove ignorant of the im­portant of the fact that it is undesirable to work a horse soon after it has eaten; and yet, of this same score, supposing them all to be present, but four would have considered the man who had considered whether the time elaps­ing between his children's dinner and their resumption of lessons was sufficient. In­doubtedly there are many persons who would disclose the latent opinion that the regimen of the nursery was no concern of his. Oh, I leave all those things to the women of a school, signifies the reply. In most cases the tone and manner of this reply would convey the implication that such cares are not consistent with masculine dign­ity.

Consider the fact from any but the conventional point of view, and it will seem strange that while the raising of first rate bul­lock and first rate animals of any kind is considered a matter of education willingly bestowed much time, inquiry, and thought, the bringing up of fine human beings is an occupation tacitly voted un­important, and the results which we have been taught little but languages, music, and accomplishments, aided by nurses full of antiquated prejudices, are held competent of the cultivation of the tender and future disciplined mass of children. Meanwhile the fathers read books and periodicals, attend agricultural meetings, try experiments, and engage in unconscious efforts to discover how to fatten prize pigs. In­finite patience will be taken to produce a racer that shall win the Derby, none to produce a modern Mr. Lux, that the nuns of the Latin­ists that the men vied with each other in learning how best to rear the offspring of other creatures, and were careless of learning how best to rear their own offspring, he would have paralleled any of the other ab­surdities he ascribes to them.

The matter is a serious one, however. Ludicrous as the fact it expresses is not less disastrous. As remarks a suggestive writer, the first requisite to suc­cess in life is to be a good eater. "And a good eater is the first con­dition to national prosperity. Not only is it the event of a war often turns on the strength and hardiness of soldiers, but it is the result of the contests of commerce in part de­termined by the bodily endurance of pro­ducers. Thus far we have found no reason to fear trials of will or spirit or other races in either of these fields. But there are not wanting signs that our powers will presently be taxed to the uttermost. Already, under the influence of the modern knowledge, the agricultural application required of almost every one is such as few can bear without more or less injury. Already thousands break down under the hard work and the pressure, and the pressure continues to increase, as it seems likely to do, it will try severely all but the soundest constitutions. Hence it is becoming of especial importance that the training of children should be so carried on as not only to fit them mentally for the struggle be­fore them, but also to make them physically fit for the battles to come.

Happily the matter is beginning to attract attention. The writings of Mr. Kingsley indicate a reaction against over­culture; and the grounds for it are somewhat too far off. Occasional letters and leaders in the newspapers have shown an awakening interest in physical training. And the for­mation of special importance that the training of children should be so carried on as not only to fit them mentally for the struggle before them, but also to make them physically fit for the battles to come.

addition, that the effects of casual rejection are less prejudicial, and more easily corrected, than those of innovation. * * *

Excess is the vice rather of adults than of the young, who are rarely either gourmands or epicures, but in whom the features of those

* * "Cyclopedia of Practical Medicine."
who rear them." This system of restriction,
which many parents think so necessary, is
based upon very inadequate observation and
reasoning. The truth is, over-legislation in the
nursery as well as an over-legislation in the
state, and one of the most injurious forms of it is this limitation in
eating.

"But are children to be allowed to surfeit
themselves? Shall they be suffered to take
their fill of dainties and make themselves ill,
as they naturally would, if left to their own
question admits of but one reply. But as
thus put, it assumes the point at issue. We
contend that, as appetite is a good guide to
all that is needed; and appetite of the infant—as it is a good guide to the invi-
 lids—as it is a good guide to the differently-
placed races of men, and as it is a good
guide for every adult who leads a healthful life,
it may safely be inferred that it is a good
guide for childhood. It would be strange indeed
were it here alone untrustworthy.

Probably not a few will read this reply with
some impatience; being able, as they think,
to cite facts totally at variance with it. It
will appear absurd if we deny the rele-
vances of this principle, the more so because
it is quite defensible. The truth is, that the
instances of excess which such persons have in
mind are usually the consequences of the
resolutions rather than the results of the
reactions caused by a more or less ascetic regimen. They illustrate on a
small scale that commonly remarked fact, that few persons, and few children in
particular, are subject to the most rigorous discipline, are apt afterward to
rush into the wildest extravagances. They are analogous to those frightful
fits of hunger which occur in convulsions, where nuns suddenly lapsed from
the extremest austerities into an almost demonic wickedness. They simply exhibit the
uncontrollable appetite for food, consis-
ting. Consider the ordinary tastes and the
ordinary treatment of children. The love
of sweets is conspicuous and almost universal among them. Probably ninety-nine
people in a hundred presume that there is nothing more in this than gratification of the palate, and
that, in common with other sensual de-
sires, it is to be satisfied by a liberal diet.
Here is the error. The physiological o-
logist, however, whose discoveries lead him
to an ever-increasing reverence for the ar-
rangements of things, will suspect that there is
something more in these excessive appetites than the current hypothesis supposes, and a little
inquiry confirms the suspicion. Any work
on organic chemistry shows that sugar plays
an important part in the economy of the
body. Both saccharine and fatty matters are
eventually oxidized in the body, and there is an
accompanying evolution of heat. Sugar is
the form in which sundry other compounds
have to be reduced before they are available
as heat-making food; and this formation of
sugar is carried on in the body. Not only is
sugar wantonly consumed in the process of
digestion, but it has been proved by M.
Claude Bernard that the liver is a factory in
which other constituents of food are trans-
formed into the sugar which is the combi-
nate art of the stomach; and even more,
that children have a marked desire for this
valuable heat-food, we join the fact that they
have usually a marked dislike to that food
which gives out the greatest amount of heat
during its oxidation (namely, fat), we shall
see strong reason for thinking that excess of the one compensates for defect of the other—
the one is an indicator of the other, and
cause it cannot deal with much fat. Again,
children are usually very fond of vegetable
fruits. Fruits of all kinds are their delight;
and for the very reason that they are vegetable,
will devour unripe gooseberries and the
sourest of crabs. Now, not only are vegetable
fruits, in common with mineral ones, very
good tonics, and beneficial as such when
they are administered in their natural forms, other
advantages. "Ripe fruit," says Dr. Andrew
Combe, "is more freely given on the Conti-
nent, is more nutritious; and the efflux of
the bowels set immediately it is often
very useful." See, then, the discord
between the instinctive wants of children and
the desire to gratify them. For the most
Dominant desires, which there is good
reason to believe express certain needs of the juvenile constitution; and not only are they
the result of a habit instilled in the recesses of
the mind, but there is a general tendency to forbid the gratification
of them. Bread-and-milk in the morning,
tea and bread-and-butter at night, or some
similar food of a nutritive character, and
any ministration to the palate is thought
not only needless but wrong. What is the
necessary consequence? When, on the
other hand, there is an unlimited access to
good things—when a gift of pocket-money
brings the contents of the confectioner's window
within reach, or when by some accident the
free run of a cupboard is obtained, then the
long-denied and therefore intense de-
sires lead to great excesses. There is an
impromptu carnival, caused not only by the
result of the ministrations of the palate,
but by the consciousness that a long Lent will begin on
the morrow. And then, when the evils of
repletion display themselves, it is argued that
the excess is the fault of excesses; and afterwards, to their appetites! These disastrous results
of artificial restrictions are themselves cited as
proving the need for further restrictions!
And, therefore, we are put upon the disagreeable
position of the politician usually found,
commonly used to justify this system of
interference is vicious. We contend that, were
children allowed daily to partake of these
natural and healthy appetites, the demand for
physiological requirement, they would rarely
exceed, as they now mostly do, when they
have the opportunity: were fruit, as Dr.
Combe says, "allowed to the boy of seventeen
the regular food," (given, as he advises, not
between meals, but along with them), there
would be none of that craving which prompts
them to demand of their parents fish and
sweets. And similarly in other cases.

Not only is it that the a priori reasons for
trusting the appetites of children are so
strong as to outweigh all others; the actual
benefit to the health resulting from the
feeding of the regular food, (as is after
what, if many years, in
thought. Parents not affording to buy much
meat, and liking meat themselves, answer
the petitions of juveniles with, "Meat is
not good for little boys and girls!" and this, at
least in part, after the long Lenten season, by
the influence of nurses drawn from the
lower classes, and in some measure by the
reaction against past animalism.

On the basis of this opinion, we find little or none. It is a dog-
ma repeated and received without proof,
that which, for thousands of years, in
Greece, Rome, and China, was called by
reason. It may indeed be true that, to the young
child's stomach, not yet endowed with much
muscular power, meat, which requires
costly in the way of digestion, is an unre-

Cyclopædia.

stric, and the other the inorganic.

It is, namely, fat), we shall
see strong reason for thinking that excess of the one compensates for defect of the other—the one is an indicator of the other, and
cause it cannot deal with much fat. Again,
children are usually very fond of vegetable
fruits. Fruits of all kinds are their delight;
and for the very reason that they are vegetable,
will devour unripe gooseberries and the
sourest of crabs. Now, not only are vegetable
fruits, in common with mineral ones, very
good tonics, and beneficial as such when
they are
his bulk, he probably wastes as much as a man. He, too, loses heat by radiation; and, as his body exposes a greater surface in proportion to his bulk, and therefore loses heat more rapidly, the quantity of heat-food he requires is, bulk for bulk, greater than that required by a man. So, success to carry on than the man has, he would need, relatively to his size, a somewhat larger supply of nutrition. But, besides repairing his worn-out tissues, the animal has to make new tissue—to grow. After waste and thermal loss have been provided for, so much of nutrition as remains after the requirements of growth and only in virtue of this surplus is normal gain possible—the growth that sometimes takes place in the absence of such surplus, in the middle-sized procrustean class, upon defective repair. How peremptory is the demand of the unfolding organism for materials is seen alike in "school-boy" hunger which after life rarely paralyses in intensity, and in the comparatively quick return of appetite. And if there needs further evidence of this extra necessity for food, look at the effects of the famines following shipwrecks and other disasters, the children are the first to die. This relatively greater need for nutrition, besides more practical reasons, the question that remains is, Shall we meet it by giving an excessive quantity of what may be called duteous food, or a more moderate quantity of so abundant a food as to give a person, obtained from a given weight of meat is obtainable only from a larger weight of bread, or from a still larger weight of potatoes, and by what means? The quantity must be increased as the nutritiveness is diminished. Shall we, then, respond to the extra wants of the growing child by giving him, not twice the food of ordinary adults? Or, regardless of the fact that its stomach has to dispose of a relatively larger quantity even of this good food, shall we further tax it by giving an inferior food in still greater quantity? The answer is tolerably obvious. The more the labor of digestion can be economized or in other words, the more rapidly the processes of growth and action the functions of the stomach and intestines cannot be performed without a large supply of blood and nervous energy, the greater is the latitude that follows a hearty meal every adult has proof that this supply of blood and nervous power is at the expense of the system. Even when furnished by a great quantity of nutriment food, more work is entailed on the visceras than when it is furnished by a moderate quantity of nutritious food. This extra work is so much sheer loss—a loss which in children shows itself either in diminished energy or in smaller growth, or both. The inference is, then, that they should have a diet which combines, as much as possible, nutritiveness and digestibility. Therefore, boys and girls may be brought up upon an exclusively, or almost exclusively, vegetable diet. Among the upper classes are to be found children to whom this system is not new, and who, nevertheless, grow and appear in good health. Animal food is scarcely tasted by the offspring of laboring people; and yet, evidently, their food, as it is naturally obtained, is characterized by a much greater nutritiveness and nutritiveness, and the seeming disadvantages have by no means the weight commonly supposed. In the first place, it does not follow that those who in general eat little flesh, and are not growing bodies, will eventually reach a fine development; and a comparison between the agricultural laborers and the gentry in England, or between the lower classes of the farmers in France, is by no means in favor of vegetable feeders. In the second place, the position is not only a question of bulk, but also a question of quality. A soft, flabby flesh makes as good a show as a firm one; but though to the careless eye a child of full, fluxed tissue may appear the equal of one whose body is more occupied with muscle, strength will prove the difference. Obesity in adults is often a sign of feebleness. Men lose weight in training. And hence the appearance of a well-fed, fat-looked horse is by no means conclusive. In the third place, not only size but energy has to be considered. Between children of the meat-eating classes and of the nonmeat-eating classes there is a marked contrast in this respect. Both in mental and physical vivacity the low-fed peasant-boy is greatly inferior to his mate, who is well fed. If we compare different classes of animals, or different races of men, or the same animals or men when differently fed, we find, generally, that the quantity of energy essentially depends on the nutritiveness of the food.

In a cow, subsisting on so ineretive a food as grass, we see that the immense quantity required to be eaten necessitates an enormous digestive system; that the limits, small in comparison with the body, are burdensome and cannot be digested without producing this heavy body and digesting this excessive quantity of food, a great amount of force is expended; and that, having but little energy left over, the energy is of very little value. Compare a cow with the cow a horse—an animal of nearly allied structure but adapted to a more concentrated food. Here we see that a cow in ordinary regions, bears a much smaller ratio to the limbs; that the powers are not taxed by the support of such massive viscera, nor the greater part of the body, and, as a consequence, there is great locomotive energy and considerable viability. If, again, we contrast the stolid inactivity of the gramineous feeder with the activity of the digestive system of the dairy beast, the difference in the digestible matter of the food, subsisting upon flesh or farinaceous food, or a mixture of the two, we see a difference similar in kind, but still greater in degree. And after walking through the Zoological Gardens, and noticing the restlessness with which the carnivorous animals pace up and down their cages, it need not be remarked, that animals that habitually display this superfluous energy, to see how clear is the relation between concentration of food and degree of activity.

That this relation is not directly consequent upon differences of constitution, as some may argue, but are directly consequent upon differences of diet, which is directly subjected to substitute on; is proved by the fact that they are observable between different divisions of the same species. Take the case of mankind. The Australians, Bushmen, and others of the lowest savages, who live on roots and berries, varied by larve of insects and the like meagre fare, are comparatively puny in stature, have large abdomen, soft and undeveloped muscles, and are quite unable to cope with Europeans, either in a struggle or in prolonged endurance. As a corollary, the horse, who is well grown, strong and active, as the Kaffirs, North American Indians, and Patagonians, and you find them large consumers of flesh. It is now probable that the English steeple-chase establishment fed on more nutritive food, to whom he is as inferior in mental as in physical energy. And generally, we think, the better fed and more plentifully provisioned the horse and potent racing horses have been the energetic and dominant races. Still stronger, however, becomes the argument when we consider that the horse, upon whose flesh increase of less or more extention according as its food is more or less nutritious. This has been clearly demonstrated. Thorough flesh may be gained by a grazing horse, strength is lost; as putting him to hard work proves. "The consequence of turning horses out to grass is relaxation of the muscular system." "Grass is a very good preparation for a bullock for Smithfield market, but a very bad one for a hunter." It was not, for instance, until the summer months in the fields, hunters required some months of stable-feeding before becoming able to follow the hounds, and then the result was not reached until the beginning of the next spring. And the modern practice is that insisted on by Mr. Apperley. "Never to give a hunter the stable for more than three months, and, except under particular and very favorable circumstances, never to turn him out at all." That is to say, never give him poor feeding; but give him plenty, and such food as can be obtained only by the continuous use of very nutritive food. So this is that, as proved by Mr. Apperley, prolonged high-feeding, corresponds to the action, and is equal, in his performances, a first-rate horse fed in the ordinary way. To which various evidences add the familiar fact that, when a horse is required to do double duty habitually the practice to give him beans—a food containing a larger proportion of nitrogenous, or flesh-making material, than his habitual oats. This practice is therefore, as the truth has been illustrated with equal or still greater clearness. We do not refer to men in training for feats of strength, whose strength is the product of a quantity of food, nor to the doctrine. We refer to the experience of railway contractors and their laborers. It has been for years past a well-established maxim that a change of food, from a large quantity of flesh, is far more beneficial than an equal quantity of vegetable food. So much more beneficial that English contractors for continental railways have habitually taken their laborers with them. That difference of diet and not difference of race can this superiority has been of late distinctly established. And it is probable that when the continental navvies live in the same style as their English competitors they present a still more favorable contrast than they had in efficiency. To which fact let us here add the converse one, to which we can give personal testimony based upon six months' experience of vegetarianism, that abstinence from meat entails diminished energy of both body and mind.

Do not these various evidences distinctly indicate the marked influence of the nature of the food of children? Do they not imply that, even supposing the same stature and bulk to be maintained on an ineretive as on a nutritive diet, that the one would be of far greater value? Do they not establish the position as to that, where energy as well as growth has to be maintained, it can only be done by high feeding? Do they not confirm the above conclusion that, though a child of whom little is expected in the way of bodily or mental activity may thrive tolerably well on farinaceous food, if of a sufficient quantity, it is not necessary, and, to form the due amount of new tissue, but to supply the waste consequent on great muscular action, and the further question of brain, must live on substances containing a larger ratio of nutritive matter? And is it not an obvious corollary that denial of this increase of energy, whether in growth, or of bodily activity, or of mental activity, as constitution and circumstances may determine? We believe no logical intellect, when the evidence is brought to bear to entertain in a disguised form the old fallacy of the perpetual-motion schemes—that it is possible to get power out of nothing. We do not believe that the words must be said on another requisite—variety. In this respect the dietetic of the young is very faulty. If not, like our soldiers, "as to twenty years of age, beef," our children have mostly to bear a monotonous which, though less extreme and less lasting, is quite as clearly at variance with the requirements of their condition, and untreated,
true, they usually have food that is more or less mixed, and that is changed day by day. But after week after week, month after month, year after year, come and go by, the diet may be, oatmeal porridge. And with like persistency the day is closed, perhaps with a second edition of the bread-and-milk, perhaps with tea and bread and milk.

This practice is opposed to the dictates of physiology. The sanity produced by an ordinary diet is the more evident and more lasting. This is caused by one long a stranger to the palate, are not meaningless, as many carelessly assume; but they are the incentives to a wholesome diet. It is illustrated by numerous experiments, that there is scarcely any one food, however good, which supplies in due proportions or right forms all the elements requisite for the vital processes in a normal manner: from whence it is to be inferred that frequent change of food is desirable to balance the deficiencies of all the elements. It is a further fact, well known to physiologists, that the enjoyment given by a much liked food is a nervous stimulus which, by increasing the weight of the blood, and the blood with increased vigor, aids in the subsequent digestion. And these truths are in harmony with the maxims of modern cattle feeders.

Not only, however, is periodical change of food very desirable, but, for the same reasons, it is very desirable that a mixture of forms of food should be eaten. This is best done by the proper balance of ingredients and the greater nervous stimulation are advantages which hold here as before. If facts are asked for, we may refer to the years of ancient history in which the stomach disposed of a French dinner, enormous in quantity but extremely varied in material. Few will contend that a meal that is long continued, however well cooked, could be digested as with much facility. If any desire further facts, they may find them in every modern book on physiology. If they will, they may thrive best when each meal is made up of several things. And indeed, among men of science the truth has been long ago established that the food of such a nature which we call "afford the most decisive proof of the advantage, or rather the necessity, of a mixture of substances, in order to produce the complete digestion of each of them and adapted for the action of the stomach."**

Should any object, as probably many will, that a rotating dietary for children, and one who has not been exposed to a fresh meal, would entail too much trouble, we reply that no trouble is thought too great which conduces to the mental development of children, and that for their future welfare good bodily development is equally important. Moreover, it seems alike sad and strange that a trouble which is cheerfully taken in the fattening of pigs should be thought too great in the rearing of children.

One more paragraph, with the view of warning those who may propose to adopt the new idea, that the change could not be made suddenly; for continued low-feeding so enfeebles the system as to disable it from at once dealing with a high diet. Deficient nutrition is itself a cause of dyspepsia. This is true even of animals. When calves are fed with skimmed milk, or whey, or other poor food, they are likelier to die than when they are fed half milk and half water, and these means furnish ample indication of the mischief thus produced, and their frequent attacks of illness might prove a warning even to those who are not acquainted with the reasons.

The reasoning on which this hardening theory rests is extremely superficial. Wealthy parents, seeing little pleasant boys and girls playing about in the open air, only half clothed, and joining with this fact the general healthiness of laboring people, draw the unwarrantable conclusion that the healthiness of the latter is due to their keeping their own offspring scantily covered! It is forgotten that these urchins who gambol upon village greens are in many respects far better fed than the infants who are fed with almost perpetual play, that they are always breathing fresh air, and that their systems are not disturbed by overtaxed brains. For aught that appears to the contrary, their good health may be maintained, not in consequence of but in spite of their deficient clothing. This alternative conclusion we believe to be the true one, and that an inevitable detriment results from the needless loss of animal heat to which they are subjected.

For when, the constitution being sound enough to bear it, exposure does produce hardness, it does so at the expense of growth. We cannot ascribe to the hardening of animals and men. The Shetland pony becomes smaller in shape than the horse of the south, but is shorter. Highland sheep and cattle, rearing in colder climate, and stunted in comparison with English breeds. In both the arctic and antarctic regions the human race falls much below its ordinary height: the Eskimo and the Inuit are famous. And the Terra del Fuogians, who go naked in a cold latitude, are described by Darwin as so stunted and hideous that one can hardly believe they are fellow-creatures.**

Science clearly explains this dwarfness produced by great abstraction of heat: showing that food, and other things being equal, it unavoidably results. For, as before pointed out, to make up for that cooling by radiation which the body is constantly undergoing, it is necessary to expend a certain portion of the power of the digestive organs is limited. Hence it follows that when they have to prepare a large quantity of this material need to prepare but a small quantity of the material which goes to build up the frame. Excessive expenditure for fuel entails diminished growth, and hence, to produce the growth necessitates a body small in size, or inferior in texture, or both.

Hence the great importance of clothing. A child, we have seen, may be as much exposed to the temperature of the body, merely an equivalent for a certain amount of food. By diminishing the loss of heat it diminishes the amount of fuel needful for maintaining the heat; and when the stomach has less to do in preparing fuel it can do more in preparing other materials. This deduction is further supported by the evidence of the cold-blooded who manager animals. Cold can be borne by animals only at an expense of fat, or muscle, or growth, as the case may be. "If fattening is the end, the economy of the government is such that, as far as their progress and health are concerned, either their progress must be retarded or a great additional expenditure of food incurred." M. Apperley insists strongly that the brute is more urgent, and it is necessary that the stable should be kept warm. And among those who rear racers it is an established doctrine that exposure is to be avoided.

The scientific truth thus illustrated by ethology, and recognized by agriculturists and sportsmen, applies with double force to children. We have the same experience among people away from a city, and the rapidity of their growth is the injury from cold great. In France new-born infants often die in winter from being carried to Paris in the summer, and when the weather is cold.

M. Quetel has pointed out that in Belgium two infants die in January for one that dies in July. And in Russia the infant mortality is something enormous. Even when near maturities the undeveloped frame is comparatively unable to bear exposure: as witness the quickness with which young animals

The ruminants are obvious. We have already adverted to the fact that, in consequence of the varying relations of the different parts of the frame, a relatively larger amount of heat than an adult; and here we must point out that the disadvantage under which the child this benefit is very great. Lehmann says:

If the carbonic acid excreted by children or young animals is calculated for an equal
bodily weight, it results that children produce nearly twice as much acid as adults. Now the quantity of carbonic acid given off varies with tolerable accuracy as the quantity of food consumed. In children the system, even when not placed at a disadvantage, is called upon to provide nearly double the proportion of material for growth. See, then, the extreme folly of clothing the young scantily. What father, full grown though he is, losing heat rapidly as he grows old, but to supply the waste of each day—what father, he ask, would think it salutary to go about with bare legs, bare arms, and bare heads? We know that instead of the flimsy, cotton, linen, or mixed fabrics commonly used, it should be made of some good non-conductor, such as coarse woolen cloth. Whereas in the clothing of children both damage from the hard wear and tear which childish sports will give it; and that its colors should be such as will not soon suffer from exposure.

To the importance of bodily exercise most people are in some degree awake. Perhaps less needs saying on this requisite of physical education than on most others; at any rate, in so far as boys are concerned. Public schools and private schools alike furnish tolerably adequate play-grounds; and there is no need of the little boys' games, and a recognition of them as needful. In this, if in no other direction, it seems admitted that the natural promptings of boyish instinct to outdoor activities will be permitted, and, indeed, in the modern practice of breaking the long days to interruptions by lessons, the game of the boys is so restricted that form school regulations to the bodily sensations of the pupils. Here, then, little needs to be said in the way of expostulation or suggestion.

But we have been obliged to qualify this admission by inserting the clause "in so far as boys are concerned." Unfortunately, the little girl's case is sometimes somewhat different. We have both boys and girls' schools, and, further, the dress of the latter is somewhat different. The case of the girl, therefore, is a more delicate one. We have as yet little or nothing in the way of separate play-grounds for girls. A girl's school is the same institution as a boy's school. But there is an education of the fancy, not less apparent than that of the body. It is not enough merely to allow girls to grow up as they will. We must make the necessary provision for their education of the fancy. And this is one of the great distinctions between the two sexes. We have always considered the mental as the superior organ of the two. And yet, in the case of the girl, this is not the case.

The rule is, therefore, not to dress in an invariably way in all cases, but to put on clothing in kind and degree that will protect the body effectually from an abiding sensation of cold, however slight. This rule, the importance of which some Gallic neighbors to British. The formation of a habit of cold is made easier by the fact that cold is the most uncomfortable, and all because it is thought needful to make frouces of a size and material dictated by French caprice. Not a little of the necessity of which mothers thus punish and injure their little ones by scantiness of covering, but it is that from an allied motive they impose a style of dress which fords heathly activity. To please the eye, colors and fabrics are chosen totally unfit to bear that rough usage which unrestrained play involves; and then to prevent the injurious result of such treatment, the garments are often doubled. But the change in the style of boys' dress is large with the other, affords no sign whatever of any provision for juvenile recreation, but is entirely laid out with prime grace. The girls are the only ones of the two classes of children, the one, by the usual suburban style. During five months we have not once had our attention drawn to the premises by a shout or a laugh. Our duty to the young is to guide them along the paths with their lesson-books in their hands, or else walking arm-in-arm. Once, indeed, we saw one chuse another round the garden, but, with this exception, nothing like vigorous exertion has been visible.

Why this astonishing difference? Is it that the constitution a girl differs so? Or, is it that the same promptings to vociferous play by which boys are impelled? Or is it, that the education of the fancy, when given so much importance, is regarded as securing that bodily activity with which there cannot be adequate development, to their sisters nature has given them in such a way as to demand a system of awe and riot? Is it, then, the execration of schoolmistresses? Perhaps, however, we mistake the aim of those who train the gentler sex. We have a vague suspicion that this education of the fancy is considered by some as an object so thought undesirable; that rude health and abundant vigor are considered somewhat plebeian; that a certain delicacy, a strength coming constant, and it has been a step's walk, an appetite fastidious and easily satisfied, joined with that timidity which commonly accompanies feebleness, are held more attractive. We do not expect that any would distinctly avow this; but we fancy the governess-mind is haunted by an ideal young lady bearing not a little resemblance to this type. If she be of this sort, and the established system is admirably calculated to realize this ideal. But to suppose that such is the ideal of the opposite sex is a profound mistake. The modesty that is tender toward masculine women, is doubtless true. That such relative weakness as calls for the protection of superior strength is not to be admitted. But the difference to which the feelings thus respond is that the natural, pre-established difference, which will assert itself without artificial aid.

And when, by artificial appliances, the degree of this difference is increased, it becomes an element of repulsion rather than of attraction.

Then girls should be allowed to run wild—to become as rude as boys, and grow up into romps and hoydens!" exclaims some one, who is not aware that the repulsive and undesirable character of the present condition of the girl is due to the present system of education. Of course, the present system of education has a considerable hold on the girl, because it is the only one upon which she has any influence. Yet in one point above others in which "pestilent custom" should be ignored it is this.

As it is needful, it is to see mothers seriously damaging the constitutions of their children out of compliance with an irrational fashion. It is bad enough that they should not step aside while the exposure of children's limbs if there is one point above others in which "pestilent custom" should be ignored it is this.

If we would guard against this one, it is needful to make frouces of a size and material dictated by French caprice. Not a little of the necessity of which mothers thus punish and injure their little ones by scantiness of covering, but it is that from an allied motive they impose a style of dress which fords heathly activity. To please the eye, colors and fabrics are chosen totally unfit to bear that rough usage which unrestrained play involves; and then to prevent the injurious result of such treatment, the garments are often doubled. But the change in the style of boys' dress is large with the other, affords no sign whatever of any provision for juvenile recreation, but is entirely laid out with prime grace. The girls are the only ones of the two classes of children, the one, by the usual suburban style. During five months we have not once had our attention drawn to the premises by a shout or a laugh. Our duty to the young is to guide them along the paths with their lesson-books in their hands, or else walking arm-in-arm. Once, indeed, we saw one chuse another round the garden, but, with this exception, nothing like vigorous exertion has been visible.

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we deny. The defects are both positive and negative. In the first place, these formal, muscular motions, necessarily much less variety, are all equally popular. As to sports, do not secure so equable a distribution of action to all parts of the body, whereas it results that the exertion falling on special parts, the noxious effects of which might have been avoided had the exercises been more general. Is it not possible, then, that somewhat taken will be deficient, not only in consequence of uneven distribution, but it will be further deficient in consequence of lack of interest. We may examine to what extent they sometimes are, by assuming the shape of appointed lessons, these monotonous movements are sure to become wearisome for the pupil. It is true, it serves as a stimulus; but it is not a lasting stimulus, like that enjoyment which accompanies varied play. Not only, educational gymnastics inferior in respect of the quantity of muscular exertion which they secure; they are still more inferior in respect of the quality. This conclusion is confirmed by experiment, we have just referred as a cause of early desistance from artificial exertions is also a cause of inferiority in the effects they produce. As a result, physical exertion and mental excitement has a highly invigorating influence. See the effect produced upon an invalid by good news, or by the visit of an old friend. Mark how careful, medical men are to recommend lively society to debilitated patients. Remember how beneficial to the health is the gratification produced by change of scene, to alter the <i>habit</i> of the body from one of the most powerful of tonics. By accelerating the circulation of the blood it facilitates the performance of every function, and so tends alike to the health and to the beauty of the individual. Is it not so also when it has been lost. Hence the essential superiority of play to gymnastics. The extreme interest felt by children in their games, and the riotous glee with which they carry on their rougher frolics are of as much importance as the accompanying exertion. And as not supplying these mental stimuli, gymnastics is also wanting in the physiological effects of a domestic nature.

Granting then, as we do, that formal exercises of the limbs are better than nothing; granting, further, that they may be used with advantage, we cannot but condemn that formal exercises can never supply the place of the exercises prompted by nature. For girls as well as boys the sporting activities to which the instincts impel are essential to bodily welfare. Whoever forbids them forbids the divinely-appointed means to physical development.

And is it not even more urgently demanding consideration than any of the foregoing? It is asserted by not a few, that among the educated classes the younger and middle-class of society are, on the average, neither so well grown nor so strong as their seniors. When first we heard this assertion we were inclined to think that the remarks were based upon the observations of the old tendency to exalt the past at the expense of the present. Calling to mind the facts that, as measured by ancient armor, modern soldiers are inferior to those of old, and that the tables of mortality show no diminution, but rather an increase in the duration of life, we paid little attention to the statement. But it is well that this belief of so-called observation, however, has greatly shaken our opinion. Omitting from the comparison the laboring classes, we have noticed a majority of cases in which the children do not reach the stature of their parents; and in massiveness, making due allowance for difference of age, there seems a like inferiority. In health the contrast appears still greater. Men of past generations, living rurally as they did, could bear much more than men of the present generation, who, in the van of the chase and the war, drank hard, kept irregular hours, were regardless of fresh air, and thought little of cleanliness, our recent ancestors were capable of withstanding the fatigues and strain even to a ripe old age; witness the annals of the bench and the bar. Yet we who think the body a trifle, whose welfare; who eat with moderation, who do not care to be called upon to attend to ventilation, and use frequent ablutions; we who make annual excursions, and the other benefit of greater medical knowledge—we who are un abnormal, are subjected to a strain from the apparent and frequent ailments of the rising generation, they are like to be even less the possessors of the tenure.

What is the meaning of this? Is it that past overfeeding, alike of adults and juveniles, was less injurious than the underfeeding of the same general? Is it that the deficient clothing which this delusive hardening theory has encouraged is to blame? Is it that the greater difference is a result of deficiency, in the first place, as the embryo, and then of a more deficient, a result of a false refinement, is the cause? From our reasonings it may be inferred that each of these has probably had a share in bringing on the evil. We have seen that the physical or constitutional, another detrimental influence at work, perhaps more potent than any of the others: we mean excess of mental application. That disastrous consequences must result from this cumulative transgression might be predicted with certainty; and that they do result every observant person knows. Go where you will, and there you will find the year round obliged to work early and late, taking little exercise and getting but short holidays. The constitutions, shaken then, this and that are bequeathed to their children. And then these comparatively feeble children, predisposed as they are to break down even under an ordi- nary amount of exertion, are forced to go through a curriculum much more ex- tended than that prescribed for the unenfeeced children of past generations. That disastrous consequences must result from this cumulative transgression might be predicted with certainty; and that they do result every observant person knows. Go where you will, and there you will find the year round obliged to work early and late, taking little exercise and getting but short holidays. The constitutions, shaken then, this and that are bequeathed to their children. And then these comparatively feeble children, predisposed as they are to break down even under an ordi- nary amount of exertion, are forced to go through a curriculum much more ex- tended than that prescribed for the unenfeeced children of past generations.

And what are the results of this "astounding regimen," as Sir John Forbes terms it? Of course feebleness, pallor, want of energy, of all general ill-health. But he describes something more. This utter disregard of physical welfare, out of extreme anxiety to cultivate the mind—this prolonged exercise of the brain
and deficient exercise of the limbs—he found to be habitually followed, not only by disor-
dered functions but by malformation. He
was therefore excused in a large town, a
boarding-school containing forty girls; and
we learned, on close and accurate inquiry,
that there was not one of the girls who had
passed the third year of school (two (and the major-
ity had been as long as) that was not more or
less crooked!*  

It may be that some 1833, while
was devoted to compliance in a large town,
a training college for young men—one of
those instituted for late years for the purpose of
supplying schools with well-disciplined
and capable instructors, where something better than the judgment
of private schoolmistresses might have been
looked for, we found the daily routine to be
as follows:

At 6 o'clock the students are called.
7 to 8, studies.
8 to 9, scripture reading, prayers, and breakfast.
9 to 10, studies.
10 to 12, 1/2 leisure, nominally devoted to walking
and restoration, but often spent in study.
12 to 2, dinner, the meal commonly occupying
two hours, or more, which exercises.
2 to 5, studies.
5 to 6, relaxation.
6 to 8, studies.
8 to 9 1/2, private studies in preparing lessons for
the next day.
10 to bed.

Thus, out of the twenty-four hours, eight
are devoted to sleep; four and a quarter are
occupied in dressing, prayers, meals, and the
brief periods of rest accompanying them;
and half an hour are given to study; and one
and a quarter to exercise, which is optional.
The other nine hours are possessed of
it that the ten and a half hours of recog-
nized study are frequently increased to eleven
and a half by devoting to looks the time set
aside for study, and the necessity for which
are not in learning get up at four
o'clock in the morning to prepare their les-
exes, and are actually encouraged by their
teachers to do this! The course to be passed
through in a given time is so extensive, the
teachers, whose credit is at stake in getting
their pupils well through the examinations
is so arduous, that the number of hours
spending the requirements is so great, that pupils
are not uncommonly induced to spend twelve,
and thirteen hours a day in mental labor!

This is no light matter; the bodily injury inflicted must be great. As we were
always by one of the inmates, those who arrive
with fresh complexions quickly become
blandished. Illness is frequent; there are al
ways some on the sick-list. Failure of appe-
tite and indigestion are very common.
Di-
arrhea is a prevalent disorder, not uncom-
monly of the whole number of stu-
dents suffering under it at the same
time. Headache is generally complained of,
and is some is borne almost daily for
months; and many even suffer for years con-
tinuously and go away.

That this should be the regimen of what
is in some sort a model institution, estab-
lished and superintended by the embodied
enlightenment of the age, is a startling fact.
That the severe examinations, joined with
the short period assigned for preparation,
are often, in the opinion of us who are not
proficient in the system which inevitably underlines the health of all who pass through it, is proof, if not of
criminal, then of foolish ignorance.

But to proceed. A high degree of degree
exceptional—perhaps to be paralleled only in
other institutions of the same class. But that
cases so extreme should exist at all indicates pretty clearly how great is the extent to
which the minds of the rising generation are
overstressed. Expressing as they do the idea of
educational community, these training
colleges, even in the absence of all other evid-
ence, would conclusively imply a prevailing
innu.ency to an unduly urgent system of cul-
ture.

It seems strange that there should be so
little consciousness of the dangers of over-
demand in teaching, that is general a consciousIness of the dangers of over-
education during childhood. Most par-
tents are more or less aware of the evil con-
tained within the doctrine of precocity. In
every society may be heard reproval of
those who too early stimulate the minds of
their little ones. And the dread of this early
stimulation is there often a tacit recognition or adequate knowledge of the effects; witness the
implied opinion of one of our most dis-
tinguished professors of physiology, who,
whilst he did not intend his little girls to
learn any lessons until he was eight years old.
But while to all it is a familiar truth that a
forced development of intelligence in
childhood entailed inevitable results—either
physical feebleness, or ultimate stupidity, or
crude death—it appears not to be perceived
that throughout youth the same truth holds.
This is an old doctrine, but it is a
a given order in which and a given rate
at which the faculties unfold. If the course
of education conforms itself to that order and
equivocal faculties, it is evident that
they are early taxed by presenting an order
of knowledge more complex and abstract than
can be readily assimilated; or if, by excess
of development, she has progressed to a
degree beyond what is natural to the
age—the abnormal result so produced
will inevitably be accompanied by some
effective injury to the mind.

Nature is strict a accountant; and if
you demand of her in one direction more
than she is prepared to lay out, she balances
the account elsewhere. This is a fact not
there is no necessity for which.

If you will let her follow her own course,
taking care to supply, in right quantities and
kinds, the raw materials of bodily and men-
tal life, she will eventually produce an individual more or less
evenly developed. If, however, you insist
on premature or undue growth of any one
part, you will, of course, contravene the
point; but that she may do your extra work she must leave some of her more
important work undone. Let it never be
forgotten that all energy which is not
employed by the body at any time possesses
limited, and that, being limited, it is impos-
able to get from it more than a fixed quan-
ty of work. And thus the extra demands upon this vital energy are various and
urgent. As before pointed out, the waste
consequent on the day's bodily exercise has
to be repaired; the wear of brain entailed
by the day's study has to be made good; a cer-
tain additional growth of body has to be
provided for, and also a certain additional
amount of energy absorbed in the digestion
of the large quantity of food required for meeting these many demands. Now, that to do extra work of these
channels is to abstract it from the others is
not only manifest a priori, but may be shown a posteriori from the experience of
every one. Every one knows, for instance,
that the digestion of a heavy meal makes
such a demand on the system as to produce
suffisance of mind and body, ending not un-
commonly in a very sleepy state. But it is
plain that excess of bodily exercise diminishes the power of thought—that the temporary pro-
stration following any sudden exertion or
heavy meal. It is when the mind is under
a hard walk, is accompanied by a disinclination to mental
Effort; that after a month's pedestrian tour
the mental inertia is such that it is not alone
that if the days have to overcome it; and that in peo-
ple who spend their lives in muscular labor
the activity of mind is very small. Again,
this is a truth familiar to all that during those

697, 695.
nature arrest of its growth, and this happens with the organ of the mind as certainly as with that of the body. For during early years is relatively large in mass but imperfect in structure, will, if required to perform its functions with undue activity, undergo permanent damage. The amount is not appropriate to the age; but the ultimate effect will be a falling short of the size and power that would else have been attained. And yet we are deluded by the deception—why precocious children, and youths who up to a certain time were carrying all before them, so often step short and disappoint us with their later efforts. But these results of over-education, disastrous as they are, are perhaps less disastrous than the results produced upon the health. For the excess of mental excitement excites the feeding energies, the morbid feelings. Recent discoveries in physiology have shown how immense is the influence of the brain over the functions of the body. The digestion of the food, the circulation of the blood, and through these all other organic processes, are profoundly affected by cerebral excitement. Thus, for instance, we have, the experiment first performed by Weber, showing the consequence of irritant the sphenic nerve which connects the brain with the stomach. It is the result of the heart suddenly arrested by the irritation of the nerve, slowly responding when the irritation is suspended, and again arrested abruptly by a violent effort to think. This is a vivid conception of the depressing influence which an overwrought brain exercises on the body. The effects thus physiological- ly produced are a violation of ordinary experience. There is no one but has felt the palpitation accompanying hope, fear, anger, joy—no one but has observed how these feelings manifest themselves even when these feelings are very violent. And though there are many who have never themselves suffered that extreme emotional excitement, yet many have seen others who have. That the pain of state mind occurs shortly after a meal, if not unfrequently happens either that the stomach rejects what it has been eaten, or digests it abnormally is a case of Neron's longed protest. And as every one who takes his brain much can testify, even purely intellectual action will, when excessive, produce analogous effects. Now the relation between brain and body which is so manifest in these extreme cases holds equally in ordinary, less-marked cases. Just as these violent but temporary cerebral excitements produce violent but temporary disturbances of the viscera, so do the less violent but chronic cerebral excitements produce less violent but chronic disturbances of the body. This is no longer an inference; it is a truth which every medical man can bear witness, and it is one to which a long and sad experience entitles us. Every one who has lived in the midst of the heart is chiefly affected—habitation palpati- tions, a pulse much enfeebled, and very generally a diminution in the number of beats. If the heart is not excessively engaged, the heart is chiefly affected—habitual palpitations, a pulse much enfeebled, and very generally a diminution in the number of beats. It is then, perhaps, the case that is chiefly affected—habitual palpitations, a pulse much enfeebled, and very generally a diminution in the number of beats. It is then, perhaps, the case that is chiefly affected. But this does not mean that the vital functions are not to be the great part of the system, for the system is so organized that the heart and brain are not the great part of the system, for the system is so organized that the heart and brain are not the great part of the system, for the system is so organized that the heart and brain are not. Sometimes the conspicuous disorder is of the stomach—a dyspepsia which makes life a burden, and is amenable to no remedy but time. In many cases both heart and stomach are implicated. Mostly the sleep is short and broken. And very generally there is some more or less mental depression. Consider, then, how great must be the damage inflicted by undue mental excitement on children and youths. More or less of this excitement is unavoidable, and in many cases is most beneficial. One can observe an exaltation of brain beyond that which nature had provided for; and when not so excessive as to produce absolute ill-health, it is of course an extreme degeneracy of physique. With a small and fastidious appetite, an imperfect digestion, and an enfeebled circulation, how can the brain function normally? And the performance of every vital process depends on the adequate supply of good blood. With- out enough good blood, no gland can secrete its products, no organ perform its office. Without enough good blood, no nerve, muscle, membrane, or other tissue can be efficiently repaired. Without enough good blood, there can be no increase in brain power; it will be no more nor less than sufficient. Judge, then, how bad must be the consequences when a growing body the weakened stomach supplies blood that is deficient in nutritive powers, and, while the debilitated heart propels this poor and scanty blood with unnatural slowness. And if, as all who candidly investigate the matter will immediately believe and fully appreciate as the consequence of excessive study, how grave is the condemnation to be passed upon this cramping system above exemplified. It is a system which has lost the command of its members, and is not regarded. It is a mistake in so far as the mere acquirement of knowledge is concerned; for it is notorious that the mind, like the body, cannot work efficiently at a great rate; and if you try it with facts faster than it can assimilate them, they are soon rejected again: they do not become permanent. But it is a mistake in another respect the most important. Few of the remarkable physical associations produced by useless mental might, or through the abnormal state of brain it leaves behind, it often generates an aver- age intellect; and if these are the consequent self-culture induced by a rational education, there comes a continued regression. It is a mistake, also, inasmuch as it assumes that the acquisition of knowledge is everything, and forgets that a much more important matter is the organization of knowledge, for which time and spontaneous thinking are the only true processes. When we are looking at the progress of intelligence in general, that “the interpretation of nature is obscured when the description language unites to the facts,” so it may be remarked, respecting the progress of intelligent, that the mind is overburdened and hampered by an excess of ill-digested/information. It is not the knowledge stored up as intellectual fat which is of value, but that which is turned into intellectual muscle. But the mistake is still deeper. Even the system good as a system of intellectual training, which it is, it would still be bad, because, as we have shown, it is fatal to that vigor of the mind which is the capital requisite for intellectual training available in the struggle of life. These who, in eagerness to cultivate their pupils' minds, are reckless of their bodies, are little less so in their zeal to impart to the world the knowledge of the world. The knowledge more than many a man's breast that complex emotion which we call love, the strongest are those produced by moral attractions; the weakest are those produced by intellectual attractions; and even those produced by intellectual knowledge than on natural faculty—quick- ness, wit, insight. If any think the answer a derogatory one, the task of the wise teacher for being thus swayed, we reply that they little know what they say when they thus call in question the divine ordination. Whatever may be the method in the arrangement, we might be sure that some important end was sub- served. But the meaning is quite obvious to those who examine. It needs but oneaker that one of nature's ends, or rather her
provenances in the dyeing of the textile fabrics, and has given employment to a very large number of our Lancashire operatives. The discovery of chlorine has also contributed to the employment of thousands of printers, by enabling espato grass to be bleached, and formed into paper for the columns of our daily press. The numerous experimental investigations in relation to coal-gas have been the means of extending the use of that substance, and of increasing the employment of the cottage labor connected with its manufacture. The discovery of the alkaline metals by Davy, of cyanide of potassium, of nickel, phosphorus, the common acids, and a multitude of other substances, is linked to the employment of a whole army of workmen in the conversion of those substances into articles of utility. The foregoing examples might be greatly enlarged upon, and a great many others might be selected from the sciences of physics and chemistry; but those mentioned will suffice. There is not a force of nature, nor scarcely a material substance that we employ, which has not been the subject of several, and in some cases of many, experiments, the results of many of which have resulted, in a greater or less degree, in increasing the employment for workmen and others."

"All this may be very true. But of what practical use will physical science be to me?"

Let me ask in return, Are none of you going to emigrate? If you have courage and wisdom, emigrate you will, some of you. Several of your number will assemble to scrape the little bit of emigrationism over each other's backs for the scraps, like black bettles in a kitchen. And if you emigrate, you will soon find out, if you have eyes and common-sense, that the vegetable wealth of the world is no more exhausted than its mineral wealth. Exhausted! Not half of it—I believe not one third of it—is yet known. Could I show you the wealth which I have seen in a single Tropic island, not sixty miles square—precious timbers, gums, fruits, water, and employment—all of them money. And I show you that you may emigrate, and get wealth to thousands and tens of thousands, wasting for want of being known and worked—and then you would see what a man who emigrates may do, by a little more knowledge and common-sense.

And if not. Suppose that any one of you, learning a little sound natural history, should abide here in Britain to your life's end, and observe nothing but the hedge-row plants; he would find that there is much more to be seen in those mere hedge-row plants than he fancies now. The microscope will reveal to him in the tissues of any wood, of any seed, wonders which will first, with a certain awe, open his heart to him, and at length to his mind and to his fortunes. But let him (I hope) love awe, as he perceives that smallness of size interferes in no way with perfection of development, and that "nature," as has been well said, "is greater in its blacker nooks than in her broadest nooks.

Suppose that he went farther still. Suppose that he extended his researches somewhat to those minute vegetable forms, the mosses, fungi, lichens; suppose that he went a little farther still, and tried what the vegetable and animal kingdom is doing in a stagnant pool, whether fresh water or salt, of desmidie, diatoms, and all those wondrous atoms which seem as yet to defy our classification into plants or animals. Suppose the same person try and find out what nothing of aught else. Would he have gained no solid wisdom? He would be a stupider man than I have a right to believe any of my readers to be if he had not gained thereby somewhat of the most valuable of treasures—namely, that inductive habit of mind; that power of judging fairly of facts, without which no good or lasting work will be done, whether in physical science, in social science, in political economy, or in all philosophy, in philology, or in history.

But more let me urge you to study natural science, on grounds which may be to you new and unexpected—on social, I mean, and political grounds.

"We all know, and I trust we all love, the names of Liberty, Equality, and Brotherhood. We feel, I trust, that these words are too beautiful not to represent true and just ideas; and I see no reason why these ideas should not come true, and be fulfilled, somewhen, somewhere, somehow. It may be in a shape very different from that which you, or I, or any man expects; but still they will be fulfilled.

But if they are to come true, it is we, the individual men, who must help them to come true for the whole world, by practising them ourselves, when and where we can. And I tell you, that in becoming scientific in our ideas, in cultivating the scientific habit of mind, you will find yourselves enjoying a freedom, an equality, a brotherhood, such as you will not find elsewhere just now.

Freedom: what do we want freedom for? For this, at least: that we may be each and all able to think what we choose; and to say what we choose also. Provided we do not say it rudely or violently, so as to provoke others to violence. That last was my poor friend Mr. Buckle's definition of freedom of speech. That was the only limit to it he would allow; and I think that that is Mr. John Stuart Mill's limit also. At all events it is mine. And I think we have that kind of freedom in these islands, as perfectly as any men are likely to have it on this earth.

But what I complain of is, that when men have got the freedom, three out of four of them will not use it. What! some of the ablest men in the land will not answer, do you suppose that I will not say what I choose, and that I dare not speak my own mind to any man? Doubtless. But are you sure, first, that you think what you choose, or only what some other chooses for you? Are you sure that you make up your own mind before you speak, or let some one else make it up for you? Your speech may be free enough, my good friend, and Heaven forbid that it should be anything else: but are your thoughts free likewise? Are you sure that, though you may hate bigotry in others, you are not somewhat of a bigot yourself? That you do not look at only one side of a question, and that the one which pleases you? that you do not take up your opinions at second hand, from some book or some newspaper, which, after all, only represents the views of others? You should ask yourselves that question, seriously and often: "Are my thoughts really free?!" No one values more highly than I do the advantage of a free press. But you must read a lot, and buy a lot of books. Whether honest or able, is no more inoffensive than the Pope: that he may, just as you may, only see one side of a question, while any question is sure to have two sides, or perhaps three; and that to see one side which suits you, day after day, month after month, you must needs become bigoted to it. Your thoughts must needs run in one groove. They cannot (as Mr. Matthew Arnold would say) "play freely round" a question, and look at it cool, boldly, patiently, rationally, charitably.

And I tell you that if you, or I, or any man, want to let our thoughts play freely round questions, and so escape from the ideas which we must keep in our heads, and which we are taught to hate—ideas of the narrow-minded which there is in every human being, then we must acquire something of that inductive habit of mind which the study of natural science gives. It is, after all, as Professor Hutchinson says, only common-sense well regulated. But then it is well regulated; and how precious it is if you can but get it! The art of seeing, the art of knowing what you see; the art of comparing and noticing true likenesses and true differences, and so of classifying and arranging what you see; the art of connecting facts together in your own mind in chains of cause and effect, and that accurately, patiently, calmly, without prejudice, vanity, or temper—this is what is wanted for true freedom of mind. But accuracy, patience, freedom from prejudice, carelessness for all except the truth, whatever the truth may be—are not these the virile qualities of a truly free spirit? That is, that now, I know no study so able to give that free habit of mind as the study of natural science.
of such scientific books as are to be found nowhere in any first-class elementary school. And if more expensive books are needed, if a microscope or apparatus is needed, can you not get them by the co-operative method, which has worked so well in other matters? To be wise was to belong to a natural science club, for buying such things and lending them round among your members; and for discussion also, the reading of scientific papers of your own writing. In this way the group of discus- sions, general mutual help and mutual in- struction? Such societies are becoming numerous now, and gladly should I see one in every town. For in science, as in most things, "as iron sharpeneth iron, so a man sharpeneth the countenance of his friend."

And brotherhood: well, if you want that; if you want to mix with men, and men, too, eminently worth mixing with, on the simple ground that "a man's a man for that"; if you want to become the acquaintances and—if you prove worthy—the friends of men who will be glad to teach you all they know, and equally glad to learn your knowledge of them, asking no questions about you, save, first, is he an honest student of science?

When the irritation is suspended, and a arrested the moment it is renewed—will a vivid conception of the world, know which an overwrought brain exerts on the body. The effects thus physiologically explained are indeed exemplified in the ordinary experience. There is no one who has not experienced accompanying by fear, anger, joy—no one but has observed how labor becomes the action of the mind when the body is very violent. And though there are many who have never felt themselves suffered that extreme emotional clement which is followed by arrest of heart's action, yet there is reason to be cause and effect.

That familiar fact, too, that disturbance of stomach is caused by mental excitement, ceding a certain intensity. Loss of appetite, the common result alike of very irritable and very painful states. When the event producing a pleasure painful, or a violent emotion, occurs, and meditates not, it unfrequently happens either the stomach rejects what has been eat digests it with great difficulty and into a shape which even the strongest man's brain can much testify, even pur came the companions and "fellow countrymen" most learned and most earth, looked up by them not as equals merely, but as teachers and guides, because philosophers and discoverers.

Do you wish to be great? Then be great with true greatness; which is, knowing the facts of nature, and being able to use them. Do you wish to be strong? Then be strong with true strength; which is, knowing the facts of nature, and being able to use them. Do you wish to be free? Then be free with true freedom; which is, knowing the facts of nature, and being able to use them.

I dare say some of my readers, especially the younger ones, will decry to that last speech of mine. Well, I hope they will not, because I mean it with the best of intentions. Hereafter, at least, shall certainly not be necessary for them. For when I was young I was very much of what I suspect is their opinion. I used to think one could get perfect free- dom, and social reform, and all that wanted, by altering the arrangements of society and legislation; by constitutions and acts of Parliament: by putting society into some sort of freedom-mill, and grinding it all down, and regenerating it so. And that something can be done by im- pudent and deceitful means, can be done by acts of Parliament, I hold still, as every rational man must hold.

But I as grew older I began to see that if things were to be got right, the freedom- mill must be put into operation, and grinding them right, however well and amazingly it was made. I began to see that what sort of flour came out at one end of the mill depended mainly on what sort of grain you fed it. If you do not know what makes a problem was to get good grain; and then good flour would be turned out, even by a very clumsy old-fashioned sort of mill. And what do I mean by good grain? Good men, honest men, accurate men, righteous men, patient men, self-restraining men, fair men, modest men. Men who are aware of their own vast ignorance compared with the vast amount that is to be learned in such a field. In the days of old some people seemed to look at both sides of a question; who, instead of making up their minds in haste like bigots and fanatics, wait, like wise men, for more facts, and more thought about the matter. It is a fact that men who had acquired just the habit of mind which the study of natural science can give and must give; for without it there is no use studying natural science; and the man that has not got that habit of mind, if he meddles with science will merely become a quack and a charlatan, only fit to get his bread as a spirit-rapper or an inventor of infallible pills.

And when I saw that I said to myself, I will train myself, by natural science, to the truly rational, and therefore truly able and useful, habit of mind; and more, I will, for it is my duty as an Englishman, train every Englishman over whom I can get influence, to the true habit of mind, that I may, if possible, make him, too, a rational and an able man.

And, therefore, knowing that most of you, my readers—probably all of you, as I think I have justly observed—think so much of social and political ques- tions—therefore, I say, I entreat you to cultivate the scientific spirit which alone you can judge justly of those ques- tions. I ask you to learn how to " conquer nature by obeying her, get better, and better, and better."

Take my advice for yourselves, dear readers, and for your children after you; for, believe me, I am showing you the way true and useful, and, therefore, to just and national science. I refer you to the way to become members of what I trust will be—what I am certain ought to be—the aristocracy of the future.

I say it deliberately, as a student of science, I refer you to the way of science; the way that has got you into the hands of scientific men; into the hands of those who have made due use of that great heirlor which the philoso- phers of the seventeenth century left for the use of future generations, and specially of the Teutonic race.

For the rest, events seem but too likely to repeat themselves again and again all over the world, in the same hopeless circle. Aristocracies of mere birth decay; and so does aristocracies of mere wealth; and they again to " aristocracies of genius," which are really aristocracies of the noisiest, of mere scribblers and speouters, such as France is writing under at this moment. On this clear ground, the organized brute force and military despotism. And, after that, what can come save anarchy, and decay, and social death?

What else, unless there be left in the nation, in the society, as the salt of the land, to keep it all from rotting, a sufficient number of wise men to form a true working aristocracy, an aristocracy of sound and rational science? If they be strong enough (and they are growing stronger), and wise enough to learn the facts and the laws of nature. They will rule; and their rule, if they are true to themselves, will be one of health and wealth, and peace, of prudence and of justice. For they alone will be able to wield for the benefit than the brute forces of nature, because they alone will have stooped to conquer nature by obeying her."

So runs my dream. I ask my young readers to help toward making that dream a fact, by doing that which I (so far as I feel the justice of my words) honest and earnest students of natural science.

But now, why should I, as a clergyman, interest myself specially in the spread of science? For, I say, the only true spiritual sense is that which comes to me through my proper sphere to meddle with secular matters? Am I not, indeed, going into a sphere out of which I had better keep my- self and all over whom I may have influ- ence? For is not science antagonistic to religion? and, if so, what has a clergyman to do save to warn the young against it, instead of attracting them toward it?

First, as to meddling with secular matters, I say, I say by so much more, and I can use any less wordy. The grain or dust is a dust; but the grain of God's wisdom gave it whatsoever properties or qualities it may possess. God's providence has put it in the place where it is now, and has ordained that it should be in that place at that moment, by a train of events which I have no wish to go back to the very creation of the universe. The grain of dust can no more go from God's presence or flee from God's Spirit than you or I can. If it go up to the physical
heaven, and float (as it actually often does) far above the clouds, in those higher strata of the air where we cannot see them. Away up to the sky, perhaps, in the fringes of the atmosphere, there never existed, whether the Alpine-snow—peaks do not rise, even there it will be obeying physical laws, which we term hastily laws of nature, but which are really the laws of God. They are, in other words, the physical abyss; if it be buried fathoms, miles, below the surface, and become an atom of some rock still in the process of consolidation, has it escaped from God, even in the form of the very first rock? Have there still obeying physical laws, of pressure, heat, crystallization, and so forth, which are laws of God—the will and mind of God concerning particles of matter? Or, on the other hand, do we look at them as they are, the expressions of God's mind and will concerning this universe in which we live—"the Word of God," as Bacon says, "revealed in facts"—and then you will not fear physical science; for you will be sure that the more you know of physical science, the more you will work of the will of God. At least you will be in harmony with the "will of God," which is the same as with you, as you may, if you please, think it. "The heavens," Thomasius, declares, "are the glory of God; and the firmament showeth his handiwork. There is neither speech nor language where their voices are not heard among them." So held the Ptolemaic astronomers, the knowledge of the heavenly bodies; and what he says of sun and stars is true likewise of the flowers around our feet, of which the greatest Christian poet of modern times has said,

"To me the meanest flow'r that grows may give
Thoughts that do lie too deep for tears."

So, again, you will be in harmony with the teaching of St. Paul, who told the Romans "that the invisible things of God are clearly seen from the creation of the world, being understood by the things that are made, even his eternal power and Godhead," and who told the savages of Lycaonsis "and the invisible things of God are made manifest in the things that are made, so that there is no excuse for any man at all; because in him the invisible things of God are clearly seen, both his eternal power and Godhead." And he who wishes to know how truly St. Paul spoke let him study the laws which produce and regulate rain and fruitful seasons, filling men's hearts with food and gladness.

Rain and fruitful seasons witness all mankind; Father of the world. And he who wishes to know how truly St. Paul spoke let him study the laws which produce and regulate rain and fruitful seasons, what we now call climatology, meteorology, geography of land and water. Let him read that truly noble Christian work, Maury's "Physical Geography of the Sea," and see, if he be a truly rational man, how advanced science, instead of disproving, has only corroborated St. Paul's assertions. He who turns to the history of the clouds, like the sun and stars, declares the glory of God. And if any one undervalue the sciences which teach us concerning stones and plants and animals, or thinks things which he knows to be true concerning God, allow one who has been from childhood only a humble, though he trusts a diligent, student of these sciences—allow him, I say, to ask in all reverence, but in all love, and consider the lilies of the field, how they grow,

"Consider the birds of the air, and how your Heavenly Father feedeth them."

So does the Bible (not to quote over again the passages which I have already given you from St. Paul, and One greater than St. Paul) declare the permanence of these laws. We see them more clearly in natural phenomena as obedient to God. And so does the Church of England. For we shall have incorporated into her services that magnificent hymn which our forefathers called the Song of the Three Children, which is, as it were, the very flower and face of St. Paul's teaching, and that in all the litany that the Lamb is to "behold them. If he has but faith, do so, can you do so too much?

I know, of course, the special application which our Lord made of these words. But I know, too, from experience, that the more you study nature, in all her forms, the more you will find that the special application of this to our physical world, wherein, in those many instances in which he drew his parables and lessons from natural objects, was leading men's minds on to dangerous ground, and pointing out to them a sublation of some of the sciences, and that this was the beginning of the special science of the natural world, and our anology with those of the spiritual world, the kingdom of God—a subject of contemplation, I say, which it was not safe to consider. I appeal to your common-sense. If He who spoke these words were (as I believe) none other than the Creator of the universe, by whom all things were made, and without whom nothing was made that is made, do you suppose that he would bid you to consider his universe had it been dangerous for you to do so? Do you suppose, moreover, that the universe which He, the Truth, the Light, the Love, has made, is not infinitely worthy to be considered? or that the careful, accurate, and patient consideration of it, even to its minutest details, can be otherwise than useful to man, and can contribute to the improvement of the body and the mind of the character of Him who made it? And if so, can it be a work unfit for, unworthy of, a clergyman, whose duty is to preach him to all and in all ways, to call on men to consider the things of God, and to contemplate the growth, the life, the spiritual world, consists, holds together, by him, and lives and moves and has its being in him?

And here I must pause to answer an objection which I have heard in my youth from many pious and virtuous people—better people in God's sight than I, I fear, can pretend to be. They used to say, "That would be all very well, but there was not a curse upon the earth." And then they seemed to deduce, from the fact of that curse, a vague notion (for it was little more) that this world was the devil's work, and that the success thereof could not be trusted, because they were disorders, and deceptive, and what not. Now, in justice to the Bible, and in justice to the Church of England, I am bound to say that such a statement, or anything like it, is not a part of the doctrine of both. It is contrary to Scripture. According to it, the earth is not cursed. For it is said in Gen. 8:21: "And the Lord said, I will not again curse the ground any more for man's sake, for the ground shall not retain any more the shame of man; from the earth shall come forth green herb, seed-time and harvest, cold and heat, summer and winter, day and night shall not cease." According to Scripture, again, physical facts are not disordered. For instance, one may observe this day according to their ordinance; for all things serve thee." And again, "Thou hast made them fast forever and ever. Thou hast given them a law which cannot be broken;" says God. So does the Bible (not to quote over again the passages which I have already given you from St. Paul, and One greater than St. Paul) declare the permanence of these laws. We see them more clearly in natural phenomena as obedient to God. And so does the Church of England. For she has incorporated into her services that magnificent hymn which our forefathers
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beasts. Whether there be no human interest in geology, whether man did not care for it, or whether he has, with the aid of specks which have seen enormous geological changes, is becoming more and more an open question.

But meanwhile all must agree that there is matter enough for interest—nay, room enough! for which the facts are given in a science which tells of the growth and decay of whole mountain-ranges, continents, oceans, whole tribes and worlds of plants and animals.

And it is so much for the vastness and grandeur of those scenes of the distant past, to which the science of geology introduces us, that I value it as a study, and wish earnestly to awaken you to its beauty and importance. It is literally true that you cannot fail to learn most easily a sound scientific habit of thought. I say most easily, and for these reasons. The most important facts of geology do not require, to discover them, any knowledge of mathematics or of chemical analysis; they may be studied in every bank, every grot, every quarry, every railway-cutting, by any one who has eyes and common-sense, and who chooses to observe. Hugh Miller, who made himself a great geologist out of a poor stonemason. Next, its most important theories are not, or need not be, wrapped up in obscure Latin and Greek terms. It is the simplest English, because they are discovered by simple common-sense. And thus geology is (orought to be), in popular parlance, the people's science—the science by which a man can explain the earth of the New Zealand Maoris, who hold that some god, when fishing, fished up their islands out of the bottom of the ocean. But a sounder and wiser man would ask of you to employ the same common-sense when you read and think of geology.

It is very necessary to do so. For in past times men have tried to explain the growth of the world according to its seas, oceans, rivers, mountains, and continents, by I know not what of fancied cataclysms and convulsions of nature; explaining the unknown by the still more unknown, till some of their geological theories were more based on known facts, than that of the New Zealand Maoris, who hold that some god, when fishing, fished up their islands out of the bottom of the ocean. But a sounder and wiser man would ask of you to employ the same common-sense when you read and think of geology.

And in the last forty years, since that great and sound idea has become rooted in the minds of students, and specially of English students, geology has thriven and developed, perhaps more than any other science, and has led men on to discoveries far beyond the ancient and obsolete methods of all fancied convulsions and cataclysms.

I have planned this series of papers, therefore, on Sir Charles Lyell's method. I have begun by trying to teach a little about the part of the earth's crust which lies nearest which is the least often examined, namely, the soil; intending, if my readers do me the honor to read the papers which follow, to lead them downwards, as it were, into the earth, deeper and deeper in each case, to depths which are probably much more easily known to the lowest or earliest strata, and I shall follow his plan.

I must ask you meanwhile to remember one law or rule, which seems to me founded on common-sense, and in it, that the uppermost strata are really almost always the newest; that when two or more layers, whether of rock or earth—or, indeed, two streets in the town, or two sheets on a bed, or two books on a table, or the like—appear as if lifeless things, in fact, lie one on the other, then the lower one was most probably put there first, and the upper one laid down on the lower. Does that seem to you a truism? From common-sense in asking you to remember it you may see the better. I shall be saved unnecessary trouble hereafter.

But some one may say, and will have a right to say, "Stop—the lower thing may have been thrust under the upper one." Quite true; and therefore I said only that the lower one was most probably put there first. And I said most probably," because it is most probable that in nature we shall always find things done by the method which costs least force, just as you do them. I will warrant that when you want to hide a thing, you lay something down on it ten times for once that you thrust it under; and it must, I say, "What? When I want to hide a paper, say, under the sofa-cover, do I not thrust it under it?" No, you lift up the cover, and slip the paper in, and let the cover fall on it again. That is one case, the paper has got into its place first.

Now why is this? Simply because, in laying one thing on another, you only move weight. In thrusting one thing under another, you have not only to move weight, but you break or do something else to one another, and not thrust under each other, because thus less force is expended in getting them into place.

There are exceptions. There are cases in which the nature does try to thrust a rock under another. But to do that she requires a force so enormous, compared with what is employed in laying one rock on another, that (so to speak) she continually fails, and, instead of producing a volcanic eruption, produces only an earthquake. Of that I may speak hereafter, and may tell you, in good time, how to distinguish rocks which have been thrust in from below, and those which have come down from above, as every rock between London and Birmingham or Exeter has been laid down. That I only assert now. But I do not wish you to take it on trust from me. I wish to prove it to you as I go on to do what is far better for you, to put you in the way of proving it for yourselves, by using your common-sense.

At the risk of seeming prolix, I must say a few more words about the subject of this. Until I can get you to "let your thoughts play freely" round this question of the superposition of soils and rocks, there will be no use in my going on with these papers.

Suppose then (in argue from the known to the unknown) that you were watching men cleaning out a pond. Atop, perhaps, they would come to a layer of soft mud,
and under that to a layer of sand. Would not common-sense tell you that the sand was there first, and that the water had laid down the mud on the top of it? Then, perhaps, they might come to a layer of clay, or ploughing, and common-sense tell you that the leaves were there before the sand above them? Then, perhaps, to a layer of mud again. Would not common-sense tell you that the mud was there before the leaves? And then, if you dig down to the bottom of the pond, where, lastly, I think common-sense would tell you that the bottom of the pond was there all the time under all the layers which were laid down on it. Is it not obvious that simple geology is made there? Apply the knowledge which you learn from them to the upland fields which are already made.

If there is, as there usually is, a river meadow, or, still better, an estuary, near your town, you have every advantage for watching the changes of the soil by the feet of made soil spread between your town and the sea; thousands more are in process of being made.

You will see now why I have begun with the soil in the fields because it is the uppermost, and therefore latest, of all the layers; and also for this reason, that, if Sir Charles Lyell’s theory be true—as it is—then the soils and rocks below the soil you have upon your field are in the very same way in which the soil of the field is made. Is it not clear that the explanation you will give for this must also hold good as an explanation for the changes which have happened in the earth. It will be a still easier matter to show that the whole of the unknown is made of the known. But you will not frighten me at present. It will be far easier to judge that, however compact the rock may be or mud, you are safe if you can make the soil less compact, and that the water has spread in spite of that.

Now this change has been produced by rain. First, mechanically, by rain in the shape of ice. The winter rain gets into the ground, and does by the rock what it has done by the stones of many an old building. It sinks into the porous stone, and makes the stone itself softer. Then, by the frost, it splits and peels the stone with a force which is slow but surely crumbling the whole of Northern Europe and America to powder.

Do you doubt me? I say nothing but what you can judge of for yourselves. The next time you go up any mountain, look at the loose broken stones with which the top is coated, just underneath the turf. It looks as if the rock had been broken, but it is not. Look again, as stronger proof, at the talus of broken stones—scree, as they call them in Scotland; raffles, as we call them in Devon—which lie along the base of many a cliff. Look at the fields, and consider whether they get under the frost or not. If you ask the country folk they will tell you whether I am right or not. If you go thither, not in the summer, but just after the winter’s frost, you will see the soils little fields of newly-broken bits, that I am right. Possibly you may find me to be even more right than is desirable, by having a few angular stones, from the size of your head to that of your body, hurled on you by the frost. But if you go to the Alps at certain seasons, and hear the thunder of the falling rocks, and see their long lines—moraines, as they are called—sliding slowly down upon the surface of the glacier, there will be ready to believe the geologist who tells you that frost, and...
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probably frost alone, has hewn out such a peak as the Matterhorn from some vast table-land, and is hewing it down still, winter after winter, till some day, when the work is done, there will be rolling uplands of rich culturable soil.

So much for the mechanical action of rain in the shape of ice. Now a few words on its chemical action.

Rain-water is seldom pure. It carries in it carbonic acid; and that acid, beating in shower after shower against the face of a cliff—especially if it be a limestone cliff—weathers the rock chemically, changing (by decaying) the carbonates of lime into a soluble bicarbonate, and carrying that away in water, which, however clear, is still hard. Hard water is usually water which has invisible lime in it; there are from ten to fifteen grains and more of lime in every gallon of limestone water. I leave you to calculate the enormous weight of lime which must be so carried down to the sea every year by a single limestone or chalk cliff, say ten miles long, fifty feet high, and three miles wide, like, ascertaining the weight of lime in each gallon, and the average quantity of water which comes down the stream in a day; and when your sum is done, you will not object to the idea that there are many pounds but probably of many tons of solid lime, which you never suspected or missed from the hills around. Again, by the time the rain has sunk through the soil and reached the water-course, it has carried in it not only carbonic acid, but acids produced by decaying vegetables—by the roots of the grasses and trees which grow above, and they dissolve the cement of the rock by the aid of which it is held together. It may be limestone or iron. You may see this for yourselves, again and again. You may see how the root of a tree, penetrating the earth, dissolves the soil with which it is in contact. You may see how the whole rock, just below the soil, has often changed in color from the compact rock below, if the soil be covered with a dense layer of peat or growing vegetation.

The rock is slowly changing at work, and quite as powerful as rain and rivers, making the soil of alluvial flats. Perhaps it has helped, likewise, to make the soil of all the lowlands in these isles; and that is a fact of the greatest importance.

If you ever go to Parkgate, in Cheshire, try if you cannot learn there a little geology.

Walk beyond the town. You find the shore protected for a long way by a sea-wall, lest it should be eaten away by the waves. What is the force of those waves can be, even on that sheltered coast, you may judge—at least you could have judged this time last year—by the masses of masonry torn from their iron clamping during the gales! You find below the sea-wall at those rolled blocks, those twisted stanchions, if they are there still; and then ask yourselves—it will be fair reasoning from the known to the unknown—What effect must such waves have on the sea, as it knows neither rest nor pity, the cruel, hungry sea. Give it but time enough, and what would it not eat up? It would eat up, in the course of ages, all the dry land of this planet, were it not baffled by another countering force, of which I shall speak hereafter.

As you go on you beyond the sea-wall, you find what it is eating up. The whole low cliff is going visibly. But whither is it going? To form new soil in the estuary, as it now is; or is it going to sink, and to go on sinking, and so often become silted up. The sea has washed the land into them. But more, the sea-currents do not allow the sands of the estuary to escape freely out to sea, they are stopped up with the rocks about the mouth of the estuary. The prevailing sea-winds, from whatever quarter, catch up the sand, and roll it up into sand-hills. Those sand-hills are again eaten by the waves, from the base of which the sea-winds, from the base of which the waters have gone back. Why should not those crags be old sea-cliffs? Why should not, following our rule of explaining the unknown by the known, as the Nile, so these are they till some one gives us a sound proof that they are not, and say, These great plains of England and Scotland were probably once covered by a shallow sea, and their soils made as the Nile plains are. Then our rule will be right.

But you may say, and most reasonably.

"The tide-flats are just at the sea level. The whole of the lowland is many feet above the sea; it must therefore have been raised out of the sea, according to your theory; and what proofs have you of that?"

Well, that is a question both grand and deep, on which I shall not enter yet; but you shall see how we shall play fair with you, I ask you to believe nothing but what you can prove for yourselves. Let me ask you this: suppose that you had proof positive that I had fallen into the river in the morning; would not your meeting me in the evening be also proof positive that somehow or other I had in the course of the day got out of the river? I think you will accept that logic as sound.

Now if I can give you proof positive, proof which you can see with your own eyes, and handle with your own hands, and, alas! often feel but too keenly with your own feet, that the whole of the lowlands look as if they were raised out of the sea, it not be certain that, somehow or other, they must have been raised out of the sea again?

And that I propose to do in my next paper. I shall speak in that of the pebbles in the street.

Meanwhile I wish you to face fairly the truly grand idea, which all I have said tends to prove true—that all the soil we live on is made by the destructive action of the sea—how soft as clay or hard as rock; that rain, rivers, and seas are perpetually melting and grinding up old land to compose new land out of it; and that it must have been done scha long as rain, rivers, and seas have existed. "But how did the first land of all get made?" I can only reply, A natural question; but we can only answer that, by working from the known to the unknown. While we are finding out how these later lands were made, we shall yet get to accept some plain rules founded on experience, which will be of infinite use to both you and me in my future papers.

I hope, meanwhile, that you will agree to the that there is plenty of geological matter to be seen and thought over in the neighborhood of any town.

Be sure that wherever there is a river, even a drain, and a stone quarry, or even a roadside bank, much more where there is a town, there you may get to accept some plain rules founded on experience, which will be of infinite use to both you and me in my future papers.

If you, dear reader, dwell in any northern town, you will almost certainly see paving courts and alleys, and sometimes—the leastLatouren—we may stumble on some hints as to how the first primal continents rose out of the bosom of the sea.

And that I end this paper. I trust it will have been nontolerably long to you, and not to have wanted, at staring, to show my readers something of the right way of finding out truth on this and perhaps on all subjects, to make some simple appeals to your common sense, and to get you to accept some plain rules founded on experience, which will be of infinite use to both you and me in my future papers.

II.

THE PEBBLES IN THE STREET.

If you, dear reader, dwell in any northern town, you will almost certainly see paving courts and alleys, and sometimes—the leastLatouren—we may stumble on some hints as to how the first primal continents rose out of the sea.

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music and the jingling of the fairy horses’ trappings. But woe to him if he fell asleep upon the mound, for he would be spirited away into fairyland for seven days, during which he would see as many sights in one day. A strange fancy, yet not so strange as the actual truth as to what these mounds are, and how they came into their places.

Again, you might find that your town’s pebbles and boulders came out of a pit of clay, in which they were stuck, without any order or bedding, like plums and raisins in a puddling. This clay goes usually by the name of boulder-clay. There are town-clays in Cheshire and Lancashire; or along Leith shore, near Edinburgh; or, to give one more instance out of hundreds, along the coast at Scarborough. If you walk along the shore southward, or take to the cliffs in the gullies of the cliff, great beds of sticky clay, stuffed full of bits of every rock between the Lake mountains and Scarborough, from rounded pebbles of most ancient chert down to fragments of ironstone and coal. There, as elsewhere, the great majority of the pebbles have nothing to do with the rock on which the clay happens to lie, but have come, with millions of them, from places many miles away.

Now, if we find spread over a low land pebbles composed of rocks which are only found in certain high lands, is it not an argument that they have been moved down? These pebbles have come from the highlands! And if the pebbles are rounded, while the rocks like them in the highlands always break off in angular shapes, is it not, again, an act of mere common-sense to say, the pebbles have been rolled, or at any rate, the rounded pebbles have been rubbed round either in getting hither or before they started hither?

Does all this seem to you mere truism, my dear reader? If so, I am sincerely glad to hear it. It was not so very long ago that such arguments would have been considered, not only no truisms, but not even common-sense.

But to return: let us take, as a simple example a piece of ground, say, 100 yards square, from the neighborhood of Liverpool and Birkenhead, made by Mr. De Rance, the government geologist:

Granite, greenstone, felspar phyllite, for instance, would, if polished, look like a marble, that is, either formed by, or altered by volcanic heat, and almost all found in the Lake mountains, 37 per cent.

Silurian grits (the common stones of the Lake mountains deposited by water), 45 per cent.

Ironstone, 1 per cent.

Carboniferous limestone, 5 per cent.

Permian or Triassic sandstones—that is, rocks immediately round Liverpool—12 per cent.

Now, does not this sample show, as far as human common-sense can be depended on, that the great majority of these stones come from the Lake mountains, sixty or eighty miles distant? But how did these stones get there? What does your common-sense tell you that these pebbles are not mere concretions—that is, formed out of the substance of the clay after it was deposited. The least knowledge of geology would teach you that such pebbles are very rare.

But even if you are no mineralogist, common-sense will tell you that if they were all concored out of the same clay, it is a most extraordinary coincidence—indeed one too strange to be believed, if any less strange explanation could be given. You would have taken the composition of the different rocks, which are found all together in one group of mountains to the northward. You will surely say, If this be granite, it has most probably got from a granite mountain; if this be grit, from the granite mountains, and so on with the whole list. Why are we to go out of our way to seek improbable explanations when there is a probable one staring us in the face?

This does not well worth your notice—if you will examine the pebbles carefully, especially the larger ones, you will find that they are not only more or less rounded, but often scratched; and we may even or even three sets of scratches crossing each other—marked as a cat marks an elder-stem when she sharpens her claws upon it; and that these scratches have not been made by the rocks, but by the pebbles; and that there are old marks which exist—as you may easily prove for yourself—while the stone is still lying in its bed of clay. Would it not be an act of mere common-sense to say, the pebbles have been rolled, or at any rate, the sharp points of other stones which have rubbed against the pebbles somewhere and somehow with great force?

So far so good. The next question is, How did the pebbles get into the clay? If we can discover that, we may also discover how they were rounded and scratched.

We must find a theory which will answer our question, and one which, as Professor Huxley would say, “will go on all fours.”

That is, a theory which will suit the case, and not only a few of them.

What, then, brought the stones?

We cannot, I think, answer the question, as some have tried to answer it, by saying that they were brought by Noah’s flood. For it is clear that very violent currents of water would be needed to carry boulders, some of them weighing many tons, for many miles. Now Scripture says nothing about floods, and from what we have we have no right to set currents or any other imagined facts into Scripture out of our own heads, and then argue from them as if not we but the text of Scripture had asserted them.

But still they may have been rolled hither by water. That theory certainly would explain their being rounded, though not their being scratched. But it will not explain their being found in the clay.

Recollect what I said in my first paper: that water drops its pebbles and coarser particles first, while it carries the finer; and probably only drops it when the water becomes still. Now, currents of such tremendous violence as to carry these boulder-stones onward would have carried the mud for many miles further still, and find the stones in the clay, but lying loose together, probably on a hard rock bottom, scoured clean by the current. That is what we find in the beds of streams; that is just what we do not find in this case.

But the boulders may have been brought by a current, and then the water may have become still, and the clay settled quietly round them. What? Under them as well as over them? On this theory the boulders should find them only at the bottom of the clay. As it is, we find them scattered anywhere and everywhere through it, from top to bottom. So that theory will not do.

Indeed, no theory will do which supposes them to have been brought by water alone.

Try yourself, dear reader, and make experiments with running water, pebbles, and mud. If you try for seven years, I believe you will never contrive to make your pebbles go into the clay, but you will lie about in every pit in the boulder-clay.

Well, then, there we are at fault, it seems. We have no explanation drawn from known facts which will do, unless we support it by another, which you will see, if you do, that stones, clay, and all were blown hither along the surface of the ground by primeval hurricanes, ten times worse than those of the West Indies, which certainly will roll a cannon a few yards, but cannot surely roll a boulder-stone a hundred miles.

Now, suppose that there was a force, an agent, known—luckily for you, not to be very difficult to understand, and that sailors and travellers; a force which is at work over the vast sheets of land at both the north and south poles; at work, too, on every high mountain range in the world, and at the height of common natural force; and suppose that this force would explain all the facts, namely,

How the stones got here.

How they were scratched and rounded; How they were dropped into the clay, because it is notoriously, and before men’s eyes now, carrying great stones hundreds of miles, and scratching and rounding them also; carrying vast deposits of mud, too, and mixing up mud and stones just as they wish, and having no regard to the fact that our common-sense have a right to try that explanation to suspect that this force, which we do not see at work in Britain now, may have been at work here ages since? That would at least be reasoning from the known to the unknown.

What state of things, then, do we find among the highest mountains, and over whole countries which, though not lofty, yet have been scoured and made smooth to be permanently covered with ice?

We find, first, an ice-cap or ice-sheet, fed by the winter’s snows, stretching over the higher land, and crawling downward and melting away, and leaving its own weight, along the valleys, as glaciers.

We find underneath the glaciers a moraine profonde, consisting of the boulders and gravel and earth, which the glacier has ground off the hillsides, and is carrying down with it.

These stones, of course, grind, scratch, and polish each other, and in likewise grind, scratch, and polish the rock over which they roll along, and increase the enormous weight of the super incumbent ice.

We find also issuing from under each glacier a stream, carrying the finest mud, the result of the grinding of the boulders against each other and the glacier.

We find, moreover, on the surface of the glaciers moraines superiores—long lines of stones and dirt which have fallen from neighboring cliffs, and are now travelling down along with the glacier.

Their fate, if the glacier ends on land, is what was to be expected. The stones from above the glacier fall over the ice-cliff at its end, to mingle with those thrown out from underneath the glacier, and form huge banks of boulders, called terminal moraines, while the mud runs...
off, as all who have seen glaciars know, in a turbid torrent.

Their fate, again, is what was to be expected if the glacier ends, as it commonly does in the Arctic regions, in the sea. The ice grows out to seaward for more than a mile sometimes, about one eighth of it being above water and seven eighths below, so that an ice-cliff one hundred feet high may project forty to fifty feet under water. This often makes confusion worse confounded. A few shells, of an Arctic or northern type, would be found in it here and there. Some would have lived near those later ice-cliffs, and sometimes near ancient oze, wherever the iceberg had left it in peace long enough for sea-animals to colonize and breed in it. But the general appearance of the dried sea-bottom would be that of sand and gravelly and sandy boulders, brown coals, and boulder-bearing clays; and wherever a buss of bare rock still stood up it would be found ground down, and probably polished by the ponderous ice-b ergs which had lumbered over it in their passage out to sea.

In a word, it would look exactly as vast tracts of the English, Scotch, and Irish lowlands must have looked before returning vegetation coated their dreary sands and clays with a layer of brown vegetable soil.

Thus, and believe thus only, can we explain the facts noted in these boulders. No agent known on earth can have stuck them in the clay save ice, which is known to do so still elsewhere.

No known agent can have scratched them as they are scratched save ice, which is known to do so still elsewhere.

No known agent—certainly not, in my opinion, the existing rivers—can have accounted the vast beds of boulders which are now occurring on the English, Scotch, and Irish rivers—notably along the Dee about Abonye—save ice, bearing them slowly down from the distant summits of the Grampians.

No known agent save ice can have produced those rounded and polished and starred and fluted _rochers monotonié_—"sheep-backed rocks"—so common in the Lake district; so common, too, in Snowdonia, especially between the two lakes of Llynberis; common in Kerry; to be seen anywhere, as far as I have ascertained, around the Scotch Highlands, where the turf is cleared away from an unwethered bedrock; and almost everywhere in Kerry. I have seen a glacier that had pressed against it had one been there. Where these polishings and scorings are found in narrow gllss, it is, no doubt, an open question whether some of them may not be work of water. But nothing but the action of ice can have produced what I have seen in landlocked and quiet fiords in Kerry—ice-flutings in polished rocks below high-water mark, so large that I could lie down in one and see the heads of ocean-going ships rising above it. This could produce what may be seen in any of our mountains—whole sheets of rock ground down into rounded flats, irrespective of the lie of the beds, not in valleys, but on the floors of wide and level lakes, which often end abruptly at the edge of some sudden cliff, where the true work of water, in the shape of rain and frost, is actually destroying the previous work of ice, and finds itself in the same situation that I think was described by Professor Gielke in his delightful book on Scotch scenery as influenced by its geology,

that ice planes down into flats, while water saws out into crags and gullies; and that the rain and frost are even now restoring Scotch scenery to something of that ruggedness and picturesque ness which it must have lost when it lay, like Greenland, under the indiscriminating grinding of a heavy sheet of ice.

This great agent save ice will explain those peregrine boulders, composed of ancient hard rocks which may be seen in so many parts of these islands and of the Continent. No water-power could have lifted those stones, and tossed them up high above the dry sand or sandy clay, upon boulders, upon terraces, upon rocks of a totally different kind.

Some of my readers surely recollect Wordsworth's noble lines about these mysterious wanderers, of which lie had seen so many, in \-_Antiquity of Man_,

"As a huge stone is sometimes seen to lie

Couched on the laid top of an eminence,

So anciently, as if it had a home;

By what means it could thither come, and whence;

So that it seems a thing endued with sense—

Like a sea-beast crawled forth, that on a sand

Of rock or sand rejoiced, there to sit itself."

Yes; but the next time you see such a stone believe that the wonder has been solved, and found to be, like most wonders in nature, more wonderful than we guessed it would be, that strong and vast creature which was crawled forth, but an ice-beast which has been left behind, lifted up thither by the ice, as surely as the famous Pierre-à-bôt, forty feet in diameter, and hundreds of tons of weight, must have been laid down, and try whether our ice-dream will account for them also. Let us investigate our ease as a good medical man does, by verifying his first induction.

He says, At the first glance, I can see symptoms _a, b, c_. It is therefore probable that my patient has got complaint _A_. But if he has he ought to have symptom _d_ also. If I find that, my guess will be yet more certain, for I expect symptoms _e, f, g, and so forth_; and as I find successively each of these symptoms which are proper to _A_, my first guess will become more and more probable, till it reaches practical certainty.

Now let us do the same, and say. If this strange dream be true, and the lowlands of the north were once under an ice sea, ought we not to find sea-shells in their sands and clays? Not abundantly, of course. We can understand that the sea animals would be too rapidly covered up in mud, and too much disturbed by ice-b ergs and boulders, to be very abundant. But still, some should surely be found here and there.

Doubtless; and if my northern-town readers will search the boulder-clay pits near them, they will most probably find a few shells, if not in the clay itself, yet in sand-beds mixed with them, and probably underlying them. And this is a notable fact, that the more species of shells they find, the more they will find—if they work out their names from any good book of classification, from the most northern type of species which notoriously, at this day, inhabit the colder seas.

It is impossible for me here to enter at length on a subject on which a whole literature has been already written. Those

See Lyell, _Antiquity of Man_, p. 294, et seq.

* See a most charming paper on the "Physics of Arctic Ice," by Dr. Robert Brown, of Computer, published in the _Transactions of the Geologists' Society_, June, 1850. This article is so remarkable, not only for its sound scientific matter, but for the vivacities and poetic beauty of its descriptions, that I must express a hope that the learned author will some day enlarge it, and publish it in a separate form.

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who wish to study it may find all that they need know, and more, in Lyell’s "Student's Elements of Geology," and in chapter xii. of his "Antiquity of Man," They will find that if the evidence of scientific conchologists is worthy anything, the period can be pointed out, in the strata, though not of course in time, at which these seas began to grow colder, and southern and Mediterranean shells to disappear, their places being taken by shells of a temperate and cold water climate. We must answer, We have no proof of it. Each quakes upheaval lands now only by slight and intermittent upward pulses; nay, some lands we know to rise without any earthquake. For example, slow, upward swelling of a few feet, and we have no reason, and therefore no right, to suppose that Snowdonia was upheaved by any means or at any rate which can be shown. We do know, therefore we are bound to allow not only that there was a past "age of ice," but that that age was one of altogether enormous duration.

But meanwhile some of you, I presume, are ready to cry, Stop. It may be our own weakness. It is a great deal too fast and too far for our small imaginations. Have you not played with us, as well as argued with us, till you have inveigled us step by step into a conclusion which we cannot and will not believe? That all this land should have been sunk beneath an icy sea? That Britain should have been Greenland is now? We can't believe it, and we won't.

If you say so, like stout, common-sense Britons, who have a wholesome dread of being taken in with fine words and wild speculations, I assure you I shall not laugh at you, even in private. On the contrary, I shall only say, is it possible that man will say, So much the better. That is the sort of audience which we want, if we are teaching national science. We do not want haste, enthusiasm, gobe-moucheur, as the French call it, which is apace to snap up an article of the day, because it is new and vast. We want our readers to be slow, suspicious, conservative, ready to "gib," as we say of a horse, and refuse the collar up a steep place, saying, I must not believe what I see, because the looks be the path ahead of me. It seems an ugly place to get up. I don't know this road, and I shall not hurry over it. I must go back a few steps and make sure. I must look around me. We believe whether there are not other roads, a dozen of them perhaps, which would do as well or better than this.

That is the temper which finds out truth, slowly, for one and for all; and I shall be glad, not sorry, to see it in my readers. And I am bound to say that it has been by that temper that this theory has been worked out, and the existence of this past age of ice, or glacial epoch, has been discovered, through many mistakes, many corruptions, and many changes of opinion about details, for nearly forty years of hard work, by many men, in many lands. As a very humble student of this subject, I have been looking at these facts in the face earnestly enough for more than twenty years, and that I am about as certain that they can only be explained by ice, as I am that my having got the scent by rai can only be explained by steam.

But I think I know what startles you. It is the being asked to believe in such an enormous change in climate, and in the shape of the land. You know that it is very astonishing, appalling—all but incredible, if we had not the facts to prove it. But of the facts there can be no doubt. There can be no doubt that the climate of this north-west were immensely changed from the climate of the same place—cold, colder, and coldest than ever—as not the evidence of my own senses.

Or, have I, or have I not, fulfilled the promise which I made—rashly, I dare
say some of you thought—in my first paper? Have I, or have I not, made you prove to yourself, by your own common sense, that the lowlands of Britain were undersea in the days in which these pebbles and clast (= pebbles) help to explain the valleys? Nay, have we not proved more? Have we not found that old sea was an icy sea? Have we not wandered on, step by step, into a whole true fairy-land of wonder? And still, you ask, is Greenland now? when mud streams have rushed down from under glaciers on to a cold sea-bottom, when ice, mast high, came floating by, as green as emerald, under the sun, which changed the ice down in fourteen hundreds of feet of its height? when (as I could prove to you, had I time) the peaks of the highest Cumberland and Scotch mountains alone stood out, as islets in a frozen sea.

We want to get an answer to one strange question, and we have found a group of questions stranger still, and got them answered too. But so it is always in science. We know them all, but we cannot cover them. But this at last, we know, that it will be far more wonderful than we had dreamed. The scientific explorer is always like Saul of old, who set out simply to find a kingdom, and found them—and a kingdom besides.

I should have liked to have told you more about this bygone age of ice. Should have liked to say something to you of the account of it—a chapter which is still an open one—whether there were two ages of ice; whether the climate here did not, after perhaps thousands of years of Arctie cold, soften somewhat for a while—a few thousand years perhaps—again into a second age of ice, somewhat less severe, probably, than the first. Should have liked to have hinted at the probable cause of this change—indeed, of the age of ice altogether—whether it was caused by a change in the distribution of land and water, or by change in the height and size of these islands, which made them large enough and high enough to carry a sheet of eternal snow inland; or whether it was caused by a change in the sun, either in its constancy, causing a change in the position of the whole planet with regard to its orbit round the sun—shifting at once the poles and the tropics; a deep question that latter, on which astronomers, whose business it is, are still at work, and on which, ere young folk are old, they will have discovered, I expect, some startling facts. On that last question, I, as no astronomer, cannot pass; but I should have liked to have said somewhat on matters on which I have knowledge enough, at least, to teach you how much there is to be learned. I should have liked to tell the student of sea-animal life to go back to the Great Bed of that great sandstone is again explained by the remarkable discoveries which Dr. Carpenter and Mr. Wyville Thompson have just made, in the deep-sea dredgings in the North Atlantic. I should have liked to have told you of the complex of the pre-glacial flora—the plants which lived here before the ice, and lasted, some of them at least, through all those ages of fearful cold, and linger still on the surface: lichens, mosses, and ferns, and some of the highest peaks of Cumberland and Scotland. I should have liked to have told the lovers of zoology about the animals which lived before the ice—of the mammoth, or woolly elephant; the woolly rhinoceros, the cave lion and hyaena, the reindeer, the musk ox, the lemmings and the marmots which inhabited Britain till the ice drove them out southward, even into the South of France; and how, as the ice retreated and the climate became tolerable once more, some of these, too, the musk ox, the bison, the lion, and many another mighty beast—reappeared on our lowlands, at a time when the hippopotamus, at least in summer, ranged freely from Africa and Spain across the western districts of Scotland and England, and felt by the side of animals which have long since retreated to Norway and to Canada. I should have liked to tell the archaeologist of the human beings—probable from the bones of their horses—of the same race as the present Laplanders, who passed northward as the ice went back, following the wild reindeer herds from the South of France into our islands, which were no islands then, to be in their drifts driven norward by stronger races from the east and south. But space presses, and I fear that I have written too much already.

At least, I have turned over for you a few pages of the great book in the library of nature, and taught you, I hope, a key by which to decipher their hieroglyphs. At least, I have, I trust, taught you to look, as I do, with something of interest, even of awe, upon the pebbles in the street.

III.

THE STONES IN THE WALL.

This is a large subject. For in the different towns of these islands the walls are built of stones of almost every age, from the earliest to the latest; and the town-geologist may find a quite different sample of stone for every wall, when moving from one town to another twenty miles off. I can do, therefore, is to take one set of towns, in the walls of which one sort of stones is commonly found, and talk of them; taking care, of course, to choose a stone which is widely distributed. And such, I think, we can find in the so-called New Red sandstone, which, with its attendant marls, covers a large part of the central district of England. From Hartlepool and the mouth of the Tees, down through Yorkshire and Nottinghamshire; over the manufacturing districts of central England; down the valley of the Severn; past Bristol and the Somersetshire flats to Torquay in South Devon; up north-westward through Shropshire and Cheshire; past Liverpool and northward through Lancashire; reappearing again, north of the Lake mountains, about Carlisle and the Scotch side of the Solway Firth, stretches the New Red sandstone plain, from under which everywhere the coal-bearing rocks rise as from a sea. It contains, in many places, grey sandstone, looking like a large pebbly beach; the most famous of which, perhaps, are the well-known Runcorn quarries, near Liverpool, from which the old Romans brought the material for the walls of Hadrian's Wall; and from which the stone for the restoration of Chester Cathedral is being taken at this time. In some quarters, especially in the north-west of England, its soil is poor, because it is too sandy. But it is very well suited for a stone which I spoke of in my last paper. But its rich red marls, wherever they come to the surface, are one of God's most precious gifts to this favored land. On them one finds one's self at once in a garden; amid the noblest of timber, evergreens, grass which is green through the driest summers, and, in the western counties, cider-orchards laden with red and golden fruit. I know, throughout northern Europe, no such charming scenery, for quiet beauty and rural wealth, as that of the New Red marls; and if I wished to show a foreigner what England was, I should take him along them, from Yorkshire to South Devon, and say, There. Is not that a country worth seeing, and worth dying for, if need be?

Another reason which I have for dealing with the New Red sandstone is this—that (as I said just now) over great tracts of country, especially in the alluvial districts, the town-geologist will find it covered immediately by the boulder clay.

The townsman, finding this, would have a fair right to suppose that the clay was and would be immediately, or at least soon after, the sandstones or marls on which it lies; that as soon as the one had settled at the bottom of some old sea, the other settled on top of it, in the same sea. But experience shows that this would in many cases, indeed in most, be quite true. But in this case it would be a mistake. The sandstone and marls are immensely older than the boulder-clay. They are, humanly speaking, some four or five worlds older.

What do I mean? This—that between the time when the one, and the time when the other, was made, the British Islands were a sea, some thousands of feet deep, covering Europe, have changed four or five times: in shape; in height above the sea, or depth below it; in climate; in the kinds of plants and animals which have dwelt on them. Also, in the rocks on their sea-bottoms. And surely it is not too strong a metaphor to call such changes a change from an old world to a new one.

Mind. I do not say that these changes were sudden or violent. It is far more probable that they are only part and parcel of that vast but slow change which is going on everywhere over our whole globe. I think that will appear probable in the course of this paper. But that brings me to the chief subj-ject. The fact I assert; and I am bound to try and prove it. And in trying to do so, I shall no longer treat my readers, as I did in the first two papers, like children. I shall take for granted that they understand something of the method by which geological problems are worked out; and can trust it, and me; and shall state boldly the conclusions of geologists, giving only proof where proof is specially needed.

Now you must understand that in England there are two great divisions of these New Red sandstones, Tris, as geologists have expressed it. One, which many Keuper, which consists, stops, of the rich red marl, below them, of sandstones, and of those vast deposits of rock-salt, which have been long worked, and worked with highly regular success. The other is white and saline, and has no such evid-ence of land has just taken place near Nantwich in Cheshire; and serious fears are entertained lest the town itself may subside, to fill up the caverns below, from which the salt is extracted. Beneath these beds again are those which carry the building-stone of Runcorn. Now these beds altogether, in Cheshire at least, are about 3400 feet thick, and were not laid down in a year, or in a century either. Below them lies a thousand feet of sand...
stones, known in Germany by the name of the 'Bunter,' from its mottled and spotted appearance. What I said of them, again, does not concern us just now.

I said that the geologists called these beds the Trias—that is, the triple group. But as yet we have heard of only two parts of it, the Bunter and the Keuper. I said that when I first saw the Bunter in Germany, I was startled at finding that it was covered with Muschelkalk. A long epoch must therefore have intervened between the laying down of the Bunter and of the Keuper. And we have a trace of that long epoch, even in England, in Gower, in South Wales, where we have the Muschelkalk laid down on it. Here again, then, as everywhere, we have evidence of time, not only beyond all counting, but beyond all imagining.

And now, perhaps, the reader will ask, 'What do you mean by words like made out of old land, and that all rocks and soils are derived from the wear and tear of still older rocks, off what land came this enormous heap of sands, more than 5000 feet thick in places, stretching across England and into Germany?'

It is difficult to answer. The shape and distribution of land in those days were so different from what they are now, that the rocks which furnished a great deal of our sandstone may be now, for aught I know, a mile beneath the sea.

But over the land which still stands out of the sea near us there has been wear and tear enough to account for any quantity of sand deposit. As a single instance: It is a provable and proven fact—as you may see from Mr. Ramsay's survey of North Wales—that over a large tract to the south of the little town of Rhuddlan, in Denbighshire, where the river Clwyd has cut its way through the mountain, there has been ground off and carried away a mass of solid rock 20,000 feet thick; thick enough, in fact, if it were there still, to make a range of mountains as high as the Andes. It is a provable and proven fact that vast tracts of the centre of poor old Ireland were once covered with coal-measures, which have been scraped off in likewise, deprived of inestimable mineral wealth.

The destruction of rocks—what an awful thought!—in the district round Malvern, is, I am told, probably enormous. Indeed, it is so over all Wales, North England, and West and North Scotland. So there is enough of 5000 feet thick in places, stretching across England and into Germany?

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minal. So the next time they find themselves running southwest to London—or the reverse way—let them keep their eyes open, and verify, with the help of a geological map, the sketch which is given in this book.

Of the "Black Countries"—the actual coal districts—I shall speak hereafter. They are in England either shores or islands yet undestroyed, which stand out of the great sea of New Red sandstone, and often carry along their edges layers of far younger rocks, called now Permain, from the ancient kingdom of Perimia, in Russia, where they cover a vast area. With the uncertain and fluctuating laws of the Cretaceous age, the sea, which to-day may roll down upon them, has left its spoor, its coral, its shells, its remains, to be seen and studied. And, in the south, geologists may find what wild spots have been the “lands” of prehistoric pastures, where horses, small and great, may have reared up the luxuriant growth of wild grass, and pricked up their ears to the cries of the wildfowl flying by. Yet, in a century, a few miles of sea may have rolled in to bury those spots, and to form new and secret banks for the future geologist to find.

And that land was not far distant is proved by the bones of the pterodactyle, of crocodiles, and of marsupials; by the fact that the shells are of shallow water or shore species; by the presence, mixed with the fossils, of fine lines of growth, and tiny impressions of plants, and even wing-shells of beetles; and lastly, if further proof was needed, by the fact that in the “dirty bed” of the Isle of Portland and the neighboring shires, the sea has been most unusually active, and has made the most splendid beds of limestone, with the richest shell-fish,

So much for the useless "hobby," as some fancy it, of poking over old bones and stones, and learning a little of the composition of this earth on which God has placed us.

How to explain the presence of this vast mass of animal matter, in or two thin bands right across England, I know not. As little do we know whether the whole length of the English coast is plain to those who look at it. But what caused so vast a destruction of animal life along that beach, must remain one of the buried secrets of the past.

First appear thin layers of a very hard blue limestone, full of shells, and parted by layers of blue marl. That rock runs in a broad belt across England, from Whitby in Yorkshire to Lyme in Dorsetshire, and is known as lias. Famous it is, as some readers may know, for holding the bones of the great fossil reptiles, the ichthyosaurs, of the Jurassic period, and plesiosaurs, such as the unequalled learned may behold in the lake at the Crystal Palace. On this rock lie the rich cheese pastures, and the best tracts of the famous "hunting" shift of England.

Lying on it, as we go south-eastward, appear alternate beds of sandy limestone, with vast depths of clay between them. These "oolites," or fossil stones, furnish the famous chalk, which the farmer may find at Ford and Farnham, the Barnack stone of Northamptonshire, of which some of the finest cathedrals are built—a stone only surpassed, I believe, by the Caen stone, which comes from beds of the same age in Normandy. These fossil stones and clays abound in fossils, but of kinds, be it remembered, which differ more and more from those of the lias beneath, as the beds are higher in the series, and nearer to the present surface of the earth. We found principally the bones of that extraordinary flying lizard, the pterodactyle, which had wings formed out of its forelegs, on somewhat the same plan as those of our birds. Among them, is the bird, now lost, bat, as any one may see, four fingers of the hand are lengthend to carry the wing, while the first alone is left free, as a thumb: but in the pterodactyle, the outer or third finger is elongated, and the other four fingers left free—one of those strange instances in nature of the same effect being produced in widely different plants and animals, and yet by slightly different means, on which a whole chapter has been written, and which natural philosophy—or, rather, natural theology—will have to be written some day.

But now consider what this lias, and the oolites and clays upon it, mean. They mean that in New Red sandstone, which after it had been dry land, or all but dry land (as is proved by the footprints of animals and the deposits of salt), was sunk again beneath the sea. Each deposit of limy rock is, therefore, a year, during which that sea was pure enough to allow reeds of coral to grow and shells to propagate at the bottom. Each great band of clay signifies a long period, during which the land was brought down from some wasting land in the neighborhood.

And long how did this period of slow sinking go on? Who can tell? The thickness of the lias and oolites together cannot be measured. It is not the lengthening of trees alluding to the modern sago-palms as they are found in the soil, which, with them, has been covered up in layers of freshwater shale and limestone. A tropical forest has thus been manufacture, and that ligou—the next, beneath the sea.

On we pass Oxford, or the Vale of Aylesbury, we enter yet another world. We are now in the meaningful world of the New Red sandstone, and the upper Greensand, which is more worthy of the name, for it does carry, in most places, a band of green or "glauconite" sand. But it and the upper layers of the chalk and its "plaster" of chalk were, in our time, of little interest; for we are all probably eating them from time to time in the form of bran.

It had been long remarked that certain parts of these beds carried admirable wheat-land; it had been remarked, too, that the finest hop-lands—those of Farnham, for instance, and Tumbling—lay upon them: but that the fertile band was very narrow; that, as in the Surrey moors, vast stretches of land have been leveled and tilled, and are not worth cultivation. What caused the striking difference?

My beloved friend and teacher, the late Dr. Henslow, when Professor of Botany at Cambridge, used to say, "When the farmer (so the story ran) a few fossils. He saw, being somewhat of a geologist and chemist, that they were not, as fossils usually are, carbonate of lime, but phosphate of lime, and at once, as by an inspiration, "You have found a treasure—not a gold mine, indeed, but a fossil mine. This is bone-earth, which we are at our wits' end to get for our grain and pulse; which we are importing, as expen- sive, from America and Australia. Only find enough of them, and you will increase immensely the food supply of England, and perhaps make her independant of foreign phosphates in case of war,"

The English farmer is by no means the stupid personage which townsfolk are too apt to fancy him. This bed of phosphates was found everywhere in the Greensand, un- til the farmers found that it could be worked from Dorsetshire through England to Cambridge, and thence, I believe, into Yorkshire. It may be traced again, I believe, all round the Weald of Kent and Sussex, and any farmer there to be peculiarly rich—and so to Eastbourne and Beachey Head; and it furnishes, in Cambridgeshire, the greater part of those so-called "coprolites," which are used perpctually now for manure, being ground up, and then treated with sulphuric acid, for the sake of becoming a "soluble superphosphate of lime."

Thus, then, from the shallow sea of these Calcareous rocks, to the rich lands of the chalk, we have a chain of geological facts, which may be called to explain the history of the vegetation and animals, which, to-day, we find in the chalk, the new red sandstone, and the lias.
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I should say, is as much as we can allow for their yearly deposit; and the chalk is at least a thousand feet thick. It may have taken, therefore, twelve thousand years to form the chalk alone. A rough guess of the thickness of the same strata at the same distance northwards, lies between two or three times too little, as two or three times too big. Such, or somewhat, such is the fact. It had long been suspected, and more than suspected; and the latest work of Dr. Carpenter and Dr. Wyville Thompson have surely placed it beyond doubt.

Thus surely, if we call the ooitite beds one new world above the New Red sandstone, we must call the chalk a second new world, as when we write.

I will not trouble the reader here with the reasons why geologists connect the chalk with the greensands below it, by regular gradations, in spite of the enormous downward leap, from sea-shore to deep ocean, which the beds seem (but only seem) to have taken. The change—like all changes in geology—was probably gradual. Not by spasmodic leaps and starts, but by slow and steady peeling, as beds of God of order, of patience, and of strength, have these great deeds been done.

But we have not yet done with new worlds or new prodigies on our way to London, as any Londoner may ascertain for himself, if he will run out a few miles by rail, and look in any cutting or pit, where the surface of the chalk and the beds which lie on it are exposed.

On the chalk, especially in the Blackheath and Woolwich district—sands and clays. And what do they tell us?

Of another new world, in which the chalk has been lifted up again, to form gradually, doubtless, and at different points in succession, the shore of the sea.

But what proof is there of this?

The surface of the chalk is not flat and smooth, as it must have been when at the bottom of the sea. It is eaten out into holes and furrows, plainly by the gnawing of the waves; and on it lie, in many places, large rolled joints out of chalk which has been destroyed, beds of shoreline, beds of oysters lying as they grew, freeway cliffs, ditches, where they lived, beds of lignite (fossil wood half turned to coal), and (as in Katesgrove pits at Reading) leaves of trees. Proof enough, one would say, that the chalk had been raised till part of it at least became dry land, and carried vegetation.

And yet we have not done. There is another world to tell of yet.

For these beds (known as the Woolwich and Vending beds) dip under the chalk of London, clay, four hundred and more feet thick, which (as I said in my last chapter) was certainly laid down by the estuary of some great tropic river, among palm-trees and anonas, crocodiles and turtles, sea.

Is the reader's power of belief exhausted?

If not: there are to be seen capping almost every high land round London, the remains of a fifth world. Some of my readers may be taken to Aldershot camp, and may recollect the table-land of the sandy moors, perfectly flat atop, dreary enough to those to whom they are not (as they have long been to me). The beds of the sand are several hundred feet thick. They lie on the London clay. And they represent—the reader must take geologists' word for it—a series of beds in some places thousands of feet thick, in the Isle of Wight, in the Paris basin, in the volcanic country of the Auvergne, in Switzerland, in Italy; a period during which the land must at first have swarmed with forms of tropic life, and then grown—but very gradually—more temperate, and then cold: the last of these beds, which is the age of ice, which spread the boulder pellies over all rocks and soils indiscriminately, from the Lake mountains to within a few miles of London.

For every foot above those Ascot moors the top of the sands has been ploughed by shore-ice in winter, as they lay a-wash in the shallow sea; and over them, in many places, is spread a thin sheet of ice gravel, more or less than it is for us to think, than the boulder and the boulder-clay.

If any of my readers asks how long the period was during which those sands of Ascot Heath and Aldershot have been laid down, I cannot tell you; we can tell it was long enough to see such changes in land and sea, that maps representing Europe during the greater part of that period (as far as we can guess at it) look no more like Europe or America than the South Sea Islands. And this is only one tel esel data, that that period was long enough for the Swiss Alps to be lifted up to at least thousand feet of their present height. And that they find what work which—though God could, if he wills it—nothing can do single-handedly—

— we have proof positive was not done in less than ages, beside which the mortal life of man is as the life of the gnat which dances in the sun.

And all this and more—as may be proved from the geology of foreign countries—happened between the date of the boulder-clay, and that of the New Red sandstone on which it rests.

IV.

THE COAL IN THE FIRE.

My dear town-dwelling readers, let me tell you now something of a geological product well known, happily, to all dwellers in towns, and of late years, thanks to railroad extension, to most dwellers in country districts: I mean coal.

Coal, as of course you know, is composed of the remains of plants and stems—a startling statement, and one which I do not wish you to take entirely on trust. I shall therefore spend a few moments with you how this fact— for fact it is—was discovered. It is a very good example of reasoning from the known to the unknown. You will have a right to say at first starting, "Coal is utterly different from leaves and stems." The only property which they seem to have in common is that they can both burn." True. But difference of mere look may be only owing to a transformation or series of transformations. There may be plenty of leaves and stems, that greater. What can be more different in look, for instance, than a green field of wheat and a basket of loaves at the baker's? And yet there is, I trust, no doubt that leaves have been once green wheat, and that the green wheat has been transformed into bread—making due allowance, of course, for the bone-dust, or gypsum, or alum with which the worthy man is generally adulterated his bread, in order to improve the digestion of Her Majesty's subjects.

But you may say, "Yes, but we can see the wheat growing, flowering, ripening, reaped, ground, kneaded, baked. We
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I say, showing every conceivable shade of resemblance or difference, till you often cannot say to what type a given individual belongs; and all of them, however different from one another, more like each other than they are like any other creature upon earth; then you are justified in saying, "All these are mere varieties of one kind."

That seems to me sound reasoning, and advanced natural science is corroborating it more and more daily.

I come then to the reasoning to coal. You may find about the world—you may see in England alone—every gradation between coal and growing forest. You may see the forest growing in its bed of vegetable matter that is dead and converted into peat, with stems and roots in it; that, again, is seen to be below high-water mark on many coasts of this island. You find gradations between them and among them. There is coal; then gradations between lignite and common or bituminous coal; and then gradations between common coal and culm, or anthracite, such as is found in South Wales, Hanover, Coburg, and the east of France, and where all but the varieties of the same kind of thing—namely, vegetable matter? They have a common origin—namely, woody fibre. And, coal, or rather culm, is the last link in the series of transformations from growing vegetation?

This is our first theory. Let us try to verify it, as scientific men are in the habit of doing, by saying, If that be true, then something will be true of coal.

If coal has all been vegetable soil, then it is likely that some of it has not been quite converted into shapeless coal. It is likely that there will be vegetable fibre still to be seen here and there; perhaps leaves, perhaps even stems of trees, as in a peat bog. Let us look for them.

You will not need to look far. The coal, and the sands and shales which accompany it, have yielded to geologists, in many principal countries, well known as Adolphe Brongniart as early as 1849, and that number has largely increased since.

My next point is specially noticeable about these plants of the coal; namely, that they at least have grown in swamps.

First, you will be interested, if you study the coal flora, with the abundance, beauty, and variety of the ferns. Now ferns in these islands grow principally in rocky woods, because there, beside the moisture, they get from decaying vegetable or decaying rock, especially limestone, the carbon-dioxide, or the carbonic acid, which they do not get on our dry pastures, and still less in our cultivated fields. But in these islands there are two noble species, at least, which are true swamp-ferns; the lasthenia thalictroides, which is a native of the ferns, but is now all but extinct; and the osmunda, or king-fern, which, as all know, will grow wherever it is damp enough about the roots. In Hampshire, in Dorset, and on the Downs in the south-west of Ireland, the king-fern too is a true swamp fern. But in the tropics I have seen more than once noble tree-ferns growing in wet savannahs at the sea-level, as freely as in the mountain-woods; ferns with such a stem as some of the coal ferns had, some fifteen feet in height, under which, as one rode on horseback, one saw the blazing blue sky, as through a parados of delicate lace, as men might have long ages since have seen it, through the plume of the old tree-ferns, which, if there had been only a man then created to enjoy its beauty.

Next we find plants called by geologists calamites. There is no doubt now that these are the club-ferns, or club-mosses, or horse-tails, a race which has, over most parts of the globe, dwindled down now from twenty or thirty feet in height, as they were in the old coal measures, to about five or six feet in the modern coal fields in England—the beautiful E. telmatica—is seldom five feet high. But they, too, are mostly mud and swamp plants; and so may the calamites have been.

And it is without doubt the splendid old representatives of a family now dwindled down to such creeping things as our club-mosses, or lycopodiums. Now it is a certain fact, which can be proved by the microscope, that a very great part of the best coal is actually made up of millions of the minute seeds of club-mosses, such as grow—a few of them, and those very small—on our moors; a proof not only of the vast quantities of club-mosses during the coal-generating age, but also of the vast time during which it lasted. The lepidodendra may have been fifty or sixty feet high. There is not a lycopodium in the world now, I believe, five feet high. But the club-mosses are now, in these islands and elsewhere, lovers of wet and peaty soils, and so may their huger prototypes have been in the old forests of the coal.

Of true trees there of course may say as much, with certainty, for botanists are not agreed as to what low order of flowerless plants they belong. But that they rooted in clay beds there is proof, as you will hear presently.

And as to the conifers, or pine-like trees—the daadoxylon, of which the pith goes by the name of sternbergia, and the uncertain tree which furnishes in some coal-gentleman's gardens—both of which are true descendants of that of the yew—we may suppose that they would find no more difficulty in growing in swamps than the cypress, which forms so large a portion of the vegetation of the swamps of the Southern United States.

I have given you these hints, because you will naturally wish to know what sort of a world it was in which all these strange plants grew and turned into coal.

My answer is, that it was most probably just like the world in which we are living now, with the one exception that the plants and animals are different.

It was the fashion a few years since, to suppose that the coal was formed as a result of geology—by some mere hypothesis of a state of things quite unlike what we see now. We were brought up to believe that in the carboniferous, or coal-bearing era, there lived millions of people, one might say, by the fires of a world that was ever hot, and overcharged with carbonic acid, which had been poured out from the interior of the planet by volcanic eruptions, or by some other convulsion. I forget the name of it now; and, really, there is no need to remember; for it is all, I very believe, a dream—an attempt to explain the unknown, not by the known, but by the still more unknown. You may find such theories lingering still in sensational school-books, if you like to be unoscientific. If you like, on the other hand, to be scientific, you will listen to those who tell you that instead of there having been one unique carboniferous epoch, with a peculiar coal-making climate, all epochs are carboniferous; that coal is formed at all times; and that it comes of every age, from that of the Scotch and English beds, up to the present day. The great coal-beds along the Rocky Mountains, for instance, are terrace growths; and yet, I think, I am forming now, I doubt not, in many places on the earth, and would form in many more, if man did not interfere with the processes of wild nature by draining the swamps and cutting the forests.

Let me by a few words prove this statement. They will give you, beside, a fresh proof of Sir Charles Lyell's great geological rule—that the best way to explain what is is to inquire what happened in the past.

When it was first seen that coal had been once vegetable, the question arose, How did all this vegetable matter get there? The Yorkshire and Derbyshire coal-fields, I hear, cover seven hundred or eight hundred square miles; the Lancashire about two hundred. How large a part of the English and Scottish coal-fields may be, I cannot say. But doubtless a great deal more than you will be got at lies under the sea, especially in the north of Wales. Coal probably exists over vast sheets of England and France, buried so deeply under limestones, or even under rocks, that it cannot be reached by mining. As an instance, a distinguished geologist has long held that there are beds of coal under London itself, which, rising, owing to a natural process, in the solid earth, become a thousand or twelve hundred feet of the surface, and that we or our children may yet see coal-mines in the marshes of the Thames. And more, it is a provable fact that only a portion of the coal-measures is left. A great part of Ireland must once have been covered with coal, which is now destroyed. Indeed, it is likely that the coal now known of in Europe and America, and which has been worked, has existed there in former ages, and has been eaten away by the inroads of the sea.

Now whence did all that enormous mass of vegetable soil come? Of some neighboring land, was the first and most natural supposition. But we may proceed from the known to the unknown. It was clear that these plants had grown on land, for they were land plants. It was clear that there must have been land close by, for between the beds of coal, as you all know, the rock is principally coarse sandstone, which could only have been laid down (as I have explained to you already) in very shallow water.

I am not now to suppose, that these plants and trees had been swept down by rivers into the sea, as the sands and muds which buried them had been. And it was known that at the mouths of certain rivers, on the beds of the sea, there are great heaps of driftwood and rush, etc., which had grounded, and stuck in the mud; and why shouldn't the coal have been formed in the same way?

Because—and this was a serious objection—then surely the coal would be impure—mixed up with mud and sand, till it was not worth burning. Instead of this, the coal is usually pure vegetable, parted sharply from the sandstone which lies on
It. 'The only other explanation was, that the coal vegetation had grown in the very places where it was found. But that seemed too strange to be true, till that great geologist, Sir W. Logan—who has since done good work in Canada—showed that the very bed of coal had a bed of clay under it, and that that clay always contained fossils called stigmarians. Then it came out that the stigmarians in the under clay had long before been changed, while they were found in the sandstones or shales, had lost their filaments, and seemed more or less rolled—in fact, that the natural place of the stigmarians was in the under clay. Then Mr. Bunby discovered that the entire thickness of the coal was mingled with the soil of the marias. Such aquatic plants as came to separate spores and seeds, would get into the bituminous coal, which would have mingled with the soil of the maria, and thus the characteristic stigmarians were kept intact in the coal-measures, with its roots attached. Those roots penetrated into the under clay of the coal; and those roots were stigmarians. That seems to have settled the question. The sigillarias, at least, had grown where they were found, and the clay beneath the coal-beds was the original soil on which they had grown. Just so, if you will look at any peat-bog, you will find that the peat is made up of leaves and twigs, the under bottom everywhere by the roots of the moss forming the peat, or of the trees, birches, alders, poplars, and willows, which grow in the bog. So the proof seems conclusive. It seems that the coal has been formed out of vegetation growing where it was buried. If any further proof for that theory was needed, it would be found in the fact, most ingeniously suggested by Mr. Boswell—namely, that the very organic matter of which the coal was formed was composed of the vegetable decomposition of the stigmarians, and therefore the bituminous coal must have been formed, not under water, but on dry land.

I have dwelt at length on these further arguments, because they seem to me as pretty a specimen as I can give my readers of that regular and gradual induction, that common-sense regulated, by which geological theories are worked out.

But how does this theory explain the peculiar character of coal? Sir C. Lyell answers that question fully in p. 383 of his 'Student's Elements of Geology.' He tells us that the dense growths of reeds and herbage which encompass the margins of forest-covered swamps in the valley and delta of the Mississippi, in passing through them, are filtered and made to clear entirely before they reach the areas in which vegetable matter may accumulate for centuries. For about one cypress, two or more large reeds are eaten down through pure peat till the water-bearing clay below is reached. But the purity of the water in peaty lagoons is observable elsewhere than in the delta of the Mississippi, for example, in the coast of Ireland, where you dare not stoop to pick, lest the peat, bending inward, slide you down into that clear, dark gulf some twenty feet in depth, bottomed and walled with yielding ooze, from which there is no escape? Most transparent, likewise, is the water of the Western Indian swamps. Though it is of the color of dirty beer, with its very dirty beer, and so impregnated with gases that it induces fever or cholera when drunk, yet it is—at least when it does not mingle with the salt water—so clear, that one might be the richer for seeing the inside of a boa-constrictor or alligator if he8 glide along the bottom under the canoe.

But now comes the question. Even if all this be true, how were the forests covered up in shale and sandstone one after another? For the spoiling of the land, one would suppose.

If we find, as we may find in a hundred coal-pits, trees rooted as they grew, with their trunks either standing up through the coal, and through the sandstones above the coal; their bark often remaining as coal while their inside is filled up with sandstone, has not our common-sense a right to say, 'The land on which they grew was covered up by the water, which killed; and the mud and sand which were brought down the streams enveloped their trunks'? As for the inside being full of sandstone, have we not all seen hollow tree stumps, with the wood in the bottom—now, know that when a tree dies its wood decays first, its bark last? It is, so especially in the tropics. There one may see huge dead trees with their bark seemingly sound, and their inside full of sandstone.

There one may find inside only a pair of trousers, or parrots, or a whole party of jolly little monkeys, one of which, quite likely, you would find a canoe made of four or five feet long, whose bote would have very certainly prevented me having the pleasure of writing this book.

Now is it not plain that if such trees as that sunk, their bark would be turned into lignite, and at last into coal, while their insides would be silted up with mud and sand? Thence a core or pillar of hard sandstone would be formed, which might do for a millstone. I believe they are long enough to say that they are too apt to do now in the Newcastle and Bristol collieries. For there, when the coal is worked out below, the sandstone stumps—"coal-pipes" as the colliers call them—in the roof of the seam, having no branches, and nothing to hold them up but their friable bark of coal, are but too apt to drop out suddenly, killing or wounding the hapless men below.

Or if, as we often find—as was found at Parkfield Colliery, near Wolverhampton, in the year 1844—a quarter of an acre of coal-seam filled with stumps of trees as they grew, their trunks joined by roots in the bottom of the coal, turned into coal, and flattened, as coal-fossils so often are, by the weight of the rock above—should we not have a right to say, These trees were snapped off where they grew by some convulsive convulsion as being buried in sudden insurce of water owing to a sudden sinking of the land, or by the very earthquake shock itself which sank the land?

But what evidence have we of such sinkings? The plain fact that you have coal-seam above coal-seam, each with its bed of under-clay; and that therefore the land must have sunk ere the next bed of soil could have been deposited, and the next forest have grown in it.

In one of the Rocky Mountain coal-fields there are more than thirty separate coal, each with its under-clay below it. What can that mean but thirty or more sub-sides of the land, and the peat of thirty or more forests or peat-mosses, one above the other? And what did it matter if you do not bring your own evidence? What is this quite new element which you have brought into your argument? You told us that you would reason from the known to the unknown. What do we need it for? We would like to explain the thing which had gone on one by that which is going on now. Where is subsidence going on now upon the surface of our planet? And where, too, upheaval, which would raise a huge mountain. I would rise up again from under the sea-level, and make them, like our British coal-field, dry land one more?

The answer is, Subsidence and elevation of the land are common now, probably just as common as they were in any age of this planet's history.

To give two instances, made now notorious by the writings of geologists. As you know, the United States, from the Connecticut river to the Mississippi, is but a short distance from the sea. No one will doubt the truth of a narrative, given in the repository of science by Mr. Cutch, at the mouth of the Indus, sunk a truet of land larger than the Lake of Geneva in some places to a depth of eighteen feet, and converted it into an inland lake. The water stood about the same level as the sea; and the water, after it was drained off, a corresponding sheet of land some fifty miles in length, and in some parts sixteen miles broad, ten feet above the level of the alluvial plain, and left it to be occupied by the land by the waters of the Indus. Every one in the world will be shocked at the sight of it, to a community, to a whole nation, to a tribe, to a family. How do you call it, God of the British Isles; or of the British Empire? God of the British Empire, I would rather say. But I do not do better than advise my readers, if they wish to know more of the way in which coal was formed, to read what is said in that book concerning the Delta of the Mississippi, and its strata of forests sunk where they grew, and in some places raised again, alternating with beds of clay and sand, vegetable soil, recent sea-shells, and what not, forming, to a depth of several hundred feet, one of the great coal regions that exists in our own coal-fields at this day.

If, therefore, the reader wishes to picture to himself the scenery of what is now central England, during the period when the coal was produced, he need not go farther afield than the country round him. As I believe, to transport himself in fancy to any great alluvial delta, in a moist and warm climate, favorable to the growth of vegetation. He has only to conceive a wood-clad hill, at the mouth of some great rivers, slowly sinking beneath the sea; the forests in them killed by the water, and then covered up by layers of sand, brought down from inland, till that new layer became dry land, to carry a fresh crop of vegetation. He has thus all that he needs.
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To explain how coal-measures were formed. I myself saw once a scene of that kind, which I thought well worth recording. There was, as I conceived, coal, making or getting ready to be made, before my eyes; a sheet of swamp, sinking slowly into the sea; for there stood trees still rooted below low-water-mark, and still bore, while the water rose, huge trees stood dy- ing, or dead, from the water at their roots. But what a scene—a labyrinth of narrow creeks, so narrow that a canoe could not pass up, haunted with alligators, crocodiles, crocodile, and other leers, amid an inextricable confusion of vegetable mud, roots of the elder-like man-groves, and tangled creepers hanging from tree to tree; and overhead huge fan-leafs, drooping down through the sedge-leaved rush, still huge broad-leaved trees in every stage of decay. The drowned vegetable soil of ages beneath me; above my head, for a hundred feet, a mass of stems and branches, and leaves and flowers, compared with which the richest hot-house in England was poor and small. But if the sinking process which was going on continued a few hundred years, all that huge mass of vegetable débris would settle and sink beneath the swamp, and covered up in mud washed down from the mountains, and sand driven in from the sea; to form a bed many feet thick, of what would be first peat, and then coal. And the higher the coal, with the stems of killed trees standing up out of it into the new mud and sand-beds above it, just as the saggital and other stems stand up in the coal-beds both of England and Nova Scotia; and over it a forest would grow up, to suffer the same fate—if the sinking process went on—as that which had preceded it.

That was a sight not easily to be forgotten. But we need not have gone so far from home, at least, a few hundred years ago, to see an exactly similar one. The fans of Norfolk and Cambridgeshire, before the rivers were embanked, the water pumped off, the forests felled yet the trees bleached up, were exactly in the same state. The vast deposits of peat between Cambridge and the sea, often filled with timber trees, either fallen or upright as the timber fell, or standing in the sand or mud, brought down in floods, were formed in exactly the same way; and if they had remained undrained, then that slow sinking, which geologists say is going on in the whole area of the fens, would have brought them gradually, but surely, below the sea-level, to be covered up by new forests, and converted in due time into coal. And future geologists would have found, if there were no pines, as is now forbib, England should become barbarous and the trees be thrown out of cultivation—instead of fossil lepido dendron and sili
caria, calamites and feras, fossil ashes and oaks, alders and poplars, bulrushes and reeds. Almost the only fossil fern would have been that tall and beautiful Eastrean thelypteris, once so abundant, now all but destroyed by drainage and the plough.

We need not, therefore, fancy any extraordinary event, or even the process by which our English coal was being formed. The climate of the northern hemisphere—Britain at least, and Nova Scotia—was warmer than now, to judge from the abun
dance of trees, and the wood of which it was formed. But not so hot, to judge from the presence of conifers (trees of the pine tribe), as the tropics. Moreover, there must have been, it seems to me, a great scarcity of animal life. Insects are found, beautifully preserved, in coal from Nova Scotia; but shells: but very few. And where are the traces of such a swarming life as would be entombed were a tropic forest now sunk; which is found entombed in many parts of the English fens? The only explanation which I can offer is this—that the club
mosses, tree-frens, pias, and other low
ranked vegetation of the coal afforded lit
tle or no food for animals, as the same minute life which makes up a spider's web or a snail's house should be able to multiply and replenish the earth. But, be that as it may, the fact that coal is buried forest is not affected.

Meanwhile, the shape and arrangement of its formation is sufficiently different from what they are now. Where was that great land, off which great rivers ran to deposit our coal-measures in their deltas? It has been supposed, for good reasons, that North-western France, Belgi
um, Holland, and Germany were then un
der the sea; that Denmark and Norway were joined to Scotland by a continent, a tongue of which ran across the centre of Scotland, and seemed to be the connecting link between northern and southern coal-fields. But how far to the west and north did that old continent stretch? Did it, as it almost certainly did long ages afterward, join Greenland, that it may have been in the land and Norway? Were the northern fields of Nova Scotia, which are of the same geological age as our own, and containing the same plants, laid down by rivers which ran off the same continent at
ours? Who can tell now? That old land, and all record of it, save what these fragmentary coal-measures can give, are buried in the dark abyss of countless ages; and we can only look back with awe, and comfort ourselves with the thought. Let Time be ever so vast, yet Time is not Eternity.

One word more. If my readers have granted that all for which I have argued is true, then I still have a right to ask for further proof.

They will be justified in saying, "You say that coal is transformed vegetable matter; but can you show us how the transforma
tion is brought about?" The answer to that, according to my knowledge, is

The chemist must answer that. And he tells us that wood can become lignite, or wood-coal, by parting with its oxygen, in the shape of carbonic acid; or choke
damp; and then common, or bituminous coal, by parting with its hydrogen, chiefly in the form of carburetted hydrogen—the gas with which we light our streets. That is what we know; but we need not know. But it is a fresh corrobora
tion of the theory that coal has been once vegetable fibre, for it shows how vegetable fibre can, by the laws of nature, become coal. And it certainly helps us to believe that a thing has been done, if we are shown that it can be done.

This fact explains, also, why in mines of wood-coal carbic acid, i.e. choke
damp, alone is given off, as there is least of the hydrogen still remains. In mines of true coal, not only is choke
damp given off, but that more terrible pest of the miners, fire-damp, or explosive car
buretted hydrogen and olefiant gas. But if the hydrogen in these mines proves that changes are still going on in the coal; that it is getting rid of its hydrogen, and so progressing toward the state of anthracite or culm—stone-coal, as it is sometimes called. In the Pennsyl
vania coal-field, which has actually done this, under the disturbing power of earthquakes; for the coal, which is bitu
minous, like our common coal, to the west
ward where the strata are horizontal, be
comes, when the earth is agitated as it is tossed and torn by the earthquakes of the Alleghany and Appalachian mountains.

And is there further transformation possible? Yes; and more than one. If we consider the anthracite cleared of all but its last atom of oxygen, hydrogen and nitrogen, till it has become all but pure carbon, it would become—as it has become in certain rocks of immense antiquity, gra
phite—what we miscall blacklead. And, after that, it might go through a transfor
mation more, and that the most start
ling of all. It would need only perfect purification and crystallization to become—a diamond; nothing less. We may con
 sider the coal upon the fire as the middle term of a series, of which the first is live wood, and the last diamond; and indulge safely in the fancy that every diamond in the world has probably, at some remote epoch, been turned into coal.

A strange transformation; which will look to us more strange, more truly poeti
cal, the more steadily we consider it.

The coal on the fire; the table at which I write; the sunbeams; with a small percentage of ash, or earthy salts, which need hardly be taken into account.

Gas and sunbeams. Strange, but true.

The life of the vegetable; and what that life is who can tell?—laid hold of the gases in the air and in the soil; of the car
bonic acid, the atmospheric air, the water, for that too is gas. It drank them in, and vapourized them into itself—through the magic process of vegetation, and what in its own true light, and in its own true colours, and in its own true conceptions—what is, Lord Lytton told us long ago, in a beautiful song, how

"The Wind and the Beam loved the Rose."  

But Nature's poetry was more beautiful than man's. The wind and the beam love the rose so well that they made the rose—or rather, the rose took the wind and the beam, and built up out of them, by her own inner life, her exquisite texture, hue, and fragrance.

What next? The rose dies; the timber tree dies, decays down into vegetable fibre, is burned, and turned to coal: but the plant cannot altogether undo its own work. Even in death and decay it cannot escape, for the sunbeams imprisoned in its tissue. The sun-force must stay, shut up age after age, invisible, but strong; working at its own prison-cells; transmitting them, or making them capable of being trans
mitted to and through the transfor
mation of coal—coke, petroleum, mineral pitch, gases, coal-tar, benzole, delicate aniline dyes, and what not, till its day of deliver
ance comes.
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Man digs it, throws it on the fire, a black, dead-seeming lump. A corner, an atom of it, warms till it reaches the igniting point; the temperature at which it is able to combine with oxygen.

For life is merely the same thing, awaking after ages to the sense of its own powers, its own needs, the whole lump is seized, atom after atom, with an infectious hunger for that oxygen which it lost centuries before in the bottom of the earth. It drinks the oxygen in at every pore; and burns.

And so the spell of ages is broken. The sun-forces burst its prison-cells, and blazes into the free atmosphere, a light and heat once more; returning in a moment into the same forms in which it entered the growing leaf a thousand centuries since.

Strange it all is, yet true. But of nature, as of the heart of man, the old saying stands—truth is stranger than fiction.

V.

THE LIME IN THE MORTAR.

I SHALL presume in all my readers some slight knowledge of the composition of lime. Let me then, for granted, for instance, that all are better informed than a certain party of Australian black fellows were a few years since.

They were prowling on the track of a party of English settlers, to see what they could pick up, they came—oh, joy!—on a sack of flour, dropped and left behind in the bush at a certain creek. The poor savages had not had such a prospect of a good meal for many a day. With endless jabbering and dancing, the whole tribe gathered round the precious flour-bag with all the pannikins, gourds and other hollow articles they possessed. But they had no water with a due quantity of water from the creek therein, and the chief began dealing out the flour by handfuls, beginning of course with the boldest warriors. But, horror of horrors, each man's porridge swelled before his eyes, grew hot, smoked, boiled over. They turned and fled, man, woman, and child, from before that supernatural prodigy; and the settlers coming back to look for the dropped sack, saw a sight they never thought see; a whole tribe of poor creatures, in their terror, had thrown away their pans and calabashes, each filled with that which it was likely to contain, seeing that the sack itself had contained, not flour, but quick-lime. In memory of which comi-tragedy, that creek is called to this day, "Flour-bag Creek!"

Now I take for granted that you are all more learned than these black fellows, and know quick-lime thoroughly, as well as all other lime. But still you are not bound to know what quick-lime is. Let me explain it to you.

Lime, properly speaking, is a metal, which goes among chemists by the name of calcium hydroxide, as lime-carbonate, for instance; but you know, in the earth, not as a metal, but as a stone, as chalk or limestone, which is a carbonate of lime; that is, calcium combined with oxygen and carbonic acid gas.

In that state it will make, if it is crystal-line and hard, excellent building stone. The finest white marble, like that of Carrara in Italy, of which the most delicate statues are carved, is carbonate of lime, although it is not the purest. But to make mortar of it, it must be softened and then brought into a state in which it can be hardened again; and ages since, some man or other, who desires to rank of one as the great inventors, one of the great benefactors of his race, discovered the art of making lime soft and hard again; in fact, of making mortar. The discovery was probably very ancient, and made, probably like most of the old discoveries, in a spirit of experiment and guesswork, gradually. The earlier Greek buildings are cyclopean, that is, of stone fitted together without mortar. The earlier Egyptian buildings, though the stones are exceptionally massive and unyielding, are all put together likewise without mortar.

So, long ages after, were the earlier Roman buildings, and even some of the later. The famous aqueduct of the Pont du Gard, near Lyons, in the province of France, has, if I recollect right, no mortar to join in a single ligament. The stones of its noble double tier of circular arches have been dropped into their places upon the wooden centres, and stand undisturbed to this day, simply by the jamming of their own weight, a miracle of art. But the fact is puzzling; for these Romans were the best mortar-makers of the world. We cannot, I believe, surmise them in the art even now; and in some of the Greco-Roman colonies, I believe, that is as true of this day harder and tougher than the stones which it holds together. And they had plenty of lime at hand if they had chosen to make mortar. The Pont du Gard is not a mile from the three beds of limestone. But I presume the cunning Romans would not trust mortar made from that coarse Nunnulite limestone, filled with gritty sand, and preferred, with their usual carelessness, lime from the very soft and crumbling limestone in the earth. For, as a general rule, the more ancient the strata is in which the limestone is found, the harder the limestone is; except in cases where volcanic action and earthquake pressure has hardened limestone in more recent strata, as in the case of the white marbles of Carrara in Italy, which are of the age of our oolites, that is, of the freestone of Bath, etc., hardens by the heat of intruded volcanic rocks.

But now: what is the limestone? and how did it get where it is—not into the mortar, I mean, but into the limestone quarry? You must, rather, help me to tell yourselves by leaving almost, as before, from the known to the unknown.

Let me lead you to places unknown indeed to most; but there may be sailors or sollic
citors, who know them far better than I do. Let me lead you, in fancy, to some island in the tropic seas. After all, I am not leading you as far away as you fancy by several thousand miles, as you will see, I trust, ere I have done.

Let me take you to some island:—what shall it be like? Shall it be a high island, with cliff piled on cliff, and peak on peak, all rich with mighty forests, like a furrow mantle of green velvet, mounting up and up till it is lost among white clouds above? Or shall it be a mere low reef, which you do not see till you are close upon it; on which nothing rises above the water, but here and there a knot of cocoa-nut palms or coconut trees, which throw out their leaves in unnumbered sea-fowl and their eggs? Let it be which you will: both are strange enough; both beautiful; but both will tell us a story.

The ship will have to lie-to, and anchor if she can; it may be a mile, it may be only a few yards, from the land. For between it and the land will be a line of breakers, ragging in before the warm trade-winds, which the whaler will tell, marks the edge of the coral reef.

You will have to go ashore in a boat, over a sea which looks unfathomable, and which may be a mile or more in depth, and to feel your foot, on the very reef, which the boat can pass without being knocked to pieces.

You find one: and in a moment, what a change! The deep has suddenly become the shallow. The coral, instead of being the white coral at the bottom. But the coral is not all white, only indeed a little of it; for as you look down through the clear water, you find that the coral is all covered with innumerable little gray, green, yellow, conceivably hue: and that these are the coral polytops, each with its ring of arms thrust out of its cell, who are building up their common habitations of lime. If you want to understand, by a rough but incorrect description, what coral
polype is: all who have been to the seas-
side know, or at least have heard of, sea-
anemones. Now coral polypes are sea-an-
emones, which make each a sickle shape, a
great many of them together. As for their
shapes, the variety of them, the beauty of
them, no tongue can describe them. If
you want to see them, go to the Coral
Rooms of the British or the Basel Mues-
seums, and look at yourselves. Only re-
member that you must re-cloth each of
those exquisite forms with a coating of
five-jelly of some delicate hue, and put
back into every one of the thousand cel-
lites, and you will have their habits in
your rooms. Then, if you have in your
rather, banks of the salt-water flower gar-
den, the gaudiest of shell-less sea-an-
emones, such as we have on our coasts,
rooted in the crevices, and live shells and
seashells, and every kind of sea-wrack,
which fills up the inter-
stices in the coral beds.

The bottom, just outside the reef, is cov-
ered with that mud, mixed with more lime-
mud, which the surge wears off the reef
upland, as they, when they have a dredge on
board, and try a haul of that mud as you row home, you may find, but
not always, animal forms rooted in it,
which will delight the soul of a scientific
man. I have seen in the mud a sort of teratome, or shell akin to it. You
would probably think it a cockle; but
you would be wrong. The animal which
dwells in it has about the same relationship
to a cockle as a dog has to a bird. It is a
brachiopeal; a family with which the an-
cient seas once swarmed, but which is rare
now, all over the world, having been sup-
planted and driven out of the seas by
newer and stronger forms of shellled ani-
mals, which now possess the seas, which
likely to dredge a live brachiopod will be
in the deep water of Loch Fyne, in Argyle-
shire, where two species still linger, fast-
cened, strangely enough, to the smooth
pebbles of the beaches, which are often
in the open air during the age of ice, but
sink now to a depth of eighty fathoms.
The first time I saw those shells come up in
the dredge out of the dark and motionless
abyss, I could sympathize with those feel-
ings of mingled delight and awe which, so
my companion told me, the great Professor
Owen had in the same spot first beheld the
same lingering remains of a primæval
world.

The other might be (but I cannot prom-
ise you even a chance of dredging that,
unless you were off the coast of Portugal,
or the windward side of some of the West
India Islands) a live crinoid, an eye-like
starfish, with long and branching arms,
but rooted in the mud by a long stalk, and
that stalk throwing out barren side
branches; the whole a living plant of
strange beauty. You may see in museums spec-
imens of this family, which are now about
extinct. And yet fifty or a hundred differ-
ent forms of the same type swarmel in the
ancient seas; whole masses of limestone
are made up of little else but the frag-
ments of such animals.

But we have not landed yet on the dry
part of the reef. Let us make for it, tak-
ing care meanwhile that we do not get our
feet cut by the coral, or stung as by netties
by the coral insects. We shall see that the
ground and broken by the waves, and
hurled inland by the storm, sometimes in
huge boulders, mostly as fine mud; and
that, under the influence of the sun and of
the air, is converted into a crumbl
chaine, the harder parts of the coral, with lime from the rotting coral, the whole
is setting, as cement sets, into rock. And
what is this? A long bank of stone stand-
ing up as a low cliff, ten or twelve feet
high, which you have to cross. It is full of frag-
ments of shell, of fragmented coral, of all
different kinds of animal remains and the lower
part of it is quite hard rock. Moreover, it is
bedded in regular layers, just such as
you see in a quarry. But how did it get there?
your companions, if you have any who know
the island, have no difficulty in telling
you. It was hove up, they say, in the
earthquake in such and such a year; and
they will tell you, perhaps, that if you will
go within a hundred fathoms of the edge
inside the reef, you may see dead coral
beds just like these lying on the old rocks,
and sloping up along the flanks of the mountains to several hundred feet above
the present sea-level, in layers and time
of ages.

Thus you find the coral being converted
gradually into a limestone rock, either fine
and homogeneous, composed of coral
grown into pulp, or filled with corals and
shells, or with angular fragments of older
rocks. But where is it now? No? Yes, you have a hundred times.
You have but to look at the marbles com-
monly used about these islands, with angu-
lar fragments imbedded in the mass, and
here and there a shell, the whole cemented
together by water holding in solution car-
bonate of lime, and there see the very
same phenomenon perpetuated to this
day.

But, I think, we have got first from the
known to the unknown; from a tropic
coral island back here to the limestone
hills of these islands; and I did not speak
at random when I said, that I was not
plete as you fancied be-
some several thousand miles.

Examine any average limestone quarry
from Bristol to Berwick, and you will see
there all that I have been describing; that
is, all of it is not one animal mat-
ter, certain to decay. You will see the
lime-mud hardened into rock beds; you
will see the shells imbedded in it; you
will see the corals in every stage of de-
composing, and you will see millions of
up of innumerable fragments of crinoinds—
no wonder they are innumerable, for, it
has been calculated, there are in a single
animal of some of the species 140,000 joints
and 20,000 bits of lime to fall apart when
its soft parts become food to sea-thieves.
And why should it not have got there
by the same process by which similar old
coral beds get up the mountain sides in the
West Indies and elsewhere; namely, by
some unknown process of upheaval. When
you see similar effects, you have a
right to presume similar causes. If you
see a man fall off a house here, and break his
neck; and some years after, in London
or anywhere else, find another man lying at the foot of another house, with his
neck broken in the same
way, is it not a very fair presumption that
he has fallen off a house likewise?
You may be wrong. He may have come
to his neck by some other means; but
you must have proof of that. You will
have a full right, in science and in common
sense, to say, That man fell off the house,
till some one proves to you that he did
not.

In fact, there is nothing which you see
in the limestones of these isles—save and
except the difference in every shell and
coral—which you would not see in the
coral beds of the West Indies, if such
were formed, yet the sea-bottom, while
they were being formed, was sinking and not
rising. This is a fact which was first
pointed out by Mr. Darwin, from the ob-
ervation of the famous Voyage of the Beagle;
and the observations of subsequent great naturalists have all gone on to corroborate
his theory.

It was supposed at first, you must under-
stand, that the coral reefs arose steeply
to the surface of the sea, cut off by a corona,
perhaps a thousand fathoms or more, that
fact was plain proof that the little coral
polypes had begun at the bottom of the
sea, and, in the course of ages, built up
the whole island an enormous depth.

But it soon came out that theory was
not correct; for the coral polypes
cannot live and build save in shallow water
say in thirty to forty fathoms. Indeed,
some species of corals and insects work best
at the very surface, and in the cut of the
richest surf. And so arose a puzzle as to how coral rock is often found of
thickness, which Mr. Darwin ex-
plicated. He showed that the coral polypes
must be formed, as we see them, in the
depths, and that the bottom of the sea
must be sinking downward into the abyss.

By applying this theory to the coral reef
of the Pacific Ocean, the following inter-
esting facts were made out:

That where you find an island rising out
of deep water, with a ring of coral round it, a little way from the shore—or, as in
Eastern Australia, a coast with a fringing
reef (the Flinders reef of Australia is
eleven thousand miles long)—and that is a
fact that shows, that moun-
tain, is sinking slowly beneath the
sea. That where you find, as you often do in
the Pacific, a mere atoll, or circular reef of
coral, with a shallow pond of smooth
water in the centre, and deep sea round
that is a pretty sure sign that the moun-
tain-top has sunk completely into the sea,
and that the corals are going on building where its peak once was.

And more. On working out the geogra-

phy, it occurs to me that the main idea, on which the system of Mr. Darwin’s, the follow-

ing extraordinary fact has been discov-

ered:

That over a great part of the Pacific Ocean, and the South Sea Islands, the sea, has been going on for ages; and that the greater number of the beautiful and precious South Sea Islands are only the remnants of a vast continent or archipelago, which once stretched over the greater part between Australia and South America.

Now, applying the same theory to lime-
stone beds, which are, as you know, only fossil coral reefs, we have a right to say, when we see in England, Scotland, or the Baltic, beds of limestone of several feet thick, that while they were being laid down as coral reef, the sea-bottom, and probably the neighboring land, must have been sinking to the amount of their thick-

ness—to several thousand feet—before that later sinking which enabled several hun-

red feet of millstone grit to be laid down on the top of the limestone.

This millstone grit is a notable and remark-

able element in our strange story. From Derby to Northumberland it forms vast and lofty moors, capping, as at Whern-

dside and Penygent, the highest limestone hills with its hard, rough, barren, and un-

found landscape. In Northumberland it lies on the top of the “mountain,” or carboniferous limestone. Almost every-

where, where coal is found in England, it lies on the millstone grit. I speak roughly,

for I am not a geologist, in order to make my readers better understand the details.

The three deposits pass one after another, in many places, into each other: but always in the order of mountain limestone below, millstone grit on it, and coal on that again.

Now what does its presence prove? What but this? That after the great coral reefs which spread over Somersetshire and South Wales, around the present estuary of the Severn—and those, once perhaps islands—have been raised and shifted to Berwick, with a western branch through North-east Wales—were laid down—after all this, I say, some change took place in the sea-bottom, and brought down on the reef the silt, which was laid on by the red tide—so that the corals and buried them in grit. Does any reader wish for proof of this? Let him examine the “cherty,” or flinty, beds which so often appear where the bottom of the millstone grit is passing into the top of the mountain limestone—the beds, to give an instance, which are now quarried on the top of the Halkin Mountain in Flintshire, for chert, which is sent to Staffordshire to be ground down for the manufacture of China-stone.

There is a whole town built of several feet in thickness, as hard as flint, but as porous as porridge. On examining their cavities he will find them to be sim-

ply hollow casts of innumerable joints of coral, sinking into the sand. In fact, their most delicate markings, that it is plain they were never washed about upon a beach, but have grown where, or nearly where, they lie. What, then, has happened to them? That they are only the cores of the corals and their limestone covering which has been taken up by the sand.

The soft part of the animals have decayed, letting the 140,000 joints (more or less) belonging to each animal fall into a heap, and be imbedded in the growing sand-rock; and then, it may be long years after, water filtering through the porous sand has removed the line of which the joints were made, and left their perfect casts behind.

So much for the millstone grits. How did the deposition of sand go on, how long after it that second deposition of sands took place, which goes by the name of the “gannister,” or lower coal meas-

ures, we cannot tell. But it is clear that the removal of the silt was no less rapid than the filling up and becoming dry land. For, coal, or fossilized vegetable matter, be-

comes more and more common as we ascend in the series of beds; till at last in some places there exists a stratum of vegetable wealth of vegetation which grew, on top of it, where it is now found, prove the exist-

ence of some such sheets of fertile and forest-clad lowland as I described in my last paper.

The beds of thick, rich coral reef; thousands of feet of barren sands; then thousands of feet of rich alluvial forest— and all these sliding into each other, if not in one place, then in another, without vio-

lent break or change; this is the story which the lime in the mortar and the coal on the fire—between the two—reveal.

VI.

THE SLATES ON THE ROOF.

The slates on the roof should be, when rightly understood, a pleasant subject for contemplation to the dweller in a town. I do not ask him to imitate the boy who, with his youth, used to spend stolen hours on the house-top, with his back against a chimney stalk, transfiguring in his imagination the roof-slopes into mountain-sides, the slates into sheets of ice, and the slate roofs into eagles. I only wish that he should—

at least after reading this paper—let the slates on the roof carry him back in fancy to the mountains whence they came; perhaps to pleasant trips to the lakes and hills of Cumberland, or to the black moorlands of Northumberland, and North Wales; and to recognize—as he will do if he have intellect as well as fancy—how beautiful and how curious an object is a common slate.

Beautiful, not only for the compactness and delicacy of its texture, and for the regu-

larity and smoothness of its surface, but still more for its color. Whether merely warm gray, as when dry, or bright purple, as when wet, it always has that beautiful and well justified Mr. Ruskin’s saying, that wherever there is a brick wall and a slate roof, there need be no want of rich color in an English landscape. But most beau-

tiful is the slate when the sun’s brilliant vort in the sunshine after a summer shower, its blue is brought out in rich contrast by golden spots of circular lichen, whose spores, I presume, have travelled with it off its mountain home. Then, indeed, it is the voyage of a sight which it almost rivals in brilliancy of the sapphire of the deep ocean, brought out into blazing intensity by the contrast of the golden patches of floating gulf-weed beneath the bright sky.

Beautiful, I say, is the slate, and curi-

ous likewise, nay, venerable; a most anci-

ent and elaborate work of God, which has lasted long enough, and endured enough, to show us that the parts of that animal which still exhibits the same powers of shapes, maybe seen there, but which has literally been—as far as such words can apply to a thing inanimate—

has stood and weathered for ages, and yet was at first naught but an ugly lump of soft and shapeless ooze.

Therefore, the slates to me are as a para-

llel, on which I will not enlarge, but will leave each reader to make his own de-

cision. I shall confine myself now to proofs that slate is hardened mud, and to hints as to how it assumed its present form.

That slate may have been once mud, is made evident by the fact that sand and mud can be turned into mud again. If you grind up slate, and then analyze it, you will find its mineral constituents to be ex-

actly those of a fine, rich, and tenacious ooze, which I have assumed to be clay (or mea-

don) carry such a rich clay on them, wherever it is not masked by the ruins of other rocks. At Ilfracombe, in North Devon, the passage from slate below to coal above is a striking example. Take the top of the slate beds, and the soil upon it, is laid bare, the black layers of slate may be seen gradually melting—if I may use the word—under the influence of rain and frost, into a rich tenacious clay, which is now not black, like its parent slate, but red, from the oxidation of the iron which it contains.

But, granting this, how did the first slate appear? It must be allowed, at starting, that time enough has elapsed, and events enough have happened, since our supposed mud began first to become slate, to allow of many fantastic and wonderful transformations. For these slates are found in the oldest beds of rocks, and have one series, in the known world; and it is notorious that the older and lower the beds in which the slates are found, the better, that is, the more perfectly elab-

orate the slate. Then, in the district of Snowdon—I must confine myself to the district which I know personally—are found in the so-called “Cambrian” beds. Below these beds but one series of beds is as yet known in the world, called the “Laurentian.” They occur, to a thick-

ness of some eighty thousand feet, in La-

brador, Canada, and the Adirondack moun-

tains of New York; but their representa-

tives in England are far less known, and as far as is known, only to be found in the north-west highlands of Scotland, and in the island of Lewis, which consists entirely of them. And it is to be remembered, as a proof of their antiquity, that the slate beds above the Cambrian have been upheaved and shifted long before the Cambrian rocks were laid down “uncon-

formably” on their worn and broken edges.

Above the “Cambrian” slates—whether the lower and older ones of Penryhn and Llanberis, which are the same—one slate mountain being worked at both sides in two opposite valleys—or the upper and newer slates of Tremadoc, lie other similar beds, but of less magnitude, and belonging to a yet newer world, the “Silurian.” To them belong the Llandilo flags and slates of Wales, and the Skiddaw slates of Cumberland, amid which, as in Penryhn, Fossil shells are found, it is true, in the upper Cambrian beds. In the lower they have all but disappeared. Whether their traces have been obliterated by heat and wind, or else buried entirely in recent strata, we cannot tell. Besides, we are actually reaching that Primordial Zone” conceived of by M. Barrande, namely, rocks which existed before living things had begun to peopled the planet. It is a question not yet answered. I believe the former theory to be the true one.
TOWN GEOLOGY.

That there was life, in the sea at least, even before the oldest Cambrian rocks were laid down, is proved by the discovery of the now famous fossil, the zo-oan, in the Laurentian limestones, which seems to have grown on the thickly wooded floors and reefs of limestone as do the living coral-building polyps. We know no more as yet. But all that we do know points downward, downward still, warning us that the lower the bed is in our column, the less the life in it will be found. The next step, as yet, before we reach the graves of the first living things.

Let this suffice at present for the Cambrian and Laurentian rocks. The next we come to is the Carboniferous upper and lower, which in these islands have their chief development in Wales, and which are nearly thirty-eight thousand feet thick; and the Devonian or Old Red sandstone beds, which lie between them, and taking their places in a steady succession of ever-varying forms, till those in the upper beds have become unlike those in the lower, and all are from the beginning more or less unlike any existing now. Perhaps the most striking thing about the later beds is the nearness of the trilobites, which seem to have swarmed in the Silurian seas, holding the same place there as crabs and shrimps do in our modern seas. They vanish after the period of the coal, and their place is taken by an allied family of crustaceans, of which only one form (as far as I am aware) lingers now on earth, namely, the "king crab," or limulus, of which there is one only, or at least, I think one, own animal, of which specimen may be sometimes seen alive in English aquaria. So perished, in the lapse of those same ages, the armored or "ganoid" fish which Hugh Miller made so justly famous—in fact, appearing first in the upper Silurian beds, and abounding in vast variety of strange forms in the Old Red Sandstone, but gradually disappearing from the waters of the world, till their only representatives, as far as known, are the leptocephali, or "bony pikes," of North America; the polypterus of the Nile and Senegal; the lepidosiren of the African lakes and Western rivers; the leptocephali of the African land (the two latter of which approach amphibians), and one or two more fantastic forms, either rudimentary or degraded, which have lasted on here and there among the lower animals of all ages, comparatively unchanged while all the world is changed around them, and their own kindred buried like the fossil ceratodus of the trias, beneath thou-sands of feet of earth. The whole contrast of scenes is all we are able to find now on earth. And these are but two examples out of hundreds of the vast changes which have taken place in the animal life in the glass, between the laying down of the Cambrian slates, and the present time.

Surely—and it is to this conclusion I have been tending throughout a seemingly wandering paragraph—surely there has been time enough during all those ages for clay to change into slate.

And what has the clay changed? I think I cannot teach my readers this more simply than by asking them first to buy Sheet No. LXXVIII. S.E. (Bangor) of the Snowdon district of the government gatherers, and, if possible, at any good stationer's, price two shil-lings, and study it with me. He will see down the right-hand margin interpretations of the different colors which mark the beds of the rocks. He will find twenty or thirty layers or younger (alluvium) atop, and going down through carboniferous limestone and sandstone, Upper Silurian, Lower Silurian, Cambrian, and below them certain rocks marked of different shades of red, which signify rocks either altered by heat or poured out of old volcanic vents. He will next see that the map is covered with a labyrinth of red patches and curved lines, signifying the outcrop or appearance at some time of the rocks. They lie at every conceivable slope; and the hills and valleys have been scooped out by rain and ice into every conceivable slope likewise. Wherefore we see, here a patch of red, and there the bank of sheet of lava, porphyry, greenstone, or what not, is exposed; there a narrow line curving often with the curve of the hill-side, where only the edge of a small sheet is exposed; and every possible variety of shape and attitude between these two. He will see also large spaces covered with little colored dots, which signify (as he will find at the margin) beds of coal. Many of these are pure red, other colored squares on the margin, he will see figures marking the strike, or direction of the inclination of the beds—inclined, vertical, horizontal, contorted; that the white lines in the map signify faults, that is, shifts in the strata the gold lines, beds of metal—the latter of which I should advise him strongly, in this district at least, not to meddle with: but to button up his pockets, and to put into the fire, in wholesale lots, all his unimportant ignorance. Any, puffs of mining companies which may be sent him—as one or two have probably been sent him already.

Furnished with which keys to the map, let him begin to con it over, sure that there is, if not an order, still a grand meaning, in all its seeming confusion; and let him, if he be a courteous and grateful person, return due thanks to Professor Ramsay for having found it all out; not without wondering, as I have often wondered, how even Professor Ramsay's acuteness and industry could find it all out.

When my reader has studied a while the constitution of the rocks at the base of the different beds, he will ask, or at least have a right to ask, what known process of nature can have produced it? How have these various volcanic rocks, which he has seen traced in with the reds, in porphyries, greenstones, and so forth, got intermingled with beds which he is told to believe are volcanic ashes, and those again with fossil-bearing Silurian beds and Cambrian sandstones, and limestone and dolomite and thrust against the other beds? were these deposits at any time under water? And his puzzle will not be lessened when he is told that, in some cases, as in that of the summit of Snowdon, these very volcanic ashes contain fossil shells.

The best answer I can give is to ask him to use his imagination, or his common-sense; and to picture to himself what must go on in the case of a submarine eruption, such as broke out off the coast of Iceland in 1783 and 1800, off the Azores in 1811, and which must have been more than one spot in the Pacific Ocean.

A main bore or vent—or more than one—opens itself between the bottom of the sea and the nether fires. From each rushes forth a violently agitated stream of other gases, which boils up through the sea, and forms a cloud above; that cloud descends again in heavy rain, and gives out often true lightning from its under side.

But it does more. It acts as a true steam-gun, hurling into the air fragments of cold rock rasped off from the sides of the bore, and fragments also of melted lava, and clouds of dust, which fall again into the sea, and form there beds either of fine mud or of breccia—that is, fragments of stone embedded in paste. This, the reader will understand, is no fantasy sketch, as far as I am concerned. The same phenomena are known in the sea and showing sections of beds of ash dipping outward and under the sea, and in them boulders and pebbles of every size, which had been hurled out of the crater; and in them also water that had been washed out through the soft ashes of the cone. Of those lava veins I will speak presently. What I want the reader to think of now is the immense quantity of ash which the steam-millileole it was so vast a height into the air, that it is often drifted many miles down to leeward. To give two instances: The jet of steam from Vesuvius, in the eruption of 1822, rose forty-two miles into the air; the jet from the Soufriére of St. Vincent in the West Indies, in 1812, probably rose higher; certainly it met the N.E. trade-wind, for it poured down a layer of ashes, several inches thick, not only on St. Vincent itself, but on Barbadoes, eighty miles to windward, and therefore on all the sea between.

Now let us consider what that represents—a layer of fine mud, laid down at a time when the ocean was empty, a forty-two-mile jet from the Soufriére, eighty miles at least, and twenty miles perhaps broad, by a single eruption. Suppose that hardened in long ages (as it would be under pressure) into a bed of fine-grained felstone, that ash; and we can understand how the ash-beds of Snowdonia—which may be traced some of them for many square miles—were laid down at the bottom of an ancient sea.

But now about the lavas or true volcanic rocks, which are painted (as is usual in geological maps) red. Let us go down to the bottom of the sea, and build up our volcano toward the surface.

First, as I said, the subterraneous steam, after having boiled up and stretched and stretched until it was rasped and blasted out of that hole would be spread about the sea-bottom as an ash-bed sloping away round the hole; then the molten lava would rise in the bore, and spread over the sea-bottom—perhaps in one direction, perhaps all round. Then, usually, the volcano, having vented itself, would be quieter for a time, till the heat accumulated below, and the lava and ash bed beneath it chill out, and a second ash-bed; and then would follow a second lava flow. Thus are produced the alternate beds of lava and ash which are so common.

Now suppose that at this point the volcano was exhausted, and lay quiet for a
few hundred years, or more. If there was any land near, from which mud and sand were washed down, we might have layers of sand, gravel, clay, driftwood, shells, etc., dwelling in them, which would be converted into fossils when they died; and so we should have fossiliferous beds over the ashes and lavas. Indeed, shells might have been washed inland from the ocean, when it cooled, and the sea grew quiet, as they have lived and thriven in Snowdonia. 

Now suppose that after these sedimentary beds are laid down by water, the volcano begins to put in an appearance. Many things: specially this, which has often happened already.

The lava, kept down by the weight of these new rocks, searches for the point of least resistance, and it finds it in the already existing and soften masses. It burrows out through the softer ash-beds, and between the sedimentary beds, spreading itself along horizontally. This process accounts for the very puzzling, though very common, case in Snowdon and elsewhere, in which we find lavas interstratified with rocks which are plainly older than those lavas. Perhaps when that is done the volcano has got rid of all its lava, and is quiet. But if not, sooner or later, it bores up through the new sedimentary rocks, faulting them by earthquake shocks till it gets free vent, and begins its layers of alternate ash and lava once more.

And further, this fact also: If near the first (as often happens) there is another volcano, the lava from one may run over the lava from the other, and we may have two lavas of different materials overlapping each other. Now, this overlapping occurs in different directions. The ashes blown out of the two craters may mingle also; and so, in the course of ages, the result may be such a confusion of ashes, lavas, and sedimentary rocks, as we find throughout our mountain ranges; in Snowdon, in the Lake Mountains, in the Auvergne in France, in Sicily round Etna, in Italy round Vesuvius, and in so many West Indian islands; the last confusion of which is very likely to be the most interesting.

That when the volcano has succeeded as it did in the case of Sabrina Island off the Azores in 1811, and as it did, perhaps, often in Snowdonia— in piling up an ash cone by successive outpouring of lava—it is very probable that— as has happened to Sabrina Island— the cone is sunk again by earthquakes, and grown down at the same time by the sea-waves, till nothing is left but a shallop under water. But where have all its vast heaps of ashes gone? To be spread about over the bottom of the sea, to mingle with the mud already there, and so make beds of which, like many in Snowdon, we cannot positively say whether they are of marine or volcanic origin, because they are of both.

But what has all this to do with the slates?

I shall not be surprised if my readers ask that question in three times during the first half of this paper. But they must be kind enough to let me tell my story my own way. The slates were not made in a day; and I fear they cannot be explained in an hour; unless we begin carefully at the beginning. But how shall we do? Let me first make my readers clearly understand that all our slate-bearing mountains, and most also of the non-slate-bearing ones likewise, are formed after the fashion which I have described, namely, beneath the sea. I do not say that there may not have been, again and again, ash-cones rising above the surface of the waves. But if so, they were washed away, again and again, ages before the land assumed its present shape; ages before the beds were twisted and upheaved as they are now.

And therefore I beg my readers to put out of their minds once and for all the idea that the old volcanoes and lands craters are to be still seen, such as exist in Etna, or Vesuvius, or other volcanoes now at work in the open air.

It is necessary to insist on this, because many suppose that wherever certain mountains are volcanic, conclusions may be drawn, naturally and harmlessly—that the circular lakes about their tops are true craters. I have been told, for instance, that that famous lake at the base of the Blue Llyn, under the highest cliff of Snowdon, is the crater of the mountain; and I have heard people insist that a similar lake, of almost equal grandeur, in the south side of Cader Idris, is a crater likewise.

But the fact is not so. Any one acquainted with recent craters would see at once that Glas Llyn is not an ancient one; and I am not surprised to find the Government geologists declaring that the Llyn on Cader Idris is a bare fact of youth. I think, for instance, that the crater, or rather the place where the crater has been, in ancient volcanoes of this kind, is probably now covered by one of the innumerable bosses of lava.

And indeed, for the simplest explanation, molten lava cools in the vents, and hardens; usually into lava infinitely harder than the ash-cone round it; and this, when the ash-cone is washed off, remains as the highest part of the mountain. The same thing has happened in the Mont Dore and the Cantal in France, and in several extinct volcanoes in the Antilles. Of course the lava must have been poured out, and the ashes blown out, from some vents or other, connected with the nether world of fire; probably from many successive vents. For in volcanoes, when one vent is choked, another is wont to open at some fresh point of least resistance among the overlapping rocks. But where are these vents? Buried deep, or else covered by the great deposits of ash and lava, and the sediments that have piled on top of ancient lava, covering the upper and the nether worlds. There are such tap-roots, probably, under each of our British mountain ranges. But Snowdon, certainly, does not even correspond to the fact of one of these old fire vents being under it. It owes its shape simply to the accident of some of the beds toward the summit being especially hard, and thus able to withstand the weight of water and air of sea and rain. Its lakes have been formed quite regardless of the lie of the rocks, though not regardless of their relative hardness. But what forces scooped them out— whether they were originally holes left in the ground by earth-takes, and deepened since by rain and rivers, or whether they were scooped out by ice, or by any other means, is a question on which the best geologists are still undecided—decided only on this, that these are not the ancient volcanoes.

As for the enormous changes which have taken place in the outline of the whole of the mountains since first their strata were laid down at the bottom of the sea, I shall give facts enough, before this paper is done, to enable readers to judge of them for themselves.

The reader will now ask, naturally enough, how such a heap of beds as I have described can take the shape of mountains like Snowdon.

At the foot of a sea-cliff in which the strata are twisted and set on slope. There are hundreds of such in these isles. The beds must have been at one time straight and horizontal. But it is equally clear that they have been curved, and turned, and twisted, and turned again, until they now stand as at the end. They will arrange themselves in folds, just as the beds of the cliff have done. And if, instead of cloth, you take some more brittle matter, you will find that, if you press those beds together, the folds will tend to snap at the points of greatest tension or stretching, which will be of course at the antecedent and synclinal lines—in plain English, the tops and bottoms of the folds. Thus cracks will be formed; and if the pressure goes on, the ends of the layers will shift against each other in the line of those cracks, forming faults like those so common in rocks.

Now suppose that instead of squeezing these broken and folded lines together any more, you took off the pressure right and left, and pressed them upwards from below, by a mimic earthquake. They would then spring forward, and the folds would have been space between them. Now if you could contrive to squeeze into them from below a paste, which would harden in the cracks and between the layers, and so keep them together, you would make them into a fair imitation of the geographers’ range—a mess—if I may use the plain old word—of rocks which have, by alternate contraction and expansion, helped in the latter case by the injection of molten lava, been thrust about as they are in most mountain ranges.

That such a contraction and expansion goes on in the crust of the earth is evident; for here are the palpable effects of them. Their operation is also the theory I can give for it this: That things expand as they are heated and contract as they are cooled.

Now I am not learned enough—and were I, I should not be, I think, able to enter into the various theories which philosophers have put forward to account for these grand phenomena.

The most remarkable, perhaps, and the most probable, is the theory of M. Elié de Beaumont, which is, in a few words, this: That this earth, like all the planets, must have been once in a state of intense heat throughout, as its mass inside is probably not.

That it must be cooling, and giving off its heat into space.

And therefore, as it cools, its crust must contract.

That, therefore, in contracting, wrinkles (for the softest mountain chains are nothings but tiny wrinkles, compared with the whole mass of the earth), wrinkles I say, must form on its surface from time to time. And that the mountain chains are these wrinkles.

Be that as it may, we may safely say this. That wherever the internal heat of the earth teuds (as in the case of volcanoes) toward a particular spot, that spot must bulge; the rocks will bulge, and swell, and slip out, and probably cracking them, and inserting melting lava into those cracks from
below. On the other hand, if the internal heat leaves that spot again, and it cools, then it must contract more or less, in falling inward toward the centre of the earth; and so the beds must be cramped, and crumpled against each other still more, as those of our mountains have been. But here may arise in some of my readers' minds, a reasonable objection. If upheavals were once horizontal, should we not be likely to find them, in some places, horizontal still? A reasonable question, and one which admits of a full and satisfactory answer. Of course, that there has been a gradual, but steady, change in the animals of this planet; and that the relative age of beds can, on the strength of that known change, be determined generally. But it is not to be forgotten that the bottom of the earth's crust, throughout its great extent, has been subject to the greatest changes, either of upheaval, or to the sea-level, or to tides, and waves, then set nearly upright once more, and faulted through and through six times, I believe, in the distance of a mile or two; they carry here and there on their backs patches of newly beds, the rest of which, after long and fearful sufferings, have huddled back to the eastward, and set upright, what is now the whole western flank of Snowdon—a mass of rock which was then several times as thick as it is now. The force which thus tortured them was probably exerted by the great mass of volcanic quartz-porphyrty, which rises from under them to the north-west, crossing the end of the lower lake of Llanberis; and which, after having been once upheaved, have taken place between them and the Menai Straits are so vast that they can only be estimated by looking at them on the section which may be found at the end of the Owen's, the 'Elder's 'Geological Observations on North Wales.' But say one who will study that section, and use (as with the map) a little imagination and common-sense, will see that the heat of that porphyry, which must have been poured out in a mighty flood, may have aided the cooling of the melted iron, and the pressure of it below, and of the Silurian beds above, the Cambrian mud-strata of Llanberis and Penrhyn quarries must have suffered enough to change them into something very different from mud, and, therefore, probably, into what they are now—namely, slate. And now, at last, we have got to the slates on the roof, and may disport ourselves in the beds of Snowdonia. Look at any piece of slate. All know that slate splits or cleaves freely, in one direction only, into flat layers. Now any one who would suppose at first sight, and fairly well, that the slate is 'full of cleavage'—was also the plane of bedding. In simpler English we should say, The mud which has hardened into the slate was laid down horizontally; and therefore each slate bed was originally horizontal, and the beds of it, perhaps just what was laid down in a single tide. We should have a right to do so, because that would be true of most sedimentary rocks. But it would not be true of the slate; for, the slate bed having been laid in a mud—which was actually horizontal when the mud was laid down—-in bits of slate, and find them sometimes perpendicular to, sometimes inclined to, and sometimes again horizontal, as far within as they have evidently acquired long after. Nay, more. These parallel planes of cleavage, at each of which the slate splits freely, but run through a whole mountain at the same angle, though the beds through which they run may be tilted at different angles, and twisted into curves. Now what has made this change in the rock? We do not exactly know. One thing is clear that the Welsh slate, like solid rock have actually moved on themselves. And this is proved by a very curious fact—which the reader, if he geologies about slate quarries much, may see with his own eyes. For in the slate are often distorted into quaint and grotesque shapes, if they bepng at the plane of cleavage, or squeezed together, or doubled down on both sides, if they lie across the plane. So that some force that has been at work on them, whether it be the pressure of hard shells, very slowly, no doubt, else it would have snapped and crumbled them. If I am asked what that force was, I do not know. I should advise young geologists to rub western flanks—any one. I say, that there has been in its admirable "Geological Observer," pp. 706-725. He will find there, too, some remarks on that equally mysterious phenomenon of jointing, which you may see in almost all the older rocks; it is common in limestones. All we can say is, that some force has gone on, or may be even now going on, in the more ancient rocks, which is similar to that which produced the jointed crystals of basalt, that is, lava, at the Giant's Causeway in Ireland, and Staffa in the Hebrides. Two philosophers—Mr. Robert Were Fox and Mr. Savery, among others, have supposed that the force which has determined the cleavage of slates may be that of the electric currents, which (as is well known) run through the crust of the earth. Mr. Sharpe, I believe, attributes the cleavage to the action of 'mechanical pressure,' that is, the weight of rock, especially where crushed by earthquakes. Professor Rogers, again, points out that as these slates may have been highly heated, thermal electricity (that is, electricity brought out by heat) may have acted on them. One thing at least is clear, that the best slates are found among ancient lavas, and also in rocks which are faulted and tilted. This, Mr. Tuzo Wilson, has frequently happened without a proportionately enormous pressure, and therefore heat; and next, that the best slates are invariably found in the oldest beds—that is, in the beds which have been the first to undergo the greatest changes, whether mechanical or chemical, which have made the earth's surface what we see it now. Another startling fact is that of Snowdonia, and I believe of most mountain chains in these islands, would prove—namely, that the contour of the earth's surface, as we see it now, depends very little, certainly in mountains composed of those slates, as at Snowdon, Menai strata, or beds, but has been carved out by great forces, long after those beds were not only laid down and hardened, but faulted and tilted on end. Snowdon itself is so remarkable an instance of this fact, that, perhaps better than any one, these happy days of excursion-trains and steamers either has seen or can see. I must say a few more words about it. Any one who saw that noble peak leaping out of the sea, without separating all the country round, at least upon three sides, and was told that its summit consisted of beds much never, not much older, than the slate-beds fifteen hundred feet deep on the northwestern flank—any one, I say, would have the right at first sight, on
hearing of earthquake faults and upheavals, to say, The peak of Snowdon has been upheaved to its present height above and out of the lower lands around. But when he came to examine sections he would find his reasonable guess utterly wrong, as there is no swelling up of the earth’s crust. The beds do not, as they would in that case, slope up to it. They slope up from it, to the north-west in one direction, and the south-south-west in the other. The top of Arran is a typical example of a mountain boss, left hanging on one slope of what was once an enormous trough, or valley, of strata far older than itself. By restoring these strata, in the direction of the tilt of the surface, which vanishes at the surface, it is found that to the north-west—the direction of the Menai Straits—they must once have risen to a height of at least six or seven thousand feet and more, by resting upon them, specially the ash-bed of Snowdon, toward the south-east—which can be done by the guidance of certain patches of it left on other hills—it is found that south of Ffestinog, where the Cambrian rocks are in the same direction, the trough must have sloped upward a height of from fifteen to twenty thousand feet, whether at the bottom of the sea, or in the upper air, we cannot tell. But the seas and rivers have all flowed away from south of Ffestinog, a mass of solid rock as high as the Andes has been worn down and carried bodily away; and that a few miles south again, the peak of Arran, Movdly, the highest in Scotland, was—one either under the sea or above it—nearer ten thousand feet.

If I am asked whether all that enormous mass of rock—millions of tons—one? Where is it now? I know not. But if I dared to hazard a guess, I should say it went to make the New Red sandstones of England.

The New Red sandstones must have come from somewhere. The most likely region for being thus the same form or type of the old rocks of Wales, where, as we know, vast masses of gritty rock have been ground off, such as would make fine sandstones if they had the chance. So that many a grain of sand in the beaches of the English coast, which is now not two thousand feet high, out of the bowels of the earth into the old Silurian sea, and after a few hundreds of thousands of years repose in a Snowdonian ash-bed, was sent eastward to build the good old city and many a good town more.

And the red marl—the great deposit of red marl which covers a wide region of England—why should it not have come from the same quarter? Why should it stop at Snowdon? Why should it not spread over all Wales, and make like beds of the red marl? Mud the slate was, and into mud it has returned. Why not? Some of the richest red marl land I know is, as I have said, actually being made now, out of the bowels of the earth into the red marl, by being weathered by rain and air. The chemical composition is the same. The difference in color between black slate and red marl is caused simply by the oxidation of the iron in the rock.

And if my readers want a probable cause why the sandstones lie undermost, and the red marl uppermost—can they not find one for themselves? I do not say that it is the cause, but it is at least a causa vera, one possible reason. It is a fact, and if it is a fact, it may be explainable in other ways. Think, then, or shall I think for my readers?

Then do they not see that when the Welsh mountains were ground down, the Silurian strata, being uppermost, would be ground down first, and would go to make the lower strata of the great New Red Sandstone Lowland; and that being sandy, they would make the sandstones. But wherever they were ground through, the rock would remain bare; and their remains, being washed away by the sea the last, would be washed on to the top of the remains of the Silurians; and so (as in most cases) the remains of the rock would be carried away by the water, and would lie on the remains of the younger rock. And do they not see that (if what I just said is true) these slates would grind up into red marl, as is the case; and that the rocks of Anglesey and Staffordshire and far away into Nottinghamshire. The red marl must almost certainly have been black slate somewhere, somewhere. Why should it not have been such in its origin as is the case? And the red marl not be the remains of the very beds which are now the marl in the fields?

And thus I end my story of the slates in the roof, and these papers on Town Geology. An impression that they are—though not, I believe, inaccrate. They are, after all, merely suggestive of the great amount that there is to be learnt about the face of the earth and how it got made, even by the booby-man, who can escape into the country and exchange the world of man for the world of God, only, perhaps, on Sundays—if, alas! even then—or only once a year by a trip in a steamer.

Little, indeed, can he learn of the planet on which he lives. Little in that direction is given to him, and of him little shall be required. But to him, for that very reason, all that can be given should be: he should have every facility for learning what he can about this earth, its composition, its capabilities; lest his intellect, crushed and fettered by that artificial drudgery which we for a time miscall civilization, should be entirely lost. He should already, that the world is composed mainly of bricks and deal, and governed by acts of parliament. If I should have awakened any townsmen here and there to think seriously of the composition and capabilties of the true poetry of the commonest objects around them, even the stones beneath their feet; if I should have suggested to them the solemn thought that all these things, and they themselves still more, are ordered by laws, utterly independent of man’s will about them, man’s belief in them; if I shall at all have helped to open their eyes that they may see, and their ears that they may hear. As Lord Bacon said of old, the Word of God revealed in the book of nature. Little, indeed, can he learn of the planet on which he lives. Little in that direction is given to him, and of him little shall be required. But to him, for that very reason, all that can be given should be: he should have every facility for learning what he can about this earth, its composition, its capabilities; lest his intellect, crushed and fettered by that artificial drudgery which we for a time miscall civilization, should be entirely lost. He should already, that the world is composed mainly of bricks and deal, and governed by acts of parliament. If I should have awakened any townsmen here and there to think seriously of the composition and capabilities of the true poetry of the commonest objects around them, even the stones beneath their feet; if I should have suggested to them the solemn thought that all these things, and they themselves still more, are ordered by laws, utterly independent of man’s will about them, man’s belief in them; if I shall at all have helped to open their eyes that they may see, and their ears that they may hear. As Lord Bacon said of old, the Word of God revealed in the book of nature. Little, indeed, can he learn of the planet on which he lives.

The particular example of the flowers of the coral to a "petite ortie" or "little nettle", is perfectly just, but needs explanation. "Ortie de mer, or "sea-nettle," is, in fact, the same animal as the "pied de mouton," a creature with which everybody, since the great aquatic mania, must have become familiar, even to the limits of boredom. In 1710 the great naturalist Reaumur had written red coral, for an essay on "expression and use of demonstrating that these "orties" are animals; and with this important paper Peyssonel must necessarily have been familiar. Therefore, when he declared, that "little coral," was the same name as saying that they were animals of the same general nature as sea-anemones. But to Peyssonel’s contemporaries

* This extract from Peyssonel’s manuscript is given by M. Lacaee Duhiers in his valuable "Histoire Naturelle du Coral" (1869).
This was an extremely startling announcement. It was hard to imagine the existence of such a thing as an association of animal branches altogether like a plant, and fixed to the soil as a plant is fixed; and the naturalists of that day preferred not to imagine it. Even Rénaut could not bring himself to accept the doctrine, although being blessed with Academicians, whose great function (as the late Bishop Wilson and an eminent modern writer have so well shown) is to cause sweetness and light to prevail, and to prevent such unreasonableness, not to say rudeness, of making public statements in opposition to the views of some of the most distinguished of their body, seems bitterly to have affected Peyssonel. For he sent all further communications to the Royal Society of London, which never had, and it is to be hoped never will have, anything of an academic constitution; and finally took himself off to Guadaloupe, and became lost to science altogether.

Fifteen or sixteen years after the date of Peyssonel’s suppressed paper, the Abbé Trembley published his wonderful researches into the colorful animal branches, which were afterwards published as ‘Bibliothèque de Muséum d’Histoire Naturelle.’ Peyssonel, who evidently was a person of savage and untamable disposition, so far from appreciating the kindness of the Academicians in giving him time to reflect, complained of the intemperance of men, and, as aforesaid, his great work remained in manuscript, and may at this day be consulted off to Guadaloupe, and became lost to science altogether.

The term ‘polypus’ is in French the name of a little animal, the discoverer of it used the term for the single animal, the coral animal, the zoologist has changed it to polype, and the adjective to polypie, whereby the term serves as an adjective in French.

The progress of discovery, since Rénaut’s time, has made us very completely acquainted with the structure and habits of all these polypes. We know that, among the sea-anemones and coral-forming animals, each polype has a mouth leading to a stomach, which is divided into the same number of compartments, first divided with soft partitions, and thus communicates freely with the general cavity of the body; that the tentacles placed round the mouth are hollow, and that they perform the part of arms in seizing and capturing prey. It is known that many of these creatures are capable of being multiplied by artificial division, the divided halves growing, after a time, into complete and separate animals; and that many are able to perform a very similar process naturally, in such a manner that individual soft partitions, or small branches, may be repeated incomplete, and the new polypes, or branches bearing polypes, until a tree-like mass, sometimes of very considerable size, is formed.

This is what happens in the case of the red coral of commerce. A minute polype, fixed to the rocky bottom of the deep sea, grows up into a branched trunk. The end of every branch and twig is terminated by a polype; and all the polypes are connected with one another by innumerable canals which place each polype in communication with every other, and carry nourishment to the substance of the supporting stem. It is a sort of natural co-operative store, every polype helping the whole, at the same time as it helps itself. The interior of the stem, like that of the branches, is solidified by the deposition of carbonate of lime in its tissue, sometimes, as in the case of the rays, are formed of animal matter impregnated with lime salts; and it is this dense skeleton (usually turned deep red by a peculiar coloring matter) cleared of the soft animal investment, as the heart-wood of a tree might be stripped of its bark, which is the red coral.

In the case of the red coral, the hard skeleton belongs to the interior of the stem and branches only; but in the common orange and yellow coral, the polype is connected with the skeleton of its own. These polypes are sometimes solitary, in which case the whole skeleton is represented by a single cup, with partitions radiating from its centre to its circumference. When the polypes formed by budding or division remain associated, the polypidom is sometimes made up of nothing but an aggregation of these cups, while at other times the cups are at the end of these tubes united together by an intermediate substance, which represents the branches of the red coral. The red coral polype again is a comparatively rare animal, inhabiting a limited area, the skeleton being formed of wood, which possesses a considerable mass; while the white corals are very common, occur in almost all seas, and form skeletons which are sometimes extremely massive.

With a very few exceptions, both the red and the white coral polypes are, in their adult state, firmly adherent to the sea-bottom; nor do their buds naturally become detached and locomotive. But, in addition to budding and division, these creatures are also capable of asexual multiplication; and, at particular seasons, they give rise to numerous eggs of minute size. Within these eggs the young are formed, and they leave the egg in a condition sufficiently to enable it to become the perfect animal. It is, in fact, a minute oval body, many hundred times smaller than the full-grown creature, and it swims about with great activity by the help of cilia. These minute filaments, called cilia, with which its body is covered. These cilia all lash the water in one direction, and do drive the little body along as if it were propelled by thousands of extremely minute paddles. After enjoying its freedom for a longer or shorter time, and being carried either by the force of its own cilia, or by currents which bear it along, the embryo coral settles down to the bottom, loses its cilia, and becomes fixed to the rock, gradually assuming the form which the polype has acquired from its parent. As the infant polypes of the coral may retain this free and active condition for many hours, or even days, and as a tidal or other current in the sea may carry them for many miles in an hour, it is clear that the embryo must often be transported to very considerable distances from the parent. And it is easily understood how a single polype, which may give rise to thousands, or perhaps thousands, of embryos, may, by this process of partly active and partly passive migration, cover an immense surface with its offspring. The masses of the coral reefs, therefore, are formed by accumulations of polypes which spring by budding, or by dividing, from a single polype, occasionally attain very considerable dimensions. Such skeletons are sometimes great plates, many feet long and several feet in thickness; or they may be divided into the half globes, like the brainstone corals, or may reach the magnitude of stout shrubs, or even small trees. There is reason to believe that some of these masses as these take a long time to form, may have been made by a polype tree, or polype turf, may attain, may be considerable. But, sooner or later, the coral polypes, like all other things, die; the soft flesh decays, while the skeleton is left as a stony mass at the bottom of the sea, where it retains its integrity for a longer or a shorter time, according as its position affords it more or less protection from the wear and tear of the waves.

The polypes which give rise to the white coral are found, as has been said, in the seas of all parts of the world; but in the temperate and cold oceans they are scattered and comparatively small in size, so that the skeletons of those which die do not accumulate in any considerable quantity. But it is otherwise in the greater part of the ocean which lies in the warmer latitudes. The depth of the water is there of the order of about 1800 miles on each side of the equator. Within the zone thus bounded, by far the greater part of the ocean is inhabited by coral polypes, which not only enter into the composition of these masses, but associate together into great masses, like the thickets and the meadow turf, or, better still, the accumulations of peat, to which plants give rise on the dry land. These masses of stony matter, piled up beneath the waters of the ocean, become as dangerous to mariners as so much ordinary rock, and to these, as to common rock ridges, the seaman gives the name of 'reefs.'

The coral reefs cover many thousand square miles in the Pacific and in the Indian Oceans. There is one reef, or rather great series of reefs, called the Barrier Reef, which stretches, almost continuous, for 1000 miles off the east coast of Australia. Multitudes of the islands in the Pacific are either reefs themselves, or are surrounded by reefs. The Red Sea is in many parts almost a maze of reefs, and the West Indies, along the coast of Florida, and even as far north as the Bahamas, have as many reefs as the coral reefs upon the west coast of America, nor upon the west coast of Africa; and it is a general fact that the reefs are inter-
ruptured, or absent, opposite the mouths of great rivers. The causes of this apparent caprice in the distribution of coral reefs are not far to seek. The polype which fabricate them require for their vigorous growth the presence of a temperature slightly below 65° Fahrenheit all the year round, and this temperature is only to be found within the distance on each side of the equator which has been mentioned, or thereabouts. Beyond this zone this degree of warmth is not everywhere to be had. On the west coast of America, and on the corresponding coast of Africa, currents of cold water from the icy lands flow along the coast of South America and set northward, and it appears to be due to their cooling influence that the sea in these regions is free from the reef-builders. Again, the coral polype cannot live in water which is rendered brackish by floods from the land, or which is perturbed by mud from the same source, and hence it is that they cease to exist opposite the mouths of rivers, which damage them in both these ways.

Some account of the general distribution of the reef-building corals, but there are some very interesting and singular circumstances to be observed in the conformation of the reefs when we consider them individually. Thus you will find two kinds; some of them stretch out from the shore, almost like a prolongation of the beach, covered only by shallow water, and in the case of an island, surrounding it like a fringe of no considerable breadth. These are termed "fringing reefs." Others are separated by a channel which may attain a width of many miles, and a depth of twenty or thirty fathoms or more, from the nearest shore, or from an island. If there is an island, the reef surrounds it like a low wall, and the sea between the reef and the land is, as it were, a moat inside this wall. Such reefs as these are called "encircling" when they surround an island, and "barrier" reefs when they stretch parallel with the coast of a continent. In both these cases there is ordinary dry land inside the reef, and separated from it only by a narrower or a wider, a shallower or a deeper, a rougher or a calmer water; and the reef itself is, either a "lagoon," or "inner passage." But there is a third kind of reef, of very common occurrence in the Pacific and Indian Oceans, which goes by the name of an "atoll." This is, to all intents and purposes, an encircling reef, without anything to encircle; or, in other words, without an island in the middle of its lagoon. The atoll has exactly the appearance of a vast, irregular circle, in fact, of three or four low, insulating smooth water in its midst. The depth of the water in the lagoon rarely exceeds twenty or thirty fathoms, but, outside the reef, it deepens with great rapidity. The depth of the water is, in fact, immediately outside the barrier, or encircling reefs, may also be very considerable; but, at the outer edge of a fringing reef, it does not amount usually to more than twenty or twenty-five fathoms; in other words, from 120 to 150 feet.

Thus, if the water of the ocean could be suddenly drained away, we should see the atolls rising from the sea-bed like vast truncated cones, and resembling so many volcanoes, except that the central part would be higher than any of those ordinary volcanoes. In the case of the encircling reefs, the cone, with the inclosed island, would look like Vesuvius with Mount Nuovo within the old crater of Somma; while, finally, the island with a fringing reef would have the appearance of an ordinary hill, or mountain, girted by a vast parapet, within which would lie a shallow moat. And the dry bed of the Pacific might afford bounds for the remains of the moor to speculate upon the extraordinary subterranean activity to which these vast and numerous "craters" bore witness.

If we consider the structure of a fringing reef as investigated, the bottom of the lagoon is found to be covered with fine whitish mud, which results from the breaking up of the dead corals. Upon this muddy floor grow the so-called "reefs," or occasionally great blocks of dead coral, which have been torn by storms from the outer edge of the reef, and washed into the lagoon. Shell-fish and worms of various kinds abound; and fish, some of which prey upon the coral, sport in the deeper pools.

But the corals which are to be seen growing in the shallow waters of the lagoon are of a different kind from those which abound on the outer edge of the reef, and on the barrier reefs. They are separated from the seaward edge of the reef, over which, even in calm weather, a surf almost always breaks, the coral rock is incrusted with a thick coat of a singular vegetable organism, or line of growth, which is the so-called Nullipora. Beyond this, in the part of the edge of the reef which is always covered by the breaking waves, the living, true, reef-polype make their appearance, and live in the soft, loose shallow sea floor of the reef to a depth of 100 or even 150 feet. Beyond this depth the sounding-lead rests, not upon the wall-like face of the reef, but on the bottom. And this depth is a certain distance to which a fringing reef extends from the land corresponds with that at which the sea has a depth of twenty or five-and-twenty fathoms.

If, as we have supposed, the sea could be suddenly withdrawn from around an island provided with a fringing reef, such as the Mauritius, the reef would present the aspect of a terrace, its seaward face, 100 feet or more high, blooming with the vivid corals, and the land side of its face would be hollowed out into a shallow and irregular moat-like excavation.

The coral mud, which occupies the bottom of the lagoon, and with which all the interstices of the coral skeletons which accumulate to form the reef are filled up, does not proceed from the washing action of the waves alone; innumerable fishes, and other creatures which prey upon the corals, and the disintegration of the calcareous matter and the mud becoming incorporated together, gradually harden and give rise to a sort of limestone rock, which may vary very greatly in its mechanical properties. It remains friable and chalky, but, more often, the infiltration of water, charged with carbonic acid, dissolves some of the calcareous matter, and deposits it elsewhere in the interested organism. Or, again, the cementing particles together into a hard mass; or it may even dissolve the carbonate of lime more extensively, and redeposit it in a crystalline form. On the beach of the lagoon this rock is divided into layers by the action of the waves, its grains become thus fused together into strata of a limestone, so hard that they ring when struck with a hammer, and inclined at a gentle angle, corresponding with that of the surface of the beach. The hard parts of the many animals which live upon the reef become imbedded in this coral limestone, so that a block may be full of shells of bivalves and univalves, or of sea-urchins, sea-stars, or even the lungs of the eggs of turtles in a state of petrification. The active and vigorous growth of the reef goes on only at the seaward margins, where the polype are exposed to the wash of the sea, and provided with an abundant supply of food. For the interior portion of the reef may be regarded as almost wholly an accumulation of dead skeletons. Where a river comes out from the land there is a break in the reef, and the corals which have been already mentioned.

The origin and mode of formation of a fringing reef, such as that just described, are plain enough. The embrys of the coral polype fixed themselves upon the submerged shore of the island, as far out as they could live, namely, to a depth of twenty or twenty-five fathoms. One generation has succeeded another, building upwards and outwards upon their predecessor. The mass has been consolidated by the infiltration of coral mud, and hardened by partial solution and redeposition, until a great rampart of coral rock is formed which encircles the island, and has been formed all round the island, with only such gaps as result from the outflow of rivers, in the place of sally-ports.

The structure of the rocky accumulation of coral reefs is in this case essentially the same as in the fringing reef. But, in addition to the differences of depth inside and out, they present other peculiarities. These reefs, and especially the fringing reefs, are quite free from coral flora, and part of their circumference, and this part is always situated on the leeward side of the reef, or that which is the more sheltered side. Now, as all these reefs are situated within the region in which the trade-winds prevail, it follows that, on the north side of the equator, where the trade-wind is a north-easterly wind, the opening of the reef is on the south-west side; while in the southern hemisphere, where the trade-winds blow in the contrary direction, the opening lies to the north-west. The curious practical result follows from this structure, that the lagoons of these reefs really form admirable harbors, if a ship can only get inside them. But the main difference between the encircling reefs and the atolls on the one hand, and the fringing reefs on the other, lies in the fact of the much greater depth of water on the seaward faces of the former. As a consequence of this fact, the whole of this face is not, as it is in the case of the fringing reef, covered with living coral polype. For, as we have seen, these polype cannot live at great depths; and, if they did, they would be nothing but dead coral and coral sand. We must, therefore, picture to ourselves an atoll, or an encircling reef, as fringed for 100 feet, or more, from its top to its base, with the three or four encircling reefs, in fabricating coral; while, below this comparatively narrow belt, its surface is a bare and smooth expanse of coral sand, supported upon and within a core of coral limestone. Thus, if the heel of the Pacific were suddenly laid bare, as was just now
supposed, the appearance of the reef-mountains would be exactly the reverse of that present in the Hong Kong and the Marquesas Islands. For these are white with snow at the top, while their bases are clothed with an abundant and gaudily-colored vegetation. But the coral cones would look gray and barren below, while their summit would be clothed with a richly-colored parterre of flower-like coral polypes.

The practical difficulties of sounding upon, and of bringing up portions of, the seaward face of an atoll, owing to the reefs being so great a distance below the surface of the sea, as a consequence of the constant and dangerous swell which sets toward it, that no exact information concerning the depth to which the reefs are composed of coral has yet been obtained. The reef-cone has the same structure from its summit to its base, and that its sea-wall is throughout mainly composed of dead coral.

And now arises a serious difficulty. If the coral polypes cannot live at a greater depth than 100 or 150 feet, how can they have built up the base of the reef cone, which may be 2000 feet, or more, below the water? In order to get over this objection, it was at one time supposed that the reef-building polypes had settled upon the summits of a chain of submarine mountains. But this hypothesis could not in any way justify the assumption of the existence of a chain of mountains stretching for 1000 miles or more, and so nearly of the same height, that none should rise above the level of the sea, nor fall 150 feet below that level?

How again, on this hypothesis, are atolls to be accounted for, unless, as some have done, we take refuge in the wild supposition that every atoll corresponds with the crater of a volcano. And what explanation does it afford of the fact that, in some parts of the ocean, only atolls and encircling reefs occur, while others present none but fringing reefs?

It is clear that the conflicting facts remained insoluble until the publication, in the year 1840, of Mr. Darwin's famous work on coral reefs, in which a key was given to all the difficult problems connected with the subject. He showed that the coral reefs were capable of solution by deductive reasoning from a happy combination of certain well-established geological and biological truths. Mr. Darwin, in fact, showed, that so long as the level of the sea remains unaltered in any area in which coral reefs are being formed, or if the level of the sea relative to that of the land is falling, the only reefs which can be formed are fringing reefs. The level of the sea is rising relatively to that of the land, at a rate not faster than at which the upward growth of the coral can keep pace with it, the reef will gradually pass from the condition of a fringing into that of an encircling or barrier reef. And, finally, that if the relative level of the sea rise so much that the encircled land is completely submerged, the reef must necessarily pass into the condition of an atoll.

For, suppose the relative level of the sea to remain stationary, after a fringing reef has reached that distance from the land at which the depth of water amounts to 150 feet. It must necessarily grow seaward by the migration of coral germs, because these coral germs would find the bottom of the sea to be too deep for them to live in. And the only manner in which the reef could extend outwards, would be by the way of a violent upheaval of the summit of its seaward face, of a talus of coral fragments torn off by the violence of the waves, which talus might, in course of time become high enough to bring its upper surface within the limit of coral growth, and in that manner provide a sort of factitious sea-bottom upon which the coral embryos might perch. If, on the other hand, the level of the sea was slowly and gradually rising, the encircling reef and the bottom originally beyond the limit of coral growth would gradually be brought within the required distance of the surface, and thus the reef might be indefinitely extended. But this process would give rise to the formation of a new atoll, but to a broad belt of upheaved coral rock, increasing the dimensions of the dry land, and continuous seaward with the fresh fringing reef.

Suppose, however, that the sea-level rose instead of falling, at the same slow and gradual rate at which we know it to be rising in some parts of the world—not more, in fact, than a few inches, or, at the most, a few feet in a thousand years. Then, while the reef would be unable to extend itself seaward, the sea-bottom outside it being gradually more and more removed from the depth at which the life of coral would rise faster than at the bottom, or, in other words, the lagoon would constantly become deeper. And, at the same time, it would gradually increase in breadth; as the rising sea, covering more and more of the land, would gradually occupy the wider space between the edge of the reef and what remained of the land. Thus the rising sea would eventually convert a large island with a fringing reef, into a small or vast lagoon, enclosed by a barrier reef.

And it will be obvious that when the rising of the sea has gone so far as completely to cover the highest points of the island, the reef will have passed into the condition of an atoll.

But how is it possible that the relative level of the land and sea should be altered to this extent? Clearly, only in one of two ways: either the sea must have risen, or the land must have been lowered. But in either case, the exact amount by which the rise upon which the sea rests must have been depressed to a corresponding extent.

If the sea has risen, its rise must have taken place over the whole world simultaneously, and it must have risen to the same height all over the parts of the coral zone. Grounds have been shown for the belief that the general level of the sea may have been different at different times; it may have been, at the time of the accumulation of ice on the poles during one of the cold periods of the earth's history necessarily implies a diminution in the volume of the sea proportioned to the amount of its water thus permanently locked up in the Arctic and Antarctic ice-cells; while, in the warm periods, the greater or less disappearance of the polar ice-cap implies a corresponding addition of water to the ocean. And no doubt this is so; but on the other hand, the rise of sea-level is a question which on principle: though it is very hard to say what practical effect the additions and subtractions thus made have had on the level of the ocean; inasmuch as such additions or subtractions, whether increased or nullified, by contemporary changes in the level of the land. And no one has yet shown that any such great melting of polar ice, and consequent raising of the level of the water of the ocean, could have taken place without the existing atolls began to be formed.

In the absence of any evidence that the sea has ever risen to the extent required to give rise to the encircling reefs and the atoll, Mr. Darwin adopted the opposite hypothesis, viz. that the land has undergone extensive and slow depression in those localities in which these structures exist.

It seems, at first, a startling paradox to suppose that the land is less fixed than the sea; but that such is the case is the uniform testimony of geology. Beds of sandstone or limestone, thousands of feet thick, have been found resting upon the various parts of the earth's surface, and prove, beyond a doubt, that when these beds were formed, that portion of the sea-bottom which they then occupied under rested upon a land surface of a certain distance which cannot have been less than the thickness of those beds, and may have been very much greater. In supposing, therefore, that the great areas of the Pacific and of the Indian Ocean over which atolls and encircling reefs are found scattered, have undergone a depression of some hundreds, or, it may be, thousands of feet, Mr. Darwin made a supposition which had nothing forced or improbable, but which is perfectly in accordance with what we know to have taken place over similarly extensive areas, in other periods of the world's history. But Mr. Darwin subjected his hypothesis to an ingenious indirect test, for he showed that neither atolls nor encircling reefs should be found in those portions of the ocean in which we have reason to believe, on independent grounds, that the sea-bottom was formerly lowered and slowly rising. Now it is known, that, as a general rule, the level of the land is either stationary, or is undergoing a slow upheaval, in the neighborhood of active volcanoes; and, therefore, neither atolls nor encircling reefs ought to be found in regions in which volcanoes are numerous and active. And this turns out to be the case. Appended to Mr. Darwin's great work is a map of the Pacific, on which atolls and encircling reefs are indicated by one color, fringing reefs by another, and active volcanoes by a third. And it is at once obvious that the lines of active volcanoes lie around the margins of the areas occupied by the atolls and the encircling reefs. It is exactly as if the up-heaving volcanic agencies had lifted up the edges of these great areas, while their centres had undergone a corresponding depression. An island might be pictured as a kind of basin, the margins of which have been pushed up by the subterranean forces, to which the craters of the volcanoes have, at intervals, given vent.

Thus we must imagine the area of the Pacific now covered by the Polynesian Archipelago as having been, at some former
time, occupied by large islands, or, may—be, by a great continent, with the ordinarily diversified surface of plain, hill, and mountain chain. The shores of this great land were doubtless fringed by coral reefs; and, as it slowly underwent depression, the hilly regions, converted into islands, became, at first, surrounded by fringing reefs, and then, as depression went on, these became converted into encircling reefs, and these finally into atolls, until a maze of reefs and coral-girtled islets took the place of the original land masses.

Thus the atolls and the encircling reefs furnish us with clear, though indirect, evidence of changes in the physical geography of large parts of the earth's surface; and even, as my lamented friend, the late Professor Jukes, has suggested, give us indications of the manner in which some of the most puzzling facts connected with the distribution of animals have been brought about. For example, Australia and New Guinea are separated by Torres Straits, a broad belt of sea one hundred or one hundred and twenty miles wide. Nevertheless, there is in many respects a curious resemblance between the land animals which inhabit New Guinea and the land animals which inhabit Australia. But, at the same time, the marine shell-fish which are found in the shallow waters of the shores of New Guinea are quite different from those which are met with upon the coasts of Australia. Now, the eastern end of Torres Straits is full of atolls, which, in fact, form the northern termination of the Great Barrier Reef which skirts the eastern coast of Australia. It follows, therefore, that the eastern end of Torres Straits is an area of depression, and it is very possible, and on many grounds highly probable, that in former times Australia and New Guinea were directly connected together, and that Torres Straits did not exist. If this were the case, the existence of casowaries and of marsupial quadrupeds, both in New Guinea and in Australia, becomes intelligible; while the difference between the littoral mollusks of the north and the south shores of Torres Straits is readily explained by the great probability that, when the depression in question took place, and what was, at first, an arm of the sea became converted into a strait separating Australia from New Guinea, the northern shore of this new sea became tenanted with marine animals from the north, while the southern shore was populated by immigrants from the already existing marine Australian fauna.

But, therefore, which it lives at a certain rate, it is clear that the reefs are records, not only of changes in physical geography, but of the lapse of time. It is by no means easy, however, to estimate the exact value of reef-chronology, and the attempts which have been made to determine the rate at which a reef grows vertically, have yielded anything but precise results. A cautious writer, Mr. Dana, whose extensive study of corals and coral reefs makes him an eminently competent judge, states his conclusion in the following terms:

"The rate of growth of the common branching madreporé is not over one and a half inches a year. As the branches are open, this would not be equivalent to more than half an inch in height of solid coral for the whole surface covered by the madrepora; and, as they are also porous, to not over three eights of an inch of solid limestones. But a coral reef is, of course, not a vast uniform mass, but has large bare patches without corals, and the coral sands are widely distributed by currents, part of them to depths over one hundred feet where there are no living corals; not more than one sixtieth of the surface of a reef region is, in fact, covered with growing species. This reduces the three eighths to one sixteenth. Shells and other organic remains of the three fourths, or more, are converted into coral. At the outside, the average upward increase of the whole reef-ground per year would not exceed one eighth of an inch."

"Now some reefs are at least two thousand feet thick, which, at one eighth of an inch a year, corresponds to one hundred and ninety-two thousand years."

Half, or quarter, this estimate if you will, in order to be certain of erring upon the right side, and still there remains a prodigious period during which the ancestors of the existing coral polypes have been undisturbedly at work; and during which, therefore, the climatal conditions over the coral area must have been much what they are now.

And all this lapse of time has occurred within the most recent period of the history of the earth. The remains of reefs formed by coral polypes of different kinds from those which exist now, enter largely into the composition of the limestones of the Jurassic period; and still more widely different coral polypes have contributed their quota to the vast thickness of the car- bouiferous and Doven Rock formations, as regards the latter group of rocks in Amer- ica, the high authority already quoted tells us:

"The Upper Heiderberg period is eminently the coral-reef period, the pale, open waters of the oceans, formed by the breaking up of the land of the world on which the reefs abounded in coral, and as are truly coral reefs to the modern reefs of the Pacific. The corals are sometimes standing on the rocks in the position they had when growing; others are lying in fragments, as they were broken and heaped by the waves; and others were reduced to a compact limestone by the finer triturating before consolidation into rock. This compact variety is the most common kind among the coral-reef rocks of the present seas; and it often contains few distinct fossils, although formed in water that abounded in life. At the fall of the Ohio, near Loui- ville, there is a magnificent display of the old reef. Hemispherical Posidonia, five or six feet in diameter, is in these states but as it when they were covered by their flower-like polypes; and besides these, there are unnumerable branching corals, and a profusion of Cyphalosphera, or cup-corals."**

Thus, in all the great periods of the earth's history of which we know anything, a part of the then living matter has had the form of polypes, competent to separate from the water of the sea the carbonate of lime necessary for their structure. Grain by grain, and particle by particle, they have built up vast masses of rock, the thickness of which is measured by hun- dred of feet, and their area by thousands of square miles; they have thus recorded the crust of the earth, producing great changes in the distribution of land and water, have often obliged the living matter of the coral-builders to shift the locality of its operations, and, by various and gradual adaptation to these modifications of condition, its forms have as often changed. The work it has done in the past is, for the most part, swept away, but fragments remain; and, if we have eyes to see, we may have a glimpse of the general constancy of the operations of Nature in this world, through periods of almost inconceivable duration.

THE END.


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