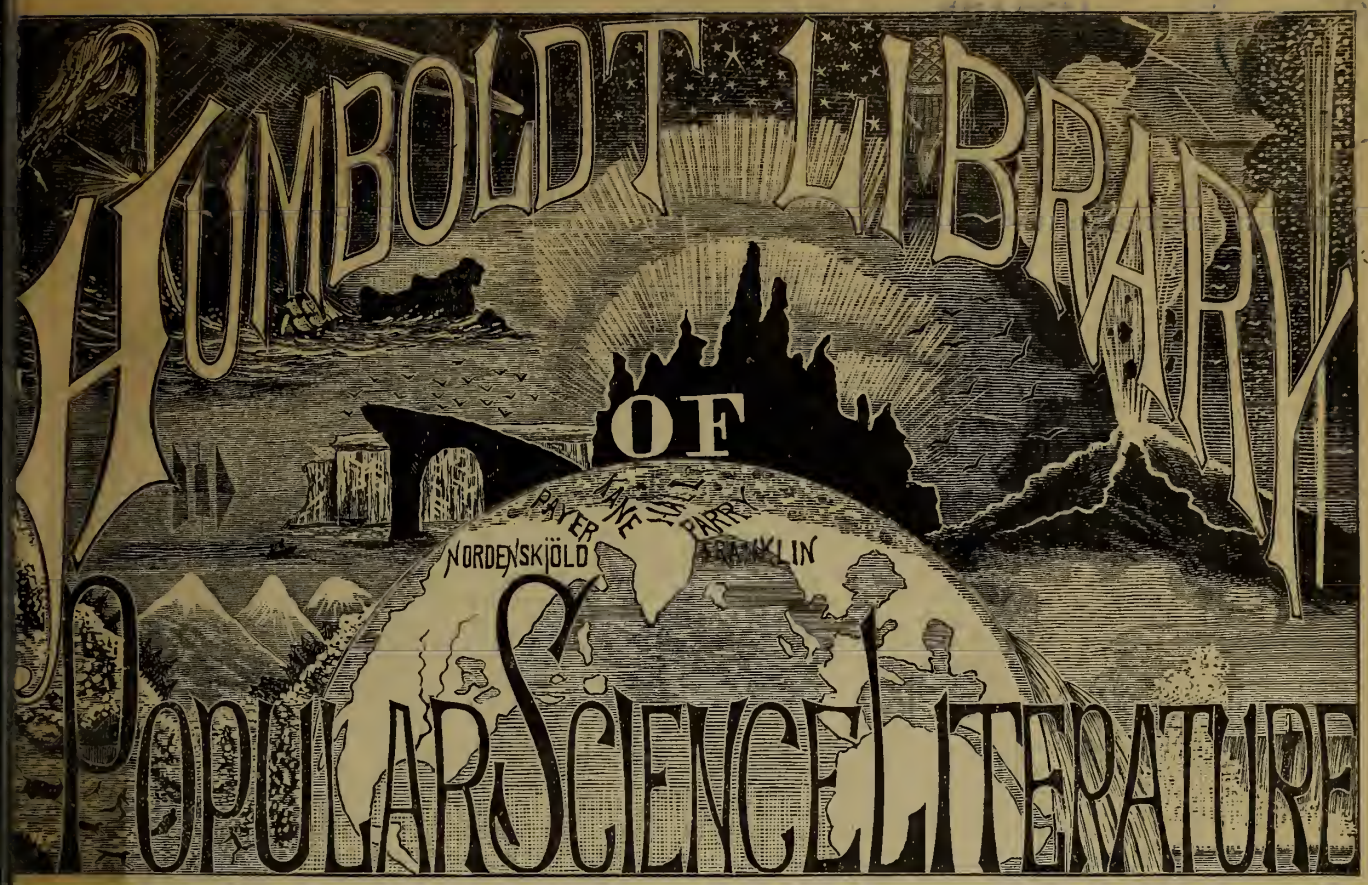
SPENCER

EDUCATION: INTELLECTUAL, MORAL, AND PHYSICAL



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EDUCATION:

INTELLECTUAL, MORAL, AND PHYSICAL.

BY HERBERT SPENCER.

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 wherewith 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 broadcloths. 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 on 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 paint 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 men the regard for appearance 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. In neither direction has this change gone so far with women. The wearing of ear-rings, finger-rings, bracelets; the elaborate dressings of the hair; the still occasional use of paint; the immense labor bestowed in making habiliments sufficiently attractive; and the great discomfort that will be submitted to for the sake of conformity; show how greatly, in the attiring of women, the desire of approbation overrides the desire for warmth and convenience. And similarly in their education, the immense preponderance of "accomplishments" proves how here, too, use is subordinated to display. Dancing, deportment, the piano, singing, drawing—what a large space do these occupy! If you ask why Italian and German are learned, you will find that, under all the sham reasons given, the real reason is, that a knowledge of those tongues is thought ladylike. It is not that the books written in them may be utilized, which they scarcely ever are; but that Italian and German songs may be sung, and that the extent of attainment may bring whispered admiration. The births, deaths, and marriages of kings, and other like historic trivialities, are committed to memory, not because of any direct benefits that can possibly result from knowing them, but because society considers them parts of a good education—because the absence of such knowledge may bring the contempt of others. When we have named reading, writing, spelling, grammar, arithmetic, and sewing, we have named about all the things a girl is taught with a view to their direct uses 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 far past down even to the present, social needs have subordinated individual needs, and that the chief social need has been the control of individuals. It is not, as we commonly suppose, that there are no governments but those of monarchs, and parliaments, and constituted authorities. These acknowledged governments are supplemented by other unacknowledged ones, that grow up in all circles, in which every man or woman strives to be king or queen or lesser dignitary. To get above some and be reverenced by them, and to propitiate those who are above us, is the universal struggle in which the chief energies of life are expended. By the accumulation of wealth, by style of living, by beauty of dress, by display of knowledge or intellect, each tries to subjugate others, and so aids in weaving that ramified network of restraints by which society is kept in order. It is not the savage chief only who, in formidable war-paint, with scalps at his belt, aims to strike awe into his inferiors; it is not only the belle who, by elaborate toilet, polished manners, and numerous accomplishments, strives to "make conquests;" but the scholar, the historian, the philosopher, use their acquirements to the same end. We are none of us content with quietly unfolding our own individualities to the full in all directions, but have a restless craving to impress our individualities upon others, and in some way subordinate them. And this it is 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 conduce to social position and influence—what 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 value of knowledge, so much as its extrinsic effects on others. And this being our dominant idea, direct utility is scarcely more regarded than by the barbarian when filling his teeth and staining his nails.

If there needs any further evidence of the rude, undeveloped character of our education, we have it in the fact that the comparative worths of different kinds of knowledge have been as yet scarcely even discussed—much less discussed in a methodic way with definite results. Not only is it that no standard of relative values has yet been agreed upon, 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 clearly conceived, but the need for it seems to have been scarcely even felt. Men read books on this topic, and attend lectures on that; decide that their children shall 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, without ever considering the enormous importance of determining in some rational way what things are really most worth learning. It is true that in all circles we have occasional remarks on the importance of this or the other order of information. But whether the degree of its importance justifies the expenditure of the time needed to acquire it, and whether there are not things of more importance to which the time might be better devoted, are queries which, if raised at all, are disposed of quite summarily, according to personal predilections. It is true, also, that from time to time we hear revived the standing controversy respecting the comparative merits of classics and mathematics. Not only, however, is this controversy carried on in an empirical manner, with no reference to an ascertained criterion, but the question at issue is totally insignificant when compared with the general question of which it is part. To suppose that deciding whether a mathematical or a classical education is the best, is deciding what is the proper *curriculum*, is much the same thing as to suppose that the whole of dietetics lies in determining whether or not bread is more nutritive than potatoes!

The question which we contend is of such transcendent moment, is, not whether such or such knowledge is of worth, but what is its *relative* worth? When they have named certain advantages which a given course of study has secured them, persons are apt to assume that they have justified themselves: quite forgetting that the adequateness of the advantages is the point to be judged. There is, perhaps, not a subject to which men devote attention that has not *some* value. A year diligently spent in getting up heraldry would very possibly give a little further insight into ancient manners and morals, and into the origin of names. Any one who should learn the distances between all the towns in England might, in the course of his life, find one or two of the thousand facts he had acquired of some slight service when arranging a journey. Gathering together all the small gossip of a county, profitless occupation as it would be, might yet occasionally help to establish some useful fact—say, a good example of hereditary transmission. But in these cases every one would admit that there was no proportion between the required labor and the probable benefit. No one would tolerate the proposal to devote some years of a boy's time to getting such information, at the cost of much more valuable information which he might else have got. And if here the test of relative value is appealed to and held conclusive, then should it be appealed to and held conclusive throughout. Had we time to master all subjects we need not be particular. To quote the old song:

> "Could a man be secure
> That his days would endure
> As of old, for a thousand long years,
> What things might he know!
> What deeds might he do!
> And all without hurry or care."

"But we that have but span-long lives" must ever bear in mind our limited time for acquisition. And remembering how narrowly this time is limited, not only by the shortness of life but also still more by the business of life, we ought to be especially solicitous to employ what time we have to the greatest advantage. Before devoting years to some subject which fashion or fancy suggests, it is surely wise to weigh with great care the worth of the results, as compared with the worth of various alternative results which the same years might bring if otherwise applied.

In education, then, this is the question of questions, which it is high time we discussed in some methodic way. The first in importance, though the last to be considered, is the problem, how to decide among the conflicting claims of various subjects on our attention. Before there can be a rational *curriculum*, we must settle which things it most concerns us to know; or, to use a word of Bacon's, now unfortunately obsolete, we must determine the relative values of knowledges.

To this end a measure of value is the first requisite. And happily, respecting the true measure of value, as expressed in general terms, there can be no dispute. Every one in contending for the worth of any particular order of information, does so by showing its bearing upon some part of life. In reply to the question, "Of what use is it?" the mathematician, linguist, naturalist, or philosopher explains the way in which his learning beneficially influences action—saves from evil or secures good—conduces to happiness. When the teacher of writing has pointed out how great an aid writing is to success in business—that is, to the obtainment of sustenance—that is, to satisfactory living—he is held to have proved his case. And when the collector of dead facts (say a numismatist) fails to make clear any appreciable effects which these facts can produce on human welfare, he is obliged to admit that they are comparatively valueless. All then, either directly or by implication, appeal to this as the ultimate test.

How to live?—that is the essential question for us. Not how to live in the mere material sense only, but in the widest sense. The general problem which comprehends every special problem is, the right ruling of conduct in all directions under all circumstances. In what way to treat the body; in what way to treat the mind; in what way to manage our affairs; in what way to bring up a family; in what way to behave as a citizen; in what way to utilize all those sources of happiness which nature supplies—how to use all our faculties to the greatest advantage of ourselves and others—how to live completely? And this being the great thing needful for us to learn, is, by consequence, the great thing which education has to teach. To prepare us for complete living is the function which education has to discharge; and the only rational mode of judging of any educational course is, to judge in what degree it discharges such function.

This test, never used in its entirety, but rarely even partially used, and used then in a vague, half-conscious way, has to be applied consciously, methodically, and throughout all cases. It behooves us to set before ourselves, and ever to keep clearly in view, complete living as the end to be achieved; so that in bringing up our children we may choose subjects and methods of instruction with deliberate reference to this end. Not only ought we to cease from the mere unthinking adoption of the current fashion in education, which has no better warrant than any other fashion, but we must also rise above that

rude, empirical style of judging displayed by those more intelligent people who do bestow some care in overseeing the cultivation of their children's minds. It must not suffice simply to *think* that such or such information will be useful in after life, or that this kind of knowledge is of more practical value than that; but we must seek out some process of estimating their respective values, so that as far as possible we may positively *know* which are most deserving of attention.

Doubtless the task is difficult—perhaps never to be more than approximately achieved. But considering the vastness of the interests at stake, its difficulty is no reason for unsillanimously passing it by, but rather for devoting every energy to its mastery. And if we only proceed systematically, we may very soon get at results of no small moment.

Our first step must obviously be to classify, in the order of their importance, the leading kinds of activity which constitute human life. They may be naturally arranged into, 1. Those activities which directly minister to self-preservation; 2. Those activities which, by securing the necessaries of life, indirectly minister to self-preservation; 3. Those activities which have for their end the rearing and discipline of offspring; 4. Those activities which are involved in the maintenance of proper social and political relations; 5. Those miscellaneous activities which make up the leisure part of life, devoted to the gratification of the tastes and feelings.

That these stand in something like their true order of subordination, it needs no long consideration to show. The actions and precautions by which, from moment to moment, we secure personal safety must clearly take precedence of all others. Could there be a man, ignorant as an infant of all surrounding objects and movements, or how to guide himself among them, he would pretty certainly lose his life the first time he went into the street, notwithstanding any amount of learning he might have on other matters. And as entire ignorance in all other directions would be less promptly fatal than entire ignorance in this direction, it must be admitted that knowledge immediately conducive to self-preservation is of primary importance.

That next after direct self-preservation comes the indirect self-preservation, which consists in acquiring the means of living, none will question. That a man's industrial functions must be considered before his parental ones is manifest from the fact that, speaking generally, the discharge of the parental functions is made possible only by the previous discharge of the industrial ones. The power of self-maintenance necessarily preceding the power of maintaining offspring, it follows that knowledge needful for self-maintenance has stronger claims than knowledge needful for family welfare—is second in value to none save knowledge needful for immediate self-preservation.

As the family comes before the state in order of time—as the bringing up of children is possible before the state exists, or when it has ceased to be, whereas the state is rendered possible only by the bringing up of children—it follows that the duties of the parent demand closer attention than those of the citizen. Or, to use a further argument, since the goodness of a society ultimately depends on the nature of its citizens, and since the nature of its citizens is more modifiable by early training than by anything else, we must conclude that the welfare of the family underlies the welfare of society. And hence knowledge directly conducing to the first must take precedence of knowledge directly conducing to the last.

Those various forms of pleasurable occupation which fill up the leisure left by grave occupations—the enjoyments of music, poetry, painting, etc.—manifestly imply a pre-existing society. Not only is a considerable development of them impossible without a long-established social union, but their very subject-matter consists in great part of social sentiments and sympathies. Not only does society supply the conditions to their growth, but also the ideas and sentiments they express. And consequently that part of human conduct which constitutes good citizenship is of more moment than that which goes out in accomplishments or exercise of the tastes; and, in education, preparation for the one must rank before preparation for the other.

Such then, we repeat, is something like the rational order of subordination: That education which prepares for direct self-preservation; that which prepares for indirect self-preservation; that which prepares for parenthood; that which prepares for 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 deny that they are intricately entangled with each other in such way that there can be no training for any that is not in some measure a training for all. Nor do we question that of each division there are portions more important than certain portions of the preceding divisions: that, for instance, a man of much skill in business, but little other faculty, may fall farther below the standard of complete living than one of but moderate power of acquiring money but great judgment as a parent; or that exhaustive information bearing on right social action, joined with entire want of general culture in literature and the fine arts, is less desirable than a more moderate share of the one joined with some of the other. But, after making all qualifications, there still remain these broadly-marked divisions: and it still continues substantially true that these divisions subordinate one another in the foregoing order, because the corresponding divisions of life make one another *possible* in that order.

Of course the ideal 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 exhaustive cultivation in any one, supremely important though it may be—not even an exclusive attention to the two, three, or four divisions of greatest importance; but an attention to all—greatest where the value is greatest, less where the value is less, least where the value is least. For the average man (not to forget the cases in which peculiar aptitude for some one department of knowledge rightly makes that one the bread-winning occupation)—for the average man, we say, the desideratum is, a training that approaches nearest to perfection in the things which most subserve complete living, and falls more and more below perfection in the things that have more and more remote bearings on complete living.

In regulating education by this standard there are some general 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 contingent. There is knowledge of intrinsic value, knowledge of quasi-intrinsic value, and knowledge of conventional value. Such facts as that sensations of numbness and tingling commonly precede paralysis, 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 truths of science in general, are of intrinsic value: they will bear on human conduct ten 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 considered to have a value that is 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 History—the mere tissue of names and dates and dead unmeaning events—has a conventional value only; it has not the remotest bearing upon any of our actions, and is of use only for the avoidance of those unpleasant criticisms which current opinion passes upon its absence. Of course, as those facts which concern all mankind throughout all time must be held of greater moment than those which concern only a portion of them during a limited era, and of far greater moment than those which concern only a portion of them during the continuance of a fashion, it follows that in a rational estimate, knowledge of intrinsic worth must, other things equal, take precedence of knowledge that is of quasi-intrinsic or conventional worth.

One further preliminary. Acquirement 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 complete living have to be considered under both these heads.

These, then, are the general ideas with which we must set out in discussing a *curriculum*: Life as divided into several kinds of activity of successively decreasing importance; the worth of each order of facts as regulating these several kinds of activity, intrinsically, quasi-intrinsically, and conventionally; and their regulative influences estimated both as knowledge and discipline.

Happily, that all-important part of education which goes to secure direct self-preservation is in great part already provided for. Too momentous to be left to our blundering, nature takes it into her own hands. While yet in its nurse's arms, the infant, by hiding its face and crying at the sight of a stranger, shows the dawning instinct to attain safety by flying from that which is unknown and may be dangerous; and when it can walk, the terror it manifests if an unfamiliar dog comes near, or the screams with which it runs to its mother after any startling sight or sound, shows this instinct further developed. Moreover, knowledge subserving direct self-preservation is that which it is chiefly busied in acquiring from hour to hour. How to balance its body; how to control its movements so as to avoid collisions; what objects are hard, and will hurt if struck; what objects are heavy, and injure if they fall on the limbs; which things will bear the weight of the body, and which not; the pains inflicted by fire, by missiles, by sharp instruments—these, and various other pieces of information needful 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 see in all these actions by which the muscles are developed the perceptions sharpened and the judgment quickened, a preparation for the safe conduct of the body among surrounding objects and movements, and for meeting those greater dangers that occasionally occur in the lives of all. Being thus, as we say, so well cared for by nature, this fundamental education needs comparatively little care from us. What we are chiefly called upon to see is, that there shall be free scope for gaining this experience and receiving this discipline—that there shall be no such thwarting of nature as that by which stupid schoolmistresses commonly prevent the girls in their charge from the spontaneous physical 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 comprehended in the education that prepares for direct self-preservation. Besides guarding the body against mechanical damage or destruction, it has to be guarded

against injury from other causes—against the disease and death that follow breaches of physiologic law. For complete living it is necessary, not only that sudden annihilations of life shall be warded off, but also that there shall be escaped the incapacities and the slow annihilation which unwise habits entail. As, without health and energy, the industrial, the parental, the social, and all other activities become more or less impossible, it is clear that this secondary kind of direct self-preservation is only less important than the primary kind, and that knowledge tending to secure it should rank very high.

It is true that here, too, guidance is in some measure ready supplied. By our various physical sensations and desires nature has insured a tolerable conformity to the chief requirements. Fortunately for us, want of food, great heat, extreme cold, produce promptings too peremptory to be disregarded. And would men habitually obey these and all like promptings when less strong, comparatively few evils 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 there were not 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 life that men do not even know that their sensations are their natural guides, and (when much reduced by habitual or long-continued disobedience) their trustworthy guides. So that though, to speak teleologically, nature has provided efficient safeguards to health, lack of knowledge makes them in a great measure useless.

If any one doubts the importance of an acquaintance with the fundamental principles of physiology as a means to complete living, let him look around and see how many men and women he sees who in middle or latter life who are thoroughly well. Occasionally only do we meet with an example of vigorous health continued to old age; hourly do we meet with examples of acute disorder, chronic ailment, general debility, premature decrepitude. Scarcely there one is there on 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 followed reckless exposure. There is a case of eyes spoiled for life by over-study. Yesterday the account was of one whose long-enduring lameness was brought on by continuing, spite of the pain, to use the limb after 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 overtaxed brain. Now we hear of an irremediable injury that followed some sudden feat of strength; and, again, of a constitution that has never recovered from the effects of excessive work needlessly undertaken; while on all sides we see the perpetual minor ailments which accompany feeblenss. Not to dwell on the natural pain, the weariness, the gloom, the waste of time and money thus entailed, only consider how greatly ill-health hinders the discharge of all duties—makes 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 makes amusement a bore. Is it not clear that the physical sins—partly our forefathers' and partly our own—which produce this ill-health, deduct more from complete living than anything else? and to a great extent make life a failure and a burden instead of a benefaction and a pleasure?

To all which add the fact that life, besides being thus immensely deteriorated, is also cut short. It is not true, as we commonly suppose, that a disorder or disease from which we have recovered leaves us as before. No disturbance of the normal course of the functions can pass away and leave things exactly as they were. In all cases a permanent damage is done—not immediately appreciable, it may be, but still there; and along with other such items which nature in her strict account-keeping never drops, will tell against us to the inevitable shortening of our days. Through the accumulation of small injuries it is that constitutions are commonly undermined, and break down long before their time. And if we call to mind how far the average duration of life falls below the possible duration we see how immense is the loss. When to the numerous partial deductions which bad health entails we add this great final deduction, it results that ordinarily more than one half of life is thrown away.

Hence, knowledge which subserves direct self-preservation by preventing this loss of health is of primary importance. We do not overrate the importance of such knowledge would by any means wholly remedy the evil. For it is clear that in our present phase of civilization men's necessities often compel them to transgress. And it is further clear that, even in the absence of such compulsion, their inclinations would frequently lead them, spite of their knowledge, to sacrifice future good to present gratification. But we do contend that the right knowledge impressed in the right way would effect much; and we further contend that as the laws of health must be recognized before they can be fully conformed to, the imparting of such knowledge must precede a more rational living, come when that may. We infer that as rigorous health usually accompanying high spirits are larger elements of happiness than any other things whatever, the teaching how to maintain them is a teaching that yields in moment to no other whatever. And therefore we assert that a knowledge of physiology as is needful for the comprehension of its general truths, and their bearings on daily conduct, is an all-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 Iphigenia instead of Iphigenia would resent as an insult any imputation of ignorance respecting the fabled labors of a fabled demigod, show not the slightest shame in confessing that they do not know where the Eustachian tubes are, that are 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 would not that they should be taught anything about the structure and functions of their own bodies—nay, would even disapprove such instruction. So overwhelming is the influence of established routine! So terribly in our education does the ornamental override the useful!

We need not insist on the value of that knowledge which aids indirect self-preservation by facilitating the gaining of a livelihood. This is admitted by all; and, indeed, by the mass is perhaps too exclusively regarded as the end of education. But while every one is ready to indorse the abstract proposition that instruction fitting youths for the business of life is of high importance, or even to consider it of supreme importance, yet scarcely any inquire what instruction will so fit them. It is true that reading, writing, and arithmetic are taught with an intelligent appreciation of their uses: but when we have said this we have said nearly all. While the great bulk of what else is acquired has no bearing on the industrial activities, an immensity of information that has a direct bearing on the industrial activities is entirely passed over.

For, leaving out only some very small classes, what are all men employed in? They are employed in the production, preparation, and distribution of commodities. And on what does efficiency in the production, preparation, and distribution of commodities depend? It depends on the use of methods fitted to the respective natures of these commodities; it depends on an adequate knowledge of their physical, chemical, or vital properties, as the case may be; that is, it depends on science. This order of knowledge, which is in great part ignored in our school courses, is the order of knowledge underlying the right performance of all those processes by which civilized life is made possible. Undeniable as is this truth, and thrust upon us as it is at every turn, there seems to be no living consciousness of it: its very familiarity makes it unregarded. 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 work by guesses acquired during his apprenticeship, equally with the builder of a Britannia Bridge, makes hourly reference to the laws of quantitative relations. The surveyor on whose survey the land is purchased; the architect in designing a mansion to be built on it; the builder in preparing his estimates; his foreman in laying out the foundations; the masons in cutting the stones; and the various artisans who put up the fittings; are all guided by geometrical rules. Railway engineers, regulated from beginning to end by mathematics: alike in the preparation of plans and sections; in staking out the line; in the mensuration of cuttings and embankments; in the designing, constructing, and ventilating of tunnels, viaducts, tunnels, stations. And similarly with the harbors, docks, piers, and various engineering and architectural works that fringe the coasts and overspread the face of the country, as well as the mines that run underneath it. Out of geometry, too, is applied to astronomy, the art of navigation has grown; and so, by this science, has been made possible that enormous foreign commerce which supports a large part of our population, and supplies us with many necessaries and most of our luxuries. And nowadays even the farmer, for the correct laying out of his drains, has recourse to the level—that is, to geometrical principles. When from those divisions of mathematics which deal with *space* and *number*, some small smattering of which is given in schools, we turn to that other division which deals with *force*, of which even a smattering is scarcely ever given, we meet with another large class of activities which this science presides over. On the application of rational mechanics depends the success of nearly all modern manufacture. The properties of the lever, the wheel and axle, etc., are involved in every machine—every machine is a solidified mechanical theorem; and to machinery in these times we owe nearly all production. Trace the history of the breakfast-roll. The soil out of which it came was drained with machine-made tiles; the surface was turned over by a machine; the seed was put in by a machine; the wheat was reaped, thrashed, and winnowed by machines; by machinery it was ground and bolted; and had the flour been sent to Gosport, it might have been made into biscuits by a machine. Look round the room in which you sit. If modern, probably the bricks in its walls were machine-made; by machinery the flooring was sawn and planed, the mantel-shelf sawn and polished, the paper-hangings made and printed; the veneer on the table, the turned legs of the chairs, the carpet, the curtains, are all products of machinery. And your clothing—plain, figured, or printed—is it not

wholly woven, nay, perhaps even sewed by machinery? And the volume you are reading—are not its leaves fabricated by one machine and covered with these words by another? Add to which that for the means of distribution over both land and sea we are similarly indebted. And then let it be remembered that according as the principles of mechanics are well or ill used to these ends comes success or failure—individual and national. The engineer who misapplies his formulæ for the strength of materials builds a bridge that breaks down. The manufacturer whose apparatus is badly devised cannot compete with another whose apparatus wastes less in friction and inertia. The shipbuilder, adhering to the old model, is outsailed by one who builds on the mechanically-justified wave-line principle. And as the ability of a nation to hold its own against other nations depends on the skilled activity of its units, we see that on such knowledge may turn the national fate. Judge then the worth of mathematics.

Pass next to physics. Joined with mathematics, it has given us the steam-engine, which does the work of millions of laborers. That science of physics which has taught us the laws of heat has taught us how to economize fuel in our various industries; how to increase the produce of our smelting furnaces by substituting the hot for the cold blast; how to ventilate our mines; how to prevent explosions by using the safety-lamp; and, through the thermometer, how to regulate innumerable processes. That division which has the phenomena of light for its subject gives eyes to the old and the myopic; aids through the microscope in detecting adulterations; and by improved lighthouses prevents shipwrecks. Researches in electricity and magnetism have saved incalculable life and property by the compass; have suggested the telegraph, the electrotype; and now, in the telegraph, have supplied us with the agency by which for the future all mercantile transactions will be regulated, political intercourse carried on, and perhaps national wars prevented or shortened. While in the details of in-door life, from the improved kitchen-range up to the stereoscope on the drawing-room table, the applications of advanced physics underlie our comforts and gratifications.

Still more numerous are the bearings of chemistry on those activities by which men obtain the means of living. The bleacher, the dyer, the calico-printer, are severally occupied in processes that are well or ill done according as they do or do not conform to chemical laws. The economical reduction from their ores of copper, tin, zinc, lead, silver, iron, are in a great measure questions of chemistry. Sugar-refining, gas-making, soap-boiling, paper-manufacture, are operations all partly chemical; as are also those by which are produced glass and porcelain. Whether the distiller's wort stops at the alcoholic fermentation or passes into the acetous is a chemical question on which hangs his profit or loss; and the brewer, if his business is sufficiently large, finds it pay to keep a chemist on his premises. Glance through a work on technology, and it becomes at once apparent that there is now scarcely any process in the arts or manufactures over some part of which chemistry does not preside. And then, lastly, we come to the fact that in these times, agriculture, to be profitably carried on, must have like guidance. The analysis of manures and soils; their adaptations to each other; the use of gypsum or other substance for fixing ammonia; the utilization of coprolites; the production of artificial manures—all these are boons of chemistry which it behooves the farmer to acquaint himself with. Be it in the lucifer match, or in disinfected sewage, or in photographs; in bread made without fermentation, or perfumes extracted from refuse, we may perceive that chemistry affects 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 not this, too, bear fundamentally upon these processes of indirect self-preservation? With what we ordinarily call manufactures, it has, indeed, little connection; but with the all-essential manufacture—that of food—it is inseparably connected. As agriculture must conform its methods to the phenomena of vegetable and animal life, it follows necessarily that the science of these phenomena is the rational basis of agriculture. Various biological truths have indeed been empirically established and acted upon by farmers while yet there has been no conception of them as science: such as that particular manures are suited to particular plants; that crops of certain kinds unfit the soil for other crops; that horses cannot be reared on poor food; that such and such diseases of cattle and sheep are caused by such and such conditions. These, and the every-day knowledge which the agriculturist gains by experience respecting the right management of plants and animals, constitute the stock of biological facts, on the largeness of which greatly depends his success. And as these biological facts, scanty, indefinite, rudimentary though they are, aid him so essentially, judge what need he has of more facts of this kind when they become positive, definite, and exhaustive. Indeed, even now we may see the benefits that rational biology is conferring on him. The truth that the production of animal heat implies waste of substance, and that, therefore, feeding more than his own, prevents the need for extra food—a purely theoretical conclusion—now guides the fattening of cattle: it is found that by keeping cattle warm fodder is saved. Similarly with other results to which the experiments of 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 a disorder known as "the staggers," of which many thousands of sheep have died annually, is caused by an entozoon which presses on the brain, and that if the creature is extracted through the softened place in the skull which marks its position the sheep usually recovers, is another debt which agriculture owes to biology. When we observe the marked contrast between our farming and farming on the Continent, and remember that the superiority of our 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 infer that ere long, 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 Society. Without knowing it, men who daily look at the state of the money-market, glance over prices current, discuss the probable crops of corn, cotton, sugar, wool, silk, weigh the chances of war, and from all those data decide on their mercantile operations, are students of social science: empirical and blundering students it may be, but still students who gain the prizes or are plucked of their profits according as they do or do not reach the right conclusion. Not only the manufacturer and the merchant must guide their transactions by calculations of supply and demand, based on numerous facts, and tacitly recognizing sundry general principles of social action, but even the retailer must do the like: his prosperity very 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 vary.

Thus, to all such as are occupied in the production, exchange, or distribution of commodities, acquaintance with science in some of its departments is of fundamental importance. Whoever is immediately or remotely implicated in any form of industry (and few are not) has a direct interest in understanding something of the mathematical, physical, and chemical properties of things; perhaps, also, has a direct interest in biology; and certainly has in sociology. Whether he does or does not succeed well in that indirect self-preservation which we call getting a good livelihood depends in a great degree on his knowledge of one or more of these sciences: not, it may be, a rational knowledge, but still a knowledge, though empirical. For what we call learning a business really implies knowledge of the sciences involved in it, though not perhaps under the name of science. And hence a grounding in science is of great importance, both because it prepares for all this, and because rational knowledge has an immense superiority over empirical 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 and processes with which he is concerned in his maker or distributor, but it is often of much moment that he should understand the *how* and the *why* of various other things and processes. In this age of joint-stock undertakings, nearly every man above the laborer is interested as capitalist in some other business than his own; and, as thus interested, his profit or loss often depends on his knowledge of the sciences bearing on this other occupation. Here is a mine, in the sinking of which many shareholders ruined themselves, by throwing away that a certain fossil belonged to the old red sandstone, below which no coal is found. Not many years ago 20,000*l.* was lost in the prosecution of a scheme for collecting the alcohol that should be from beneath the ship which would have been saved to the subscribers had they known that less than a hundredth part by weight of the flour is changed in fermentation. Numerous attempts have been made to construct electro-magnetic engines, in the hopes of superseding steam; but had those who supplied the money understood the general law of the correlation and equivalence of forces they might have had better balances at their bankers. Daily are men indeed 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 fortunes thrown away over some impossible project.

And if already the loss from want of science is so frequent and so great, still greater and more frequent will it be to those who hereafter lack science. Just as fast as productive processes become more scientific, which competition will inevitably make them do, and just as fast as joint-stock undertakings spread, which they certainly will, so fast will scientific knowledge grow necessary to every one.

That which 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 that information which men begin to 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 accumulated and spread by unofficial means, these industries would never have existed. Had there been no teaching but such as is given in our public schools, England would now be what it was in feudal times. That increasing acquaintance with the laws of phenomena which has through successive ages enabled us 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 instructing our youth. The vital knowledge—that by which we have grown as a nation to what we are, and which now underlies our whole existence—is a knowledge that has got itself taught in nooks and corners, while the ordained agencies for teaching have been mumbling little else but dead formulas.

We come now to the third great division of human activities—a division for which no preparation whatever is made. If by some strange chance not a vestige of us descended to the remote future save a pile of our school-books or some college examination papers, we may imagine how puzzled an antiquary of the period would be on finding in them no indication that the learners were ever likely to be parents. "This must have been the *curriculum* for their celibates," we may fancy him concluding. "I perceive here an elaborate preparation for many things, especially for reading the books of extinct nations and of co-existing nations (from which indeed it seems clear that these people had very little worth reading in their own tongue); but I find no reference whatever to the bringing up of children. They could not have been so absurd as to omit all training for this gravest of responsibilities. Evidently then this was the school course of one of their monastic orders."

Seriously, is it not an astonishing fact, that though on the treatment of offspring depend their lives or deaths, and their moral 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 monstrous that the fate of a new generation should be left to the chances of unreasoning custom, impulse, fancy, joined with the suggestions of ignorant nurses and the prejudiced counsel of grandmothers? If a merchant commenced business without any knowledge of arithmetic and book-keeping, we should exclaim at his folly and look for disastrous consequences. Or if, before studying anatomy, a man set up as a surgical operator, we should wonder at his audacity and pity his patients. But that parents should begin the difficult task of rearing children without ever having given a thought to the principles—physical, moral, or intellectual—which ought to guide them, excites neither surprise at the actors nor pity for their victims.

To tens of thousands that are killed, add hundreds of thousands that survive with feeble constitutions, and millions that grow 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, and that there are twenty ways of going wrong to one way of going right, and you will get some idea of the enormous mischief that is almost everywhere inflicted by the thoughtless, haphazard system in common use. Is it decided that a boy shall be clothed 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 been, and consequent hindrances to success and happiness. Are children doomed to a monotonous dietary, or a dietary that is deficient in nutritiveness? Their ultimate physical power, and their efficiency as men and women, will inevitably be more or less diminished by it. Are they forbidden vociferous play, or (being too ill-clothed to bear exposure) are they kept indoors in cold weather? 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 of Providence. Thinking after the prevalent chaotic fashion, they assume that these evils come without causes, or that the causes are supernatural. Nothing of the kind. In some cases the causes are doubtless inherited, but in most cases foolish regulations are the causes. Very generally parents themselves are responsible for all this pain, this debility, this depression, this misery. They have undertaken to control the lives of their offspring from hour to hour; with cruel carelessness they have neglected to learn anything about these vital processes which they are unceasingly affecting by their commands and prohibitions; in utter ignorance of the simplest physiologic laws, they have been year by year undermining 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 injury, when we turn from physical training to moral training. Consider the young mother and her nursery legislation. But a few years ago she was at school, where her memory was crammed with words and names and dates, and her reflective faculties scarcely in the slightest degree exercised—where not one idea was given her respecting the methods of dealing with the opening mind of childhood, and where her discipline did not in the least fit her for thinking out methods of her own. The intervening years have been passed in practising music, in fancy-work, in novel-reading, and in party-going: no thought having yet been given to the grave responsibilities of maternity, and scarcely any of that solid intellectual culture obtained which would be some preparation for such responsibilities. And now see her with an unfolding human character committed to her charge—see her profoundly ignorant 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 profoundest knowledge. She knows nothing about the nature of the emotions, their order of evolution, their functions, or where use ends and abuse begins. She is under the impression that some of the feelings are 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. And then, ignorant as 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. What can be more inevitable than the disastrous results we see hourly arising? Lacking knowledge of mental phenomena, with their causes and consequences, her interference is frequently more mischievous than absolute passivity would have been. This and that kind of action, which are quite normal and beneficial, she perpetually thwarts, and so diminishes the child's happiness and profit, injures its temper and her own, and produces estrangement. Deeds which she thinks it desirable to encourage she gets performed by threats and bribes, or by exciting a desire for applause, considering little what the inward motive may be, so long as the outward conduct conforms, and thus cultivating hypocrisy, and fear, and selfishness, in place of good feeling. While insisting on truthfulness, she constantly sets an example of untruth, by threatening penalties which she does not inflict. While inculcating self-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 nursery, as in the world, that alone is the truly salutary discipline which visits on all conduct, good and bad, the natural consequences—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 processes 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 overwhelming tendency of the growing mind to assume the moral type of the race usually subordinates all minor influences.

And then the culture of the intellect—is not this, too, mismanaged in a similar manner? Grant that the phenomena of intelligence conform to laws; grant that the evolution of intelligence in a child also conforms to laws, and it follows inevitably that education can be rightly guided only by a knowledge of these laws. To suppose that you can properly regulate this process of forming and accumulating ideas without understanding the nature of the process is absurd. How widely, then, must teaching as it is differ from teaching as it should be; when hardly any parents, and but few teachers, know anything about psychology. As might be expected, 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 common limited idea of education which confines it to knowledge gained from books, parents thrust primers into the hands of their little ones years too soon, to their great injury. Not recognizing the truth that the function of books is supplementary—that they form an indirect means to knowledge when direct means fail—a means of seeing through other men what you cannot see for yourself, they are eager to give second-hand facts in place of first-hand facts. Not perceiving the enormous value of that spontaneous education which goes on in early years—not perceiving that a child's restless observation, instead of being ignored or checked, should be diligently administered to, and made as accurate and complete as possible, they insist on occupying its eyes and thoughts with things that are, for the time being, incomprehensible and repugnant. Possessed by a superstition which worships the symbols of knowledge instead of the knowledge itself, they do not see that only when his acquaintance with the objects and processes of the household, the streets, and the fields, is becoming tolerably exhaustive—only then should a child be introduced to the new sources of information which books supply; and this, not only because immediate cognition is of far greater value than mediate cognition, but also because the words contained in books can be rightly interpreted into ideas only in proportion to the antecedent experience of things. Observe next that this formal instruction, far too soon commenced, is carried on with but little reference to the laws of mental development. Intellectual progress is of necessity from the concrete to the abstract. But regardless of this, highly abstract subjects, such as grammar, which should come quite late, are begun quite early. Political geography, dead and uninteresting to a child, and which should be an appendage of sociological studies, is commenced betimes, while physical geography, comprehensible and comparatively attractive to a child, is in great part passed over. Nearly every subject dealt with is arranged in abnormal order: definitions and rules and principles being put first, instead of being disclosed, as they are in the order of nature, through the study of cases. And then pervading the whole is the vicious system of rote learning—a system of sacrificing the spirit to the letter. See the results. What with perceptions unnaturally dulled by early thwarting, and a coerced attention to books; what with the mental confusion 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-

ing him to be an active inquirer or self-instructor; and what with taxing the faculties to excess, there are very few minds that become as efficient as they might be. Examinations being once passed, books are laid aside; the greater part of what has been acquired, being unorganized, soon drops out of recollection; what remains is mostly inert—the art of applying knowledge not having been cultivated—and there is but little power either of accurate observation or independent thinking. To all which add that while much of the information gained is of relatively small value, an immense mass of information of transcendent value is entirely passed over.

Thus we find the facts to be such as might have been inferred *à priori*. The training of children—physical, moral, and intellectual—is dreadfully defective. And in great measure it is so because parents are devoid of that knowledge by which this training can alone be rightly guided. What is to be expected when one of the most intricate of problems is undertaken by those who have given scarcely a thought to the principles on which its solution depends? For shoe-making or house-building, for the management of a ship or a locomotive-engine, a long apprenticeship is needful. Is it, then, that the unfolding of a human being in body and mind is so comparatively simple a process that any one may superintend and regulate it with no preparation whatever? If not—if the process is with one exception more complex than any in nature, and the task of administering to it one of surpassing difficulty—is it not madness to make no provision for such a task? Better sacrifice accomplishments than omit this all-essential instruction. When a father, acting on false dogmas adopted without examination, has alienated his sons, driven them into rebellion by his harsh treatment, ruined them, and made himself miserable, he might reflect that the study of Ethology would have been worth pursuing, even at the cost of knowing nothing about Æschylus. When a mother is mourning over a first-born that has sunk under the sequelæ of scarlet fever—when perhaps a candid medical man has confirmed her suspicion that her child would have recovered had not its system been enfeebled by over-study—when she is prostrate under the pangs of combined grief and remorse, it is but a small consolation that she can read Dante in the original.

Thus we see that for regulating the third great division of human activities a knowledge of the laws of life is the one thing needful. Some acquaintance with the first principles of physiology and the elementary truths of psychology is indispensable for the right bringing up of children. We doubt not that this assertion will by many be read with a smile. That parents in general should be expected to acquire a knowledge of subjects so abstruse will seem to them an absurdity. And if we proposed that an exhaustive knowledge of these subjects should be obtained by all fathers and mothers, the absurdity would indeed be glaring enough. But we do not. General principles only, accompanied by such detailed illustrations as may be needed to make them understood, would suffice. And these might be readily taught—if not rationally, then dogmatically. Be this as it may, however, here are the indisputable facts: that the development of children in mind and body rigorously obeys certain laws; that unless these laws are in some degree conformed to by parents death is inevitable; that unless they are in a great degree conformed to there must result serious physical and mental defects; and that only when they are completely conformed to can a perfect maturity be reached. Judge, then, whether all who may one day be parents should not strive with some anxiety to learn what these laws are.

From the parental functions let us pass now to the functions of the citizen. We have here to inquire what knowledge best fits a man for the discharge of these functions. It cannot be alleged, as in the last case, that the need for knowledge fitting him for these functions is wholly overlooked; for our school courses contain certain studies which, nominally at least, bear upon political and social duties. Of these the only one that occupies a prominent place is history.

But, as already more than once hinted, the historic information commonly given is almost valueless for purposes of guidance. Scarcely any of the facts set down in our school-histories, and very few even of those contained in the more elaborate works written for adults, give any clew to the right principles of political action. The biographies of monarchs (and our children commonly learn little else) throw scarcely any light upon the science of society. Familiarity with court intrigues, plots, usurpations, or the like, and with all the personalities accompanying them, aids very little in elucidating the principles on which national welfare depends. We read of some squabble for power, that it led to a pitched battle; that such and such were the names of the generals and their leading subordinates; that they had each so many thousand infantry and cavalry, and so many cannon; that they arranged their forces in this and that order; that they manœuvred, attacked, and fell back in certain ways; that at this part of the day such disasters were sustained, and at that such advantages gained; that in one particular movement some leading officer fell, while in another a certain regiment was decimated; that after all the changing fortunes of the fight, the victory was gained by this or that army; and that so many were killed and wounded on each side, and so many captured by the conquerors. And now, out of the accumulated details which make up the narrative, say which it is that helps you in deciding on your conduct as a citizen. Supposing even that you had diligently read, not only "The Fifteen Decisive Battles of the World," but accounts of all other battles that history mentions, how much more judicious would your vote be at the next election? "But these are facts—interesting facts," you say. Without doubt they are facts (such, at least, as are not wholly or partially fictions), and to many they may be interesting facts. But this by no means implies that they are valuable. Factitious or morbid opinion often gives seeming value to things that have scarcely any. A tulipomaniac will not part with a choice bulb for its weight in gold. To another man an ugly piece of cracked old china seems his most desirable possession. And there are those who give high prices for the relics or celebrated murderers. Will it be contended that these tastes are any measures of value in the things that gratify them? If not, then it must be admitted that the liking felt for certain classes of historical facts is no proof of their worth, and that we must test their worth as we test the worth of other facts, by asking to what uses they are applicable. Were some one to tell you that your neighbor's cat kittened yesterday, you would say the information was worthless. Fact though it might be, you would say it was an utterly useless fact—a fact that could in no way influence your actions in life—a fact that would not help you in learning how to live completely. Well, apply the same test to the great mass of historical facts, and you will get the same result. They are facts from which no conclusions can be drawn—*unorganizable* facts, and therefore facts which can be of no service in establishing principles of conduct, which is the chief use of facts. Read them, if you like, for amusement, but do not flatter yourself they are instructive.

That which constitutes history, properly so called, is in great part omitted from works on the subject. Only of late years have historians commenced giving us, in any considerable quantity, the truly valuable information. As in past ages the king was everything and the people nothing, so in past histories the doings of the king fill the entire picture to which the national life forms but an obscure background. While only now, when the welfare of nations rather than of rulers is becoming the dominant idea, are historians beginning to occupy themselves with the phenomena of social progress. That which it really concerns us to know is the natural history of society. We want all facts which help us to understand how a nation has grown and organized itself. Among these, let us of course have an account of its government, with as little as may be of gossip about the men who officered it, and as much as possible about the structure, principles, methods, prejudices, corruptions, etc., which it exhibited; and let this account not only include the nature and actions of the central government, but also those of local governments, down to their minutest ramifications. Let us of course also have a parallel description of the ecclesiastical government—its organization, its conduct, its power, its relations to the state; and accompanying this, the ceremonial, creed, and religious ideas—not only those nominally believed, but those really believed and acted upon. Let us at the same time be informed of the control exercised by class over class, as displayed in all social observances—in titles, salutations, and forms of address. Let us know, too, what were all the other customs which regulated the popular life out of doors and in-doors, including those which concern the relations of the sexes, and the relations of parents to children. The superstitions, also, from the more important myths down to the charms in common use, should be indicated. Next should come a delineation of the industrial system, showing to what extent the division of labor was carried; how trades were regulated, whether by caste, guilds, or otherwise; what was the connection between employers and employed; what were the agencies for distributing commodities, what were the means of communication; what was the circulating medium. Accompanying all which should come an account of the industrial arts technically considered, stating the processes in use, and the quality of the products. Further, the intellectual condition of the nation in its various grades should be depicted, not only with respect to the kind and amount of education, but with respect to the progress made in science, and the prevailing manner of thinking. The degree of æsthetic culture, as displayed in architecture, sculpture, painting, dress, music, poetry, and fiction, should be described. Nor should there be omitted a sketch of the daily lives of the people—their food, their homes, and their amusements. And lastly, to connect the whole, should be exhibited the morals, theoretical and practical, of all classes, as indicated in their laws, habits, proverbs, deeds. All these facts, given with as much brevity as consists with clearness and accuracy, should be so grouped and arranged that they may be comprehended in their *ensemble*, and thus may be contemplated as mutually dependent parts of one great whole. The aim should be so to present them that we may readily trace the *consensus* subsisting among them, with the view of learning what social phenomena co-exist with what others. And then the corresponding delineations of succeeding ages should be so managed as to show us, as clearly as may be, how each belief, institution, custom, and arrangement was modified, and how the *consensus* of preceding structures and functions was developed into the *consensus* of succeeding ones. Such alone is the kind of information respecting past times which can be of service to the citizen for the regulation of his

conduct. The only history that is of practical value is what may be called Descriptive Sociology. And the highest office which the historian can discharge is that of so narrating the lives of nations as to furnish materials for a Comparative Sociology, and for the subsequent determination of the ultimate laws to which social phenomena conform.

But now mark, that even supposing an adequate stock of this truly valuable historical knowledge has been acquired, it is of comparatively little use without the key. And the key is to be found only in science. Without an acquaintance with the general truths of biology and psychology, rational interpretation of social phenomena is impossible. Only in proportion as men obtain a certain rude empirical knowledge of human nature are they enabled to understand even the simplest facts of social life, as, for instance, the relation between supply and demand. And if not even the most elementary truths of sociology can be reached until some knowledge is obtained of how men generally think, feel, and act under given circumstances, then it is manifest that there can be nothing like a wide comprehension of sociology unless through a competent knowledge of man in all his faculties, bodily and mental. Consider the matter in the abstract, and this conclusion is self-evident. Thus: Society is made up of individuals; all that is done in society is done by the combined actions of individuals; and therefore in individual actions only can be found the solutions of social phenomena. But the actions of individuals depend on the laws of their natures, and their actions cannot be understood until these laws are understood. These laws, however, when reduced to their simplest expression, are found to depend on the laws of body and mind in general. Hence it necessarily follows that biology and psychology are indispensable as interpreters of sociology. Or, to state the conclusions still more simply: all social phenomena are phenomena of life, are the most complex manifestations of life, are ultimately dependent on the laws of life, and can be understood only when the laws of life are understood. Thus, then, we see that for the regulation of this fourth division of human activities we are, as before, dependent on science. Of the knowledge commonly imparted in educational courses very little is of any service in guiding a man in his conduct 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. He commonly lacks not only the materials for, but the very conception of, descriptive 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 division of human life which includes the relaxations, pleasures, and amusements filling leisure hours. After considering what training best fits for self-preservation, for the obtainment of sustenance, for the discharge of parental duties, and for the regulation of social and political conduct, we have now to consider what training best fits for the miscellaneous ends not included in these—for the enjoyments of nature, of literature, and of the fine arts, in all their forms. Postponing them as we do to things that bear more vitally upon human welfare, and bringing everything, as we have, to the test of actual value, it will perhaps be inferred that we are inclined to slight these less essential things. No greater mistake could be made, however. We yield to none in the value we attach to æsthetic 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 means of production have been brought to perfection—when labor has been economized to the highest degree—when education has been so systematized that a preparation for the more essential activities may be made with comparative rapidity—and when, consequently, there is a great increase of spare time, then will the poetry, both of art and nature, rightly fill a large space in the minds of all.

But it is one thing to admit that æsthetic culture is in a high degree conducive to human happiness, and another thing to admit that it is a fundamental requisite to human happiness. However important it may be, it must yield precedence to those kinds of culture which bear more directly upon the duties of life. As before hinted, literature and the fine arts are made possible by those activities which make individual and social life possible; and manifestly, that which is made possible must be postponed to that which makes it possible. A florist cultivates a plant for the sake of its flower, and regards the roots and leaves as of value chiefly because they are instrumental in producing the flower. But while, as an ultimate product, the flower is the thing to which everything else is subordinate, the florist very well knows that the root and leaves are intrinsically of greater importance, because on them the evolution of the flower depends. He bestows every care in rearing a healthy plant, and knows it would be folly if, in his anxiety to obtain the flower, he were to neglect the plant. Similarly in the case before us. Architecture, sculpture, painting, music, poetry, etc., may be truly called the efflorescence of civilized life. But even supposing them to be of such transcendent worth as to subordinate the civilized life out of which they grow (which can hardly be asserted), it will still be admitted that the production of a healthy civilized life must be the first consideration, and that the knowledge conducing to this must occupy the highest place.

And here we see most distinctly the vice of our educational system. It neglects the plant for the sake of the flower. In anxiety for elegance it forgets substance. While it gives no knowledge conducive to self-preservation—while of knowledge that facilitates gaining a livelihood it gives but the rudiments, and leaves the greater part to be picked up anyhow in after life—while for the discharge of parental functions it makes not the slightest provision—and 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, éclat. However fully we may admit that extensive acquaintance with modern languages is a valuable accomplishment, which, through reading, conversation, and travel, aids in giving a certain finish, it by no means follows that this result is rightly purchased at the cost of that vitally important knowledge sacrificed to it. Supposing it true that classical education conduces to elegance 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 the poetry written in extinct languages, yet it is not to be inferred that such improvement of taste is equivalent in value to an acquaintance with the laws of health. Accomplishments, the fine arts, *belles-lettres*, and all those things which, as we say, constitute the efflorescence of civilization, should be wholly subordinate to that knowledge and discipline in which civilization rests. *As they occupy the leisure part of life, so should they occupy the leisure part of education.*

Recognizing thus the true position of æsthetics, and holding that while the cultivation of them should form a part of education from its commencement, such cultivation should be subsidiary, we have now to inquire what knowledge is of most use to this end—what knowledge best fits for this remaining sphere of activity. To this question the answer is still the same as heretofore. Unexpected as the assertion may be, it is nevertheless true, that the highest art of every kind is based upon science—that without science there can be neither perfect production nor full appreciation. Science, in that limited technical acceptation current in society, may not have been possessed by many artists of high repute; but acute observers as they have been, they have always possessed a stock of those empirical generalizations which constitute science in its lowest phase, and they have habitually fallen far below perfection, partly because their generalizations were comparatively few and inaccurate. That science necessarily underlies the fine arts becomes manifest *à priori* when we remember that art-products are all more or less representative of objective or subjective phenomena; that they can be true only in proportion as they conform to the laws of these phenomena; and that before they can thus conform the artist must know what these laws are. That this *à priori* conclusion tallies with experience we shall soon see.

Youths preparing for the practice of sculpture have to acquaint themselves with the bones and muscles of the human frame in their distribution, attachments, and movements. This is a portion of science; and it has been found needful to impart it for the prevention of those many errors which sculptors who do not possess it commit. For the prevention of other mistakes, a knowledge of mechanical principles is requisite; and such knowledge not being usually possessed, grave mechanical mistakes are frequently made. Take an instance. For the stability of a figure it is needful that the perpendicular from the centre of gravity—"the line of direction," as it is called—should fall within the base of support; and hence it happens, that when a man assumes the attitude known as "standing at ease," in which one leg is straightened and the other relaxed, the line of direction falls within the foot of the straightened leg. But sculptors unfamiliar with the theory of equilibrium not uncommonly so represent this attitude that the line of direction falls midway between the feet. Ignorance of the laws of momentum leads to analogous errors, as witness the admired Discobolus, which, as it is posed, must inevitably fall forward the moment the quoit is delivered.

In painting, the necessity for scientific knowledge, empirical if not rational, is still more conspicuous. In what consists the grotesqueness of Chinese pictures, unless in their utter disregard of the laws of appearances—in their absurd linear perspective, and their want of aërial perspective? In what are the drawings of a child so faulty, if not in a similar absence of truth—an absence arising, in great part, from ignorance of the way in which the aspects of things vary with the conditions? Do but remember the books and lectures by which students are instructed, or consider the criticisms of Ruskin, or look at the doings of the Pre-Raffaelites, and you will see that progress in painting implies increasing knowledge of how effects in nature are produced. The most diligent observation, if not aided by science, fails to preserve from error. Every painter will indorse the assertion that unless it is known what appearances must exist under given circumstances they often will not be perceived; and to know what appearances must exist, is, in so far, to understand the science of appearances. From want of science Mr. J. Lewis, careful painter as he is, casts the shadow of a lattice-window in sharply-defined lines upon an opposite wall;

which he would not have done had he been familiar with the phenomena of penumbræ. From want of science Mr. Rosetti, catching sight of a peculiar iridescence displayed by certain hairy surfaces under particular lights (an iridescence caused by the diffraction of light in passing the hairs), commits the error of showing this iridescence on surfaces and in positions where it could not occur.

To say that music, too, has need of scientific aid will seem still more surprising. Yet it is demonstrable that music is but an idealization of the natural language of emotion, and that consequently music must be good or bad according as it conforms to the laws of this natural language. The various inflections of voice which accompany feelings of different kinds and intensities have been shown to be the germs out of which music is developed. It has been further shown that these inflections and cadences are not accidental or arbitrary, but that they are determined by certain general principles of vital action, and that their expressiveness depends on this. Whence it follows that musical phrases and the melodies built of them can be effective only when they are in harmony with these general principles. It is difficult here properly to illustrate this position. But perhaps it will suffice to instance the swarms of worthless ballads that infest drawing-rooms, as compositions which science would forbid. They sin against science by setting to music ideas that are not emotional enough to prompt musical expression; and they also sin against science by using musical phrases that have no natural relation to the ideas expressed, even where these are emotional. They are bad because they are untrue. And to say they are untrue is to say they are unscientific.

Even in poetry the same thing holds. Like music, poetry has its root in those natural modes of expression which accompany deep feeling. Its rhythm, its strong and numerous metaphors, its hyperboles, its violent inversions, are simply exaggerations of the traits of excited speech. To be good, therefore, poetry must pay respect to those laws of nervous action which excited speech obeys. In intensifying and combining the traits of excited speech it must have due regard to proportion—must not use its appliances without restriction; but, where the ideas are least emotional, must use the forms of poetical expression sparingly; must use them more freely as the emotion rises; and must carry them all to their greatest extent only where the emotion reaches a climax. The entire contravention of these principles results in bombast or doggerel. The insufficient respect for them is seen in didactic poetry. And it is because they are rarely fully obeyed that we have so much poetry that is inartistic.

Not only is it that the artist, of whatever kind, cannot produce a truthful work without he understands the laws of the phenomena he represents, but it is that he must also understand how the minds of spectators or listeners will be affected by the several peculiarities of his work—a question in psychology. What impression any given art-product generates manifestly depends upon the mental natures of those to whom it is presented; and as all mental natures have certain general principles in common, there must result certain corresponding general principles on which alone art-products can be successfully framed. These general principles cannot be fully understood and applied unless the artist sees how they follow from the laws of mind. To ask whether the composition of a picture is good is really to ask how the perceptions and feelings of observers will be affected by it. To ask whether a drama is well constructed is to ask whether its situations are so arranged as duly to consult the power of attention of an audience, and duly to avoid overtaxing any one class of feelings. Equally in arranging the leading divisions of a poem or fiction, and in combining the words of a single sentence, the goodness of the effect depends upon the skill with which the mental energies and susceptibilities of the reader are economized. Every artist, in the course of his education and after-life, accumulates a stock of maxims by which his practice is regulated. Trace such maxims to their roots, and you find they inevitably lead you down to psychological principles. And only when the artist rationally understands these psychological principles and their various corollaries can he work in harmony with them.

We do not for a moment believe that science will make an artist. While we contend that the leading laws both of objective and subjective phenomena must be understood by him, we by no means contend that knowledge of such laws will serve in place of natural perception. Not only the poet, but also the artist of every type, is born, not made. What we assert is that innate faculty alone will not suffice, but must have the aid of organized knowledge. Intuition will do much, but it will not do all. Only when genius is married to science can the highest results be produced.

As we have above asserted, science is necessary not only for the most successful production, but also for the full appreciation of the fine arts. In what consists the greater ability of a man than of a child to perceive the beauties of a picture, unless it is in his more extended knowledge of those truths in nature or life which the picture renders? How happens the cultivated gentleman to enjoy a fine poem so much more than a boor does, if it is not because his wider acquaintance with objects and actions enables him to see in the poem much that the boor cannot see? And if, as is here so obvious, there must be some familiarity with the things represented before the representation can be appreciated, then the representation can be completely appreciated only in proportion as the things represented are completely understood. The fact is that every additional truth which a work of art expresses gives an additional pleasure to the percipient mind—a pleasure that is missed by those ignorant of this truth. The more realities an artist indicates in any given amount of work the more faculties does he appeal to, the more numerous associated ideas does he suggest, the more gratification does he afford. But to receive this gratification the spectator, listener, or reader must know the realities which the artist has indicated, and to know these realities is to know so much science.

And now let us not overlook the further great fact that not only does science underlie sculpture, painting, music, poetry, but that science is itself poetic. The current opinion that science and poetry are opposed is a delusion. It is doubtless true that as states of consciousness, cognition and emotion tend to exclude each other. And it is doubtless also true that an extreme activity of the reflective powers tends to deaden the feelings, while an extreme activity of the feelings tends to deaden the reflective powers; in which sense, indeed, all orders of activity are antagonistic to each other. But it is not true that the facts of science are unpoetical, or that the cultivation of science is necessarily unfriendly to the exercise of imagination or the love of the beautiful. On the contrary, science opens up realms of poetry where to the unscientific all is a blank. Those engaged in scientific researches constantly show us that they realize not less vividly, but more vividly, than others, the poetry of their subjects. Whoever will dip into Hugh Miller's works on geology, or read Mr. Lewes's "Seaside Studies," will perceive that science excites poetry rather than extinguishes it. And whoever will contemplate the life of Goethe will see that the poet and the man of science can coexist in equal activity. Is it not, indeed, an absurd and almost a sacrilegious belief that the more a man studies nature the less he reverces it? Think you that a drop of water, which to the vulgar eye is but a drop of water, loses anything in the eye of the physicist who knows that its elements are held together by a force which, if suddenly liberated, would produce a flash of lightning? Think you that what is carelessly looked upon by the uninitiated as a mere snowflake does not suggest higher associations to one who has seen through a microscope the wondrously varied and elegant forms of snow-crystals? Think you that the rounded rock marked with parallel scratches calls up as much poetry in an ignorant mind as in the mind of a geologist, who knows that over this rock a glacier slid a million years ago? The truth is that those who have never entered upon scientific pursuits know not a tithe of the poetry by which they are surrounded. Whoever has not in youth collected plants and insects knows not half the halo of interest which lanes and hedgerows can assume. Whoever has not sought for fossils has little idea of the poetical associations that surround the places where imbedded treasures were found. Whoever at the seaside has not had a microscope and aquarium has yet to learn what the highest pleasures of the seaside are. Sad, indeed, is it to see how men occupy themselves with trivialities, and are indifferent to the grandest phenomena—care not to understand the architecture of the heavens, but are deeply interested in some contemptible controversy about the intrigues of Mary Queen of Scots!—are learnedly critical over a Greek ode, and pass by without a glance that grand epic written by the finger of God upon the strata of the earth!

We find, then, that even for this remaining division of human activities scientific culture is the proper preparation. We find that æsthetics in general are necessarily based upon scientific principles, and can be pursued with complete success only through an acquaintance with these principles. We find that for the criticism and due appreciation of works of art a knowledge of the constitution of things, or in other words a knowledge of science, is requisite. And we not only find that science is the handmaid to all forms of art and poetry, but that, rightly regarded, science is itself poetic.

Thus far our question has been the worth of knowledge of this or that kind for purposes of guidance. We have now to judge the relative values of different kinds of knowledge for purposes of discipline. This division of our subject we are obliged to treat with comparative brevity; and happily no very lengthened treatment of it is needed. Having found what is best for the one end, we have by implication found what is best for the other. We may be quite sure that the acquirement of those classes of facts which are most useful for regulating conduct involves a mental exercise best fitted for strengthening the faculties. It would be utterly contrary to the beautiful economy of nature if one kind of culture were needed for the gaining of information and another kind were needed as a mental gymnastic. Everywhere throughout creation we find faculties developed through the performance of those functions which it is their office to perform, not through the performance of artificial exercises devised to fit them for these functions. The Red Indian acquires the swiftness and agility which make him a successful hunter by the actual pursuit of animals; and by the miscellaneous activities of his life he gains a better balance of physical powers than gymnastics ever give. That skill in tracking enemies and prey which he has reached by long practice implies a subtlety of perception far exceeding anything produced by artificial training. And similarly throughout. From the Bushman, whose eye, which being habitually employed in identifying distant objects that are to be

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 the highest power of a faculty results from the discharge of those duties which the conditions of life require it to discharge. And we may be certain, *à priori*, that the same law holds throughout education. The education of most value for guidance must at the same time be the education of most value for discipline. Let us consider the evidence.

One advantage claimed for that devotion to language-learning which forms so prominent a feature in the ordinary *curriculum* is that the memory is thereby strengthened. And it is apparently assumed that this is an advantage peculiar to the study of words. But the truth is that the sciences afford far wider fields for the exercise of memory. It is no slight task to remember all the facts ascertained 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 affinities of all these compounds is scarcely possible without making chemistry the occupation of life. In the enormous mass of phenomena presented by the earth's crust, and in the still more enormous mass of phenomena presented by the fossils it contains, there is matter which it takes the geological student years of application to master. In each leading division of physics—sound, heat, light, electricity—the facts are numerous enough to alarm any one proposing to learn them all. And when we pass to the organic sciences, the effort of memory required becomes still greater. In human anatomy alone, the quantity of detail is so great that the young surgeon has commonly 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 some 320,000, while the varied forms of animal life with which the zoölogist deals are estimated at some two millions. So vast is the accumulation of facts which men of science have before them that only by dividing and subdividing their labors can they deal with it. To a complete knowledge of his own division each adds but a general knowledge of the rest. Surely, then, science, cultivated even to a very moderate extent, affords adequate exercise for memory. To say the very least, it involves quite as good a 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 correspond to facts that are in great measure accidental; whereas in the acquirement of science the connections of ideas to be established in the mind correspond to facts that are mostly necessary. It is true 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, though very rarely to 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 since it will not be contended that in the acquisition of languages, as ordinarily carried on, these natural relations between words and their meanings are habitually traced, and the laws regulating them explained, it 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 understanding.

Observe next that a great superiority of science over language as a means of discipline is that it cultivates the judgment. As, in a lecture on mental education delivered at the Royal Institution, Professor Faraday well remarks, the most common intellectual fault is deficiency of judgment. He contends that "society, speaking generally, is not only ignorant as respects education of the judgment, but it is also ignorant of its ignorance." And the cause to which he ascribes this state is want of scientific culture. The truth of his conclusion is obvious. Correct judgment with regard to all surrounding things, events, and consequences becomes possible only through knowledge of the way in which surrounding phenomena depend on each other. No extent of acquaintance with the meanings of words can give the power of forming correct inferences respecting causes and effects. The constant habit of drawing conclusions from data, and then of verifying those conclusions by observation and experiment, can alone give the power of judging correctly. And that it necessitates this habit is one of the immense advantages of science.

Not only, however, for intellectual discipline is science the best; but also for *moral* discipline. The learning of languages tends, if anything, further to increase the already undue respect for authority. Such and such are the meanings of these words, says the teacher or the dictionary. So and so is the rule in this case, says the grammar. By the pupil these dicta are received as unquestionable. His constant attitude of mind is that of submission to dogmatic teaching. And a necessary result is a tendency to accept without inquiry whatever is established. Quite opposite is the attitude of mind generated by the cultivation of science. By science constant appeal is made to individual reason. Its truths are not accepted upon authority alone, but all are at liberty to test them—nay, in many cases the pupil is required to think out his own conclusions. Every step in a scientific investigation is submitted to his judgment. He is not asked to admit it without seeing it to be true. And the trust in his own powers thus produced is further increased by the constancy with which nature justifies his conclusions when they are correctly drawn. From all which there flows that independence which is a most valuable element in character. Nor is this the only moral benefit bequeathed by scientific culture. When carried on, as 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 industry, and an humble and conscientious acceptance of what nature reveals. The first condition of success is an honest receptivity and a willingness to abandon all preconceived notions, however cherished, if they be found to contradict the truth. Believe me, a self-renunciation which has something noble in it, and of which the world never hears, is often enacted in the private experience of the true votary of science."

Lastly we have to assert—and the assertion will, we doubt not, cause extreme surprise—that the discipline of science is superior to 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 their ordinary limited acceptations, but in their widest and highest acceptations. Doubtless, to the superstitions that pass under the name of religion, science is antagonistic, 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 irreligion, but not in that true science which has passed beyond the superficial into the profound.

"True science and true religion," says Professor Huxley, at the close of a recent course of lectures, "are twin-sisters, and the separation of either from the other is sure to prove the death of both. Science prospers exactly in proportion as it is religious; and religion flourishes in exact proportion to the scientific depth and firmness of its basis. The great deeds of philosophers have been less the fruit of their intellect than of the direction of that intellect by an eminently religious tone of mind. Truth has yielded herself rather to their patience, their love, their single-heartedness, and their self-denial, than to their logical acumen."

So far from science being irreligious, as many think, it is the neglect of science that is irreligious—it is the refusal to study the surrounding creation that is irreligious. Take a humble simile. Suppose a writer were daily saluted with praises couched in superlative language. Suppose the wisdom, the grandeur, the beauty of his works, were the constant topics of the eulogies addressed to him. Suppose those who unceasingly uttered these eulogies on his works were content with looking at the outsides of them, and had never opened them, much less tried to understand them. What value should we put upon their praises? What should we think of their sincerity? Yet, comparing small things to great, such is the conduct of mankind in general in reference to the universe and its cause. Nay, it is worse. Not only do they pass by without study these things which they daily proclaim to be so wonderful, but very frequently they condemn as mere triflers those who give time to the observation of nature—they actually scorn those who show any active interest in these marvels. We repeat, then, that not science, but the neglect of science, is irreligious. Devotion to science is a tacit worship—a tacit recognition of worth in the things studied, and by implication in their cause. It is not a mere lip-homage, but a homage expressed in actions; not a mere professed respect, but a respect proved by the sacrifice of time, thought, and labor.

Nor is it thus only that true science is essentially religious. It is religious, too, inasmuch as it generates a profound respect for and an implicit faith in those uniform laws which underlie all things. By accumulated experiences the man of science acquires a thorough belief in the unchanging relations of phenomena—in the invariable connection of cause and consequence—in the necessity of good or evil results. Instead of the rewards and punishments of traditional belief, which men vaguely hope they may gain, or escape, spite of their disobedience, he finds that there are rewards and punishments in the ordained constitution of things, and that the evil results of disobedience are inevitable. He sees that the laws to which we must submit are not only inexorable but beneficent. He sees that in virtue of these laws the process of things is ever toward a greater perfection and a higher happiness. Hence he is led constantly to insist on these laws, and is indignant when men disregard them. And thus does he, by asserting the eternal principles of things and the necessity of conforming to them, prove himself intrinsically religious.

To all which add the further religious aspect of science, that it alone can give us true conceptions of ourselves and our relation to the mysteries of existence. At the same time that it shows us all which can be known, it shows us the limits beyond which we can know nothing. Not by dogmatic assertion does it teach the impossibility of comprehending the ultimate cause of things, but it leads us clearly to recognize this impossibility by bringing us in every direction to boundaries we cannot cross. It realizes to us in a way which nothing else can, the littleness of human intelligence in the face of that which transcends human intelligence. While toward the traditions and authorities

of men its attitude may be proud, before the impenetrable veil which hides the absolute its attitude is humble—a true pride and a true humility. Only the sincere man of science (and by this title we do not mean the mere calculator of distances, or analyzer of compounds, or labeller of species, but him who through lower truths seeks higher, and eventually the highest)—only the genuine man of science, we say, can truly know how utterly beyond, not only human knowledge but human conception, is the universal power of which nature and life and thought are manifestations.

We conclude, then, that for discipline as well as for guidance, science is of chiefest value. In all its effects, learning the meanings of things is better than learning the meanings of words. Whether for intellectual, moral, or religious training, the study of surrounding phenomena is immensely superior to the study of grammars and lexicons.

Thus 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-preservation, or 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 of greatest value is—science. For the due discharge of parental functions, the proper guidance is to be found only in—science. For that interpretation of national life, past and present, without which the citizen cannot rightly regulate his conduct, the indispensable key is—science. Alike for the most perfect production and highest enjoyment of art in all its forms, the needful preparation is still—science. And for purposes of discipline—intellectual, moral, religious—the most efficient study is, once more—science. The question which at first seemed so perplexed has become, in the course of our inquiry, comparatively simple. We have not to estimate the degrees of importance of different orders of human activity, and different studies as severally fitting us for them, since we find that the study of science, in its most comprehensive meaning, is the best preparation for all these orders of activity. We have not to decide between the claims of knowledge of great though conventional value, and knowledge of less though intrinsic value, seeing that the knowledge which we find to be of most value in all other respects is intrinsically most valuable: its worth is not dependent upon opinion, but is as fixed as is the relation of man to the surrounding world. Necessary and eternal as are its truths, all science 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 value is that which, in our age of boasted education, receives the least attention. While this which we call civilization could never have arisen had it not been for science, science forms scarcely an appreciable element in what men consider civilized training. Though to the progress of science we owe it that millions find support where once there was food only for thousands, yet of these millions but a few thousands pay any respect to that which has made their existence possible. Though this increasing knowledge of the properties and relations of things has not only enabled wandering tribes to grow into populous nations, but has given to the countless members of those 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 educational institutions. To the slowly growing acquaintance with the uniform coexistences and sequences of phenomena—to the establishment of invariable laws—we owe our emancipation from the grossest superstitions. But for science we should be still worshipping fetishes, or, with hecatombs of victims, propitiating diabolical deities. And yet this science, which in place of the most degrading conceptions of things has given us some insight into the grandeurs of creation, is written against in our theologies and frowned upon from our pulpits.

Paraphrasing an Eastern fable, we may say that in the family of knowledges science is the household drudge, who, in obscurity, hides unrecognized perfections. To her has been committed all the work; by her skill, intelligence, and devotion have all the conveniences and gratifications been obtained; and while ceaselessly occupied ministering to the rest, she has been kept in the background, that her haughty sisters might flaunt their fripperies in the eyes of the world. The parallel holds yet further. For we are fast coming to the *dénouement*, when the positions will be changed; and while these haughty sisters sink into merited neglect, science, proclaimed as highest alike in worth and beauty, will reign supreme.

CHAPTER II.

INTELLECTUAL EDUCATION.

There cannot fail to be a relationship between the successive systems of education and the successive social states with which they have coexisted. Having a common origin in the national mind, the institutions of each epoch, whatever be their special functions, must have a family likeness. When men received their creed and its interpretations from an infallible authority deigning no explanations, it was natural that the teaching of children should be purely dogmatic. While "believe and ask no questions" was the maxim of the Church, it was fitly the maxim of the school. Conversely, 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 juvenile instruction a process of exposition addressed to the understanding. Along with political despotism, stern in its commands, ruling by force of terror, visiting trifling crimes with death, and implacable in its vengeance on the disloyal, there necessarily grew up an academic discipline similarly harsh—a discipline of multiplied injunctions and blows for every breach of them—a discipline of unlimited autocracy upheld by rods, and ferules, 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: the pupil is hampered by fewer restraints, and other means than punishments are used to govern him. In those ascetic days when men, acting on the greatest-misery principle, held that the more gratifications they denied themselves the more virtuous they were, they, as a matter of course, considered that the best education which most thwarted the wishes of their children, and cut short all spontaneous activity with "You mustn't do so." While on the contrary, now that happiness is coming to be regarded as a legitimate aim—now that hours of labor are being shortened and popular recreations provided—parents and teachers are beginning to see that most childish desires may rightly be gratified, that childish sports should be encouraged, and that the tendencies of the growing mind are not altogether so diabolical as was supposed. The age in which all thought that trades must be established by bounties and prohibitions, that manufacturers needed their materials and qualities and prices to be prescribed, and that the value of money could be determined by law, was an age which unavoidably cherished the notions that a child's mind could be made to order, that its powers were to be imparted by the schoolmaster, that it was a receptacle into which knowledge was to be put and there built up after its teacher's ideal. In this free-trade era, however, when we are learning that there is much more self-regulation in things than was supposed; that labor, and commerce, and agriculture, and navigation can do better without management than with it; that political governments, to be efficient, must grow up from within, and not be imposed from without, we are also beginning to see that there is a natural process of mental evolution which is not to be disturbed without injury; that we may not force on the unfolding mind our artificial forms; but that psychology also discloses to us a law of supply and demand, to which, if we would not do harm, we must conform. Thus alike, in its oracular dogmatism, in its harsh discipline, in its multiplied restrictions, in its professed asceticism, and in its faith in the devices of men, the old educational regime was akin to the social systems with which it was contemporaneous; and similarly, in the reverse of these characteristics our modern modes of culture correspond to our more liberal religious and political institutions.

But there remain further parallelisms to which we have not yet adverted: that, namely, between the processes by which these respective changes have been wrought out, and that between the several states of heterogeneous opinion to which they have led. Some centuries ago there was uniformity of belief—religious, political, and educational. All men were Romanists, all were Monarchists, all were disciples of Aristotle, and no one thought of calling in question that grammar-school routine under which all were brought up. The same agency has in each case replaced this uniformity by a constantly increasing diversity. That tendency toward assertion of the individuality which, after contributing to produce the great Protestant movement, has since gone on to produce an ever-increasing number of sects—that tendency which initiated political parties, and out of the two primary ones has, in these modern days, evolved a multiplicity to which every year adds—that tendency which led to the Baconian rebellion against the schools, and has since originated here and abroad sundry new systems of thought—is a tendency which, in education also, has caused division and the accumulation of methods. As external consequences of the same internal change, these processes have necessarily been more or less simultaneous. The decline of authority, whether papal, philosophic, kingly, or tutorial, is essentially one phenomenon; in each of its aspects a leaning toward free action is seen alike in the working out of the change itself, and in the new forms of theory and practice to which the change has given birth.

While many will regret this multiplication of schemes of juvenile culture, the catholic observer will discern in it a means of insuring the final establishment of a rational system. Whatever may be thought of theological dissent, it is clear that dissent in education results in facilitating inquiry by the division in labor. Were we in possession of the true method, divergence from it would, of course, be prejudicial; but the true method having to be found, the efforts of numerous independent seekers, carrying out their researches in different directions, constitute a better agency for finding it than any that could be devised. Each of them struck by some new thought which probably contains more or less of basis in facts—each of them zealous on behalf of his plan, fertile in expedients to test its correctness, and untiring in his efforts to make known its success—each of them merciless in his criticism

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 them has discovered, must, by the constant exhibition of its results, force itself into adoption; whatever wrong practices he has joined with it must, by repeated experiment and failure, be exploded. And by this aggregation of truths and elimination of errors there must eventually be developed a correct and complete body of doctrine. Of the three phases through which human opinion passes—the unanimity of the ignorant, the disagreement of the inquiring, and the unanimity of the wise—it is manifest that the second is the parent of the third. They are not sequences in time only; they are sequences in causation. However impatiently, therefore, we may witness the present conflict of educational systems, and however much we may regret its accompanying evils, we must recognize it as a transition stage needful to be passed through, and beneficent in its ultimate effects.

Meanwhile may we not advantageously take stock of our progress? After fifty years of discussion, experiment, and comparison of results, may we not expect a few 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 become established, and many others must be in process of general abandonment or adoption. Probably we may see in these various changes, when put side by side, similar characteristics—may find in them a common tendency, and so, by inference, may get a clew to the direction in which experience is leading us, and gather hints how we may achieve yet further improvements. Let us then, as a preliminary to a deeper consideration of the matter, glance at the leading contrasts between the education of the past and of the present.

The suppression of every error is commonly followed by a temporary ascendency of the contrary one; and it so happened that after the ages when physical development alone was aimed at, there came an age when culture of the mind was the sole solicitude—when children had lesson-books put before them at between two and three years old—when school-hours were protracted, and the getting of knowledge was thought the one thing needful. As, further, it usually happens, that after one of these reactions the next advance is achieved by co-ordinating the antagonist errors, and perceiving that they are opposite sides of one truth, so we are now coming to the conviction that body and mind must both be cared for, and the whole being unfolded. The forcing system has been in great measure given up, and precocity 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 found of little service if there be not 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 the eventual failure of juvenile prodigies constantly illustrates. Thus we are discovering the wisdom of the saying, that one secret in education is "to know how wisely to lose time."

The once universal practice of learning by rote is daily falling more into discredit. All modern authorities condemn the old mechanical way of teaching the alphabet. The multiplication table is now frequently taught experimentally. In the acquirement of languages the grammar-school plan is being superseded by plans based on the spontaneous process followed by the child in gaining its 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 everything; to understand their meaning nothing: 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 necessary; that in proportion as there is attention to the signs there must be inattention to the things signified; or that, as Montaigne long ago said, *Sçavoir par cœur n'est pas sçavoir.*

Along with rote-teaching is declining also the nearly allied teaching by rules. The particulars first, and then the generalization, is the new method—a method, as the Battersea School Reports remark, which, though "the reverse of the method usually followed, which consists in giving the pupil the rule first," is yet proved by experience to be the right one. Rule-teaching is now condemned as imparting a merely empirical knowledge—as 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 and permanent use, must be earned. "Easy come easy go" is a saying as applicable to knowledge as to wealth. While rules, lying isolated in the mind—not joined to its other contents as outgrowths from them—are continually forgotten, the principles which those rules express piecemeal become, when once reached by the understanding, enduring possessions. While the rule-taught youth is at sea when beyond his rules, the youth instructed in principles solves a new case as readily as an old one. Between a mind of rules and a mind of principles there exists a difference such as that between a confused heap of materials and the same materials organized into a complete whole, with all its parts bound together. Of which types this last has not only the advantage that its constituent parts are better retained, but the much greater advantage, that it forms an efficient agent for inquiry, for independent thought, for discovery—ends for which the first is useless. Nor let it be supposed that this is a simile only: it is the literal truth. The union of facts into generalizations *is* the organization of knowledge, whether considered as an objective phenomenon or a subjective one; and the mental grasp may be measured by the extent to which this organization is carried.

From the substitution of principles for rules, and the necessarily co-ordinate practice of leaving abstractions untaught until the mind has been familiarized with the facts from which they are abstracted, has resulted the postponement of some once early studies to a late period. This is exemplified in the abandonment of that intensely stupid custom, the teaching of grammar to children. As M. Marcel says: "It may without hesitation be affirmed that grammar is not the stepping-stone, but the finishing instrument." As Mr. Wyse argues: "Grammar and syntax are a collection of laws and rules. Rules are gathered from practice; they are the results of induction to which we come by long observation and comparison of facts. It is, in fine, the science, the philosophy of language. In following the process of nature, neither individuals nor nations ever arrive at the science *first.* A language is spoken, and poetry written, many years before either a grammar or prosody is even thought of. Men did not wait till Aristotle had constructed his logic, to reason. In short, as grammar was made after language, so ought it to be taught after language; an inference which all who recognize the relationship between the evolution of the race and of the individual will see to be unavoidable.

Of new practices that have grown up during the decline of these old ones, the most important is the systematic culture of the 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. What was once thought mere purposeless action, or play, or mischief, as the case might be, is now recognized as the process of acquiring a knowledge on which all after-knowledge is based. Hence the well-conceived but ill-conducted system of *object-lessons.* The saying of Bacon, that physics is the mother of sciences, has come to have a meaning in education. Without an accurate acquaintance with the visible and tangible properties of things, our conceptions must be erroneous, our inferences fallacious, and our operations unsuccessful. "The education of the senses neglected, all after-education partakes of a drowsiness, a haziness, an insufficiency which it is impossible to cure." Indeed, if we consider it, we shall find that exhaustive observation is an element in all great success. It is not to artists, naturalists, and men of science only that it is needful; it is not only that the skilful physician depends on it for the correctness of his diagnosis, and that to the good engineer it is so important that some years in the workshop are prescribed for him; but we may see that the philosopher also is fundamentally one who *observes* relationships of things which others had overlooked, and that the poet, too, is one who *sees* the fine facts in nature which all recognize when pointed out, but did not before remark. Nothing requires more to be insisted on than that vivid and complete impressions are all essential. No sound fabric of wisdom can be woven out of a rotten raw-material.

While the old method of presenting truths in the abstract has been falling out of use, there has been a corresponding adoption of the new method of presenting them in the concrete. The rudimentary facts of exact science are now being learned by direct intuition, as textures, and tastes, and colors are learned. Employing the ball-frame for first lessons in arithmetic exemplifies this. It is well illustrated, too, in Professor De Morgan's mode of explaining the decimal notation. M. Marcel, rightly repudiating the old system of tables, teaches weights and measures by referring to the actual yard and foot, pound and ounce, gallon and quart, and lets the discovery of their relationships be experimental. The use of geographical models and models of the regular bodies, etc., as introductory to geography and geometry respectively, are facts of the same class. Manifestly a common trait of these methods is that they carry each child's mind through a process like that which the mind of humanity at large has gone through. The truths of number, of form, of relationship in position, were all originally drawn from objects; and to present these truths to the child in the concrete is to let him learn them as the race learned them. By and by, perhaps, it will be seen that he cannot possibly learn them in any other way; for that if he is made to repeat them as abstractions, the abstractions can have no meaning for him until he finds that they are simply statements of what he intuitively discerns.

But of all the changes taking place, the most significant is the growing desire to make the acquirement of knowledge pleasurable rather than painful—a desire based on the more or less distinct perception that at each age the intellectual action which a child likes is a healthful one for it, and conversely. There is a spreading opinion that the rise of an appetite for any kind of knowledge implies that the unfolding mind has become fit to assimilate it, and needs it for the purposes of growth, and that, on the other hand, the disgust felt toward any kind of knowledge is a sign either that it is prematurely presented, or that it is presented in an indigestible form. Hence the efforts to make early education amusing and all edu-

cation interesting. Hence the lectures on the value of play. Hence the defence of nursery rhymes and fairy tales. Daily we more and more conform our plans to juvenile opinion. Does the child like this or that kind of teaching? does he take to it? we constantly ask. "His natural desire of variety should be indulged," says M. Marcel; "and the gratification of his curiosity should be combined with his improvement." "Lessons," he again remarks, "should cease before the child evinces symptoms of weariness." And so with later education. Short breaks during school-hours, excursions into the country, amusing lectures, choral songs—in these and many like traits the change may be discerned. Asceticism is disappearing out of education as out of life, and the usual test of political legislation—its tendency 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 nature ever rebels, and the leaving of the first years for exercise of the limbs and senses show this. The superseding of rote-learned lessons by lessons orally and experimentally given, like those of the field and play-ground, shows this. The disuse of rule-teaching, and the adoption of teaching by principles—that is, the leaving of generalizations until there are particulars to base them on—show this. The system of object-lessons shows this. The teaching of the rudiments of science in the concrete instead of the abstract shows this. And, above all, this tendency is shown in the variously directed efforts to present knowledge in attractive forms, and so to make the acquirement of it pleasurable. For as it is the order of nature in all creatures that the gratification accompanying the fulfilment of needful functions serves as a stimulus to their fulfilment—as during the self-education of the young child the delight taken in the biting 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 modes 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 alike in its order and its methods 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 partial applications of this general principle. A nebulous perception of it now prevails among teachers, and it is daily more insisted on in educational works. "The method of nature is the archetype of all methods," says M. Marcel. "The vital principle in the pursuit is to enable the pupil rightly to instruct himself," writes Mr. Wyse. The more science familiarizes us with the constitution of things the more do we see in them an inherent self-sufficingness. A higher knowledge tends continually to limit our interference with the processes of life. As in medicine the old "heroic treatment" has given place to mild treatment, and often no treatment save a normal regimen—as we have found that it is not needful to mould the bodies of babes by bandaging them in papoose fashion or otherwise—as in jails it is being discovered that no cunningly devised discipline of ours is so efficient in producing reformation as the natural discipline, the making prisoners maintain themselves by productive labor, so in education we are finding that success is to be achieved only by rendering our measures subservient to that spontaneous unfolding which all minds go through in their progress to maturity.

Of course this fundamental principle of tuition, that the arrangement of matter and method must correspond with the order of evolution and mode of activity of the faculties—a principle so obviously true that once stated it seems almost self-evident—has never been wholly disregarded. Teachers have unavoidably made their school-courses coincide with it in some degree, for the simple reason that education is possible only on that condition. Boys were never taught the rule-of-three until after they had learned addition. They were not set to write exercises before they had got into their copy-books. Conic sections have always been preceded by Euclid. But the error of the old methods consists in this, that they do not recognize in detail what they are obliged to recognize in the general. Yet the principle applies throughout. If from the time when a child is able to conceive two things as related in position, years must elapse before it can form a true concept of the earth, as a sphere made up of land and sea, covered with mountains, forests, rivers, and cities, revolving on its axis, and sweeping round the sun—if it gets from the one concept to the other by degrees—if the intermediate concepts which it forms are consecutively larger and more complicated, is it not manifest that there is a general succession through which only it can pass; that each larger concept is made by the combination of smaller ones, and presupposes them; and that to present any of these compound concepts before the child is in possession of its constituent ones is only less absurd than to present the final concept of the series before the initial one? In the mastering of every subject some course of increasingly complex ideas has to be gone through. The evolution of the corresponding faculties consists in the assimilation of these, which, in any true sense, is impossible without they are put into the mind in the normal order. And when this order is not followed, the result is that they are received with apathy or disgust; and that unless the pupil is intelligent enough to eventually fill up the gaps himself, they lie in his memory as dead facts, capable of being turned to little or no use.

"But why trouble ourselves about any *curriculum* at all?" it may be asked. "If it be true that the mind like the body has a 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 *wholly* to the discipline of nature? why not remain quite passive and let them get knowledge as they best can? why not be consistent throughout?" This is an awkward-looking question. Plausibly 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 them by *reductio ad absurdum*. In truth, however, they do not, when rightly understood, commit us to any such untenable position. A glance at the physical analogies will clearly show this. It is a general law of all life that the more complex the organism to be produced, the longer the period during which it is dependent on a parent organism for food and protection. The contrast between the minute, rapidly-formed, and self-moving spore of a conferva, and the slowly-developed seed of a tree, with its multiplied envelopes and large stock of nutriment 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 contrasts from the monad whose spontaneously-divided halves are as self-sufficing the moment after their separation as was the original whole, up to man, whose offspring not only passes through a protracted gestation, and subsequently long depends on the breast for sustenance, but after that must have its food artificially administered, must, after it has learned to feed itself, continue to have bread, clothing and shelter provided, and does not acquire the power of complete self-support until a time varying from fifteen to twenty years after its birth. Now this law applies to the mind as to the body. For mental pabulum also every higher creature, and especially man, is at first dependent on adult aid. Lacking the ability to move about, the babe is as powerless to get materials on which to exercise its perceptions as it is to get supplies for its stomach. Unable to prepare its own food, it is in like manner unable to reduce many kinds of knowledge to a fit form for assimilation. The language through which all higher truths are to be gained it wholly derives from those surrounding it. And we see in such an example as the Wild Boy of Aveyron the arrest of development that results when no help is received from parents and nurses. Thus, in providing from day to day the right kind of facts, prepared in the right manner, and giving them in due abundance at appropriate intervals, there is as much scope for active ministration to a child's mind as to its body. In either case it is the chief function of parents to see that the *conditions* requisite to growth are maintained. And as in supplying aliment, and clothing, and shelter, they may fulfil this function without at all interfering with the spontaneous development of the limbs and viscera, either in their order or mode, so they may supply sounds for imitation, objects for examination, books for reading, problems for solution, and if they use neither direct nor indirect coercion, may do this without in any way disturbing the normal process of mental evolution; or rather may greatly facilitate that process. Hence the admission of the doctrines enunciated does not, as some might argue, involve the abandonment of all teaching, but leaves ample room for an active and elaborate course of culture.

Passing from generalities to special considerations, it is to be remarked that in practice the Pestalozzian system seems scarcely to have fulfilled the promise of its theory. We hear of children not at all interested in its lessons—disgusted with them rather; and, so far as we can gather, the Pestalozzian schools have not turned out any unusual proportion of distinguished men, if even they have reached the average. We are not surprised at this. The success of every appliance depends mainly upon the intelligence with which it is used. It is a trite remark that, having the choicest tools, an unskilful artisan will botch his work; and bad teachers will fail even with the best methods. Indeed, the goodness of the method becomes in such case a cause of failure; as, to continue the simile, the perfection of the tool becomes in undisciplined hands a source of imperfection in results. A simple, unchanging, almost mechanical routine of tuition may be carried out by the commonest intellects, with such small beneficial effect as it is capable of producing; but a complete system—a system as heterogeneous in its appliances as the mind in its faculties—a system proposing a special means for each special end, demands for its right employment powers such as few teachers possess. The mistress of a dame-school can hear spelling-lessons; any hedge-schoolmaster can drill boys in the multiplication-table; but to teach spelling rightly by using the powers of the letters instead of their names, or to instruct in numerical combinations by experimental synthesis, a modicum of understanding is needful; and to pursue a like rational course throughout the entire

range of studies asks an amount of judgment, of invention, of intellectual sympathy, of analytical faculty, which we shall never see applied to it while the tutorial office is held in such small esteem. The true education is practicable only to the true philosopher. Judge, then, what prospect a philosophical method now has of being acted out! Knowing so little as we yet do of psychology, and ignorant as our teachers are of that little, what chance has a system which requires psychology for its basis?

Further hindrance and discouragement has arisen from confounding the Pestalozzian principle with the forms in which it has been embodied. Because particular plans have not answered expectation, discredit has been cast upon the doctrine associated with them, no inquiry being made whether these plans truly conform to such doctrine. 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 Papin's futile 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 while right in his fundamental ideas Pestalozzi was not therefore right in all his applications of them; and we believe the fact to be that he was often wrong. As described even by his admirers, Pestalozzi was a man of partial intuitions, a man who had occasional flashes of insight rather than a man of systematic thought. His first great success at Stantz was achieved 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 instruction his children stood peculiarly in need of, and what was the best manner of connecting it with the knowledge they already possessed." Much of his power was due, not to calmly reasoned-out plans of culture, but to his profound sympathy, which gave him an instinctive perception of childish needs and difficulties. He lacked the ability logically to 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 their details his own plans, and those vicariously devised, contain numerous crudities and inconsistencies. His nursery-method, described in "The Mother's Manual," beginning as it does with a nomenclature of the different parts of the body, and proceeding next to specify their relative positions, and next their connections, may be proved not at all in accordance with the initial stages of mental evolution. His process of teaching the mother-tongue by formal exercises in the meanings of words and in the construction of sentences, is quite needless, and must entail on the pupil loss of time, labor, and happiness. His proposed mode of teaching geography is utterly unpestalozzian. And often where his plans are essentially sound they are either incomplete or vitiated by some remnant of the old regime. While, therefore, we would defend in its entire extent the general doctrine which Pestalozzi inaugurated, we think great evil likely to result from an uncritical reception of his specific devices. That tendency which mankind constantly exhibit to canonize the forms and practices along with which any great truth has been bequeathed to them—their liability to prostrate their intellects before the prophet, and swear by his every word—their proneness to mistake the clothing of the idea for the idea itself, renders it needful to insist strongly upon 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, we 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 mode and order of unfolding, it is first needful that we ascertain with some completeness how the faculties do unfold. At present our knowledge of the matter extends only to a few general notions. These general notions must be developed in detail—must be transformed into a multitude of specific propositions, before we can be said to possess that *science* on which the *art* of education must be based. And then when we have definitely made out in what succession and in what combinations the mental powers become active, it remains to choose out of the many possible ways of exercising each of them that which best conforms to its natural mode of action. Evidently, therefore, it is not to be supposed that even our most advanced modes of teaching are the right ones, or nearly the right ones.

Bearing in mind then this distinction between the principle and the practice of Pestalozzi, and inferring from the grounds assigned that the last must necessarily be very defective, the reader will rate at its true worth the dissatisfaction with the system which some have expressed, and will see that the due realization of the Pestalozzian idea remains to be achieved. Should he argue, however, from what has just been said, that no such realization is at present practicable, and that all effort ought to be devoted to the preliminary inquiry, we reply, that though it is not possible for a scheme of culture to be perfected either in matter or form until a rational psychology has been established, it is possible, with the aid of certain guiding principles, to make empirical approximations toward a perfect scheme. To prepare the way for further research we will now specify these principles. Some of them have already been more or less distinctly implied in the foregoing pages; but it will be well here to state them all in logical order.

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 professedly, indeed, nor by any means consistently. The mind grows. Like all things that grow, it progresses from the homogeneous to the heterogeneous; and a normal training system being an objective counterpart of this subjective process, must exhibit the like progression. Moreover, regarding it from this point of view, we may see that this formula has much wider applications than at first appears. For its *rationale* involves not only that we should proceed from the single to the combined in the teaching of each branch of knowledge, but that we should do the like with knowledge as a whole. As the mind, consisting at first of but few active faculties, has its later-completed faculties successively awakened, and ultimately comes to have all its faculties in simultaneous action, it follows that our teaching should begin with but few subjects at once, and successively adding to these, should finally carry on all subjects abreast—that not only in its details should education proceed from the simple to the complex, but in its *ensemble* also.

2. To say that our lessons ought to start from the concrete and end in the abstract may be considered as in part a repetition of the foregoing. Nevertheless it is a maxim that needs to be stated: if with no other view, then with the view of showing in certain cases what are truly the simple and the complex. For unfortunately there has been much misunderstanding on this point. General formulas which men have devised to express groups of details, and which have severally simplified their conceptions by uniting many facts into one fact, they have supposed must simplify the conceptions of the child also, quite forgetting that a generalization is simple only in comparison with the whole mass of particular truths it comprehends—that it is more complex than any one of these truths taken singly—that only after many of these single truths have been acquired does the generalization ease the memory and help the reason—and that to the child not possessing these single truths it is necessarily a mystery. Thus confounding two kinds of simplification, teachers have constantly erred by setting out with "first principles," a proceeding essentially, though not apparently, at variance with the primary rule, which implies that the mind should be introduced to principles through the medium of examples, and so should be led from the particular to the general—from the concrete to the abstract.

3. The education of the child must accord both in mode and arrangement with the education of mankind as considered historically; 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 enunciation of this doctrine—a doctrine which we may accept without committing ourselves to his theory of the genesis of knowledge, either in its causes or its order. In support of this doctrine two reasons may be assigned, either of them sufficient to establish it. One is deducible from the law of hereditary transmission as considered in its wider consequences. For if it be true that men exhibit likeness to ancestry both in aspect and character—if it be true that certain mental manifestations, as insanity, will occur in successive members of the same family at the same age—if, passing from individual cases in which the traits of many dead ancestors mixing with those of a few living ones greatly obscure the law, we turn to national types, and remark how the contrasts between them are persistent from age to age—if we remember that these respective types came from a common stock, and that hence the present marked differences between them must have arisen from the action of modifying circumstances upon successive generations who severally transmitted the accumulated effects to their descendants—if we find the differences to be now organic, so that the French child grows into a French man even when brought up among strangers—and if the general fact thus illustrated is true of the whole nature, intellect inclusive, then it follows that if there be an order in which the human race has mastered its various kinds of knowledge, there will arise in every child an aptitude to acquire these kinds of knowledge in the same order. So that even were the order intrinsically indifferent, it would facilitate education to lead the individual mind through the steps traversed by the general mind. But the order is *not* intrinsically indifferent, and hence the fundamental reason why education should be a repetition of civilization in little. It is alike provable that the historical sequence 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 causes in detail, it will suffice here to point out that as the mind of humanity placed in the midst of phenomena, and striving to comprehend them has, after endless comparisons, speculations, experiments, and theories, reached its present knowledge of each subject by a specific route, it may rationally be inferred that the relationship between mind and phenomena is such as to prevent this knowledge from being reached by any other route, and that as each child's mind stands in this same relationship to phenomena, they can be accessible to it only through the same route. Hence in deciding upon the right method of education, an inquiry into the method of civilization will help to guide us.

4. One of the conclusions to which such an inquiry leads, is that in each branch of instruction we should proceed from the empirical to the rational. A leading fact in human progress is that every science is evolved

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 with its empirical generalizations before there can be science. Science is organized knowledge; and before knowledge can be organized, some of it must first be possessed. Every study, therefore, should have a purely experimental introduction; and only after an ample fund of observations has been accumulated should reasoning begin. As illustrative applications of this rule, we may instance the modern course of placing grammar, not before language but after it; or the ordinary custom of prefacing perspective by practical drawing. By and by further applications of it will be indicated.

5. 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. Humanity has progressed solely by self-instruction; and that to achieve the best results each mind must progress somewhat after the same fashion is continually proved by the marked success of self-made men. Those who have been brought up under the ordinary school-drill, and have carried away with them the idea that education is practicable only in that style, will think it hopeless to make children their own teachers. If, however, they will call to mind that the all-important knowledge of surrounding objects which a child gets in its early years is got 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 experience of life, that out-of-school wisdom which every boy gathers for himself—if they will mark the unusual intelligence of the uncared-for London *gamin*, as shown in all the directions in which his faculties have been tasked—if, further, they will think how many minds have struggled up unaided, not only through the mysteries of our irrationally-planned *curriculum*, but through hosts of other obstacles besides, they will find it a not unreasonable conclusion, that if the subjects be put before him in right order and right form, any pupil of ordinary capacity will surmount his successive difficulties with but little assistance. Who indeed can watch the ceaseless observation and inquiry and inference going on in a child's mind, or listen 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 *within 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 drag it away from the facts in which it is interested, and which it is actively assimilating of itself; we put before it facts far too complex for it to understand, and therefore distasteful to it; finding that it will not voluntarily acquire these facts, we thrust them into its mind by force of threats and punishment; by thus denying the knowledge it craves, and cramming 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 partly of the stolid indolence we have brought on, and partly of still continued unfitness in its studies, the child can understand nothing without explanation, and becomes a mere passive recipient of our instruction, we infer that education must necessarily be carried on thus. Having by our method induced helplessness, 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 is 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 plan of culture should come the question, Does it create a pleasurable excitement in the pupils? When in doubt whether a particular mode or arrangement is or is not more in harmony with the foregoing principles than some other, we may safely abide by this criterion. Even when, as considered theoretically, the proposed course seems the best, yet if it produce no interest, or less interest than 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 not healthful. Though at present very incompletely conformed to by the emotional nature, yet by the intellectual nature, or at least by those parts of it which the child exhibits, this law is almost wholly conformed to. The repugnances to this and that study which vex the ordinary teacher are not innate, but result from his unwise system. Fellenberg says, "Experience has taught me that *indolence* in young persons is so directly opposite to their natural disposition to activity that unless it is the consequence of bad education it is almost invariably connected with some constitutional defect." And the spontaneous activity to which children are thus prone is simply the pursuit of those pleasures which the healthful exercise of the faculties gives. It is true that some of the higher mental powers as yet but little developed in the race, and congenitally possessed in any considerable degree only by the most advanced, are indisposed to the amount of exertion required of them. But these, in virtue of their very complexity, will, in a normal course of culture, come last into exercise, and will 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 indirect pleasure made to counterbalance a direct displeasure. With all faculties lower than these, however, the direct gratification consequent on activity is the normal stimulus, and under good management the only needful stimulus. When we are obliged to fall back upon some other, we must take the fact as evidence that we are on the wrong track. Experience is daily showing with greater clearness 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. Partly, therefore, to exemplify their application, and partly with a view of making sundry specific suggestions, we propose now to pass from the theory of education to the practice of it.

It was the opinion of Pestalozzi—an opinion which has ever since his day been gaining ground—that education of some kind should begin from the cradle. Whoever has watched, with any discernment, the wide-eyed gaze of the infant at surrounding objects knows very well that education *does* begin thus early, whether we intend it or not; and that these fingerings and suckings of everything it can lay hold of, these open-mouthed listenings to every sound are the first steps in the series which ends in the discovery of unseen planets, 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 exercise themselves; and to the question so put none but an affirmative answer can be given. As before said, however, agreement with Pestalozzi's theory does not involve agreement with his practice; and here occurs a case in point. Treating of instruction in spelling he says:

> "The spelling-book ought, therefore, to contain all the sounds of the language, and these ought to be taught in every family from the earliest infancy. The child who learns his spelling-book ought to repeat them to the infant in the cradle, before it is able to pronounce even one of them, so that they may be deeply impressed upon its mind by frequent repetition."

Joining this with the suggestions for "a nursery-method," as set down in his "Mother's Manual," in which he makes the names, positions, connections, numbers, properties, and uses of the limbs and body his first lessons, it becomes clear that Pestalozzi's notions on early mental development were too crude to enable him to devise judicious plans. Let us inquire into the course which psychology dictates.

The earliest impressions which the mind can assimilate are those given to it by the undecomposable sensations—resistance, light, sound, etc. Manifestly decomposable states of consciousness cannot exist before the states of consciousness out of which they are composed. There can be no idea of form until some familiarity with light in its gradations and qualities, or resistance in its different intensities, has been acquired; for, as has been long known, we recognize visible form by means of varieties of light, and tangible form by means of varieties of resistance. Similarly, no articulate sound is cognizable until the inarticulate sounds which go to make it up have been learned. And thus must it be in every other case. Following, therefore, the necessary law of progression from the simple to the complex, we should provide for the infant a sufficiency of objects presenting different degrees and kinds of resistance, a sufficiency of objects reflecting different amounts and qualities of light, and a sufficiency of sounds contrasted in their loudness, their pitch and their *timbre*. How fully this *à priori* conclusion is confirmed by infantile instincts all will see on being reminded of the delight which every young child has in biting its toys, in feeling its brother's bright jacket-buttons, and pulling papa's whiskers—how absorbed it becomes in gazing at any gaudily-painted object, to which it applies the word "pretty," when it can pronounce it, wholly in virtue of the bright colors—and how its face broadens into a laugh at the tattlings of its nurse, the snapping of a visitor's fingers, or any sound which it has not before heard. Fortunately, the ordinary practices of the nursery fulfil these early requirements of education to a considerable degree. Much, however, remains to be done; and it is of more importance that it should be done than at first appears. Every faculty during the period of its greatest activity—the period in which it is spontaneously evolving itself—is capable of receiving more vivid impressions than at any other period. Moreover, as these simplest elements must eventually be mastered, and as the mastery of them whenever achieved must take time, it becomes an economy of 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. Add to which that both temper and health will be improved by the continual gratification resulting from a due supply of these impressions which every child so greedily assimilates. Space, could it be spared, might here be well filled by some suggestions toward a more systematic ministration to these simplest of the perceptions. But it must suffice to point out that any such 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, colors very remote from each other, and substances widely unlike 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 manifestly form a natural continuation of this primary culture of the senses, it is to be remarked 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 course of civilization. "The child," says M. Marcel, "must be *shown* how all the parts of an object are connected, etc.;" and the various manuals of these object-lessons severally contain lists of 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 certain visual appearances, the possession of particular forms and colors by particular persons, the production of special sounds by animals of special aspects, are phenomena which it observes for itself. In manhood too, when there are no longer teachers at hand, the observations and inferences required for daily guidance must be made unhelped; and success in life depends upon the accuracy and completeness with which they are made. Is it probable, then, that while the process displayed 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 manhood? and that, too, even in so simple a thing as learning the properties of objects? Is it not obvious, on the contrary, that one method must be pursued throughout? And is not nature perpetually thrusting this method upon us, if we had 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 creak with its wet finger on the table, how it turns and looks at you; does it again, and again looks at you; thus saying as clearly as it can, "Hear this new sound." Watch how the elder children come into the room exclaiming, "Mamma, see what a curious thing," "Mamma, look at this," "Mamma, look at that;" and would continue the habit, did not the silly mamma tell them not to tease her. 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 how pretty it is, and to get her also to say it is pretty. Listen to the eager volubility with which every urchin describes any novelty he has been to see, if only he can find some one who will attend with any interest. Does not the induction lie on the surface? Is it not clear that we must conform our course to these intellectual instincts—that we must just systematize the natural 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 such object, must occasionally draw its attention to facts it has not yet observed, with the view of leading it to notice them itself whenever they recur, and must go on by and by to indicate or supply new series of things 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 this to show her that it 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 it in some fresh thing which he brings her, she takes care to mention in connection with those he already knows; so that by the natural tendency to imitate he may get into the habit of repeating them 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, she introduces the practice of asking him whether there is not something more that he can tell her about the thing he has got. Probably he does not understand. After letting him puzzle awhile she tells him, perhaps laughing at him a little for his failure. A few recurrences of this and he perceives what is to be done. When next she says she knows something more about 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 the problem being easy, presently finds it out. He is full of glee at his success, and she sympathizes with him. In common with every child, he delights in the discovery of his powers. He wishes for more victories, and goes in quest of more things about which to tell her. As his faculties unfold she adds quality after quality to his list, progressing from hardness and softness to roughness and smoothness, from color to polish, from simple bodies to composite ones—thus constantly complicating the problem as he gains competence, constantly taxing his attention and memory 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 out that spontaneous process that was going on during a still earlier period—simply aiding self-evolution; and is aiding it in the mode suggested by the boy's instinctive behavior to her. Manifestly, too, the course she is pursuing is 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 strengthens its powers of self-instruction—which deprives it of the pleasures resulting from successful activity—which presents this all-attractive knowledge under the aspect of formal tuition—and which thus generates that indifference 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 sympathy; to induce by the union of all these an intensity of attention which insures perceptions alike vivid and complete; and to habituate the mind from the beginning to that practice of self-help which it must ultimately follow.

Object-lessons should not only be carried on after quite a different fashion from that commonly pursued, but should be extended to a range of things far wider, and continue to a period far later, than now. They should not be limited to the contents of the house, but should include those of the fields and the hedges, the quarry and the seashore. They should not cease with early childhood, but should be so kept up during youth as insensibly to merge into the investigations of the naturalist and the man of science. Here again we have but to follow nature's leadings. Where can be seen an intenser delight than that of children picking up new flowers and watching new insects, or hoarding pebbles and shells? And who is there but perceives that by sympathizing with them they may be led on to any extent of inquiry into the qualities and structures of these things? Every botanist who has had children with him in the woods and the lanes must have noticed how eagerly they joined in his pursuits, how keenly they searched out plants for him, how intently they watched while he examined them, how they overwhelmed him with questions. The consistent follower of Bacon, the "servant and interpreter of nature," will see that we ought modestly to adopt the course of culture thus indicated. Having gained due familiarity with the simpler properties of inorganic objects, the child should by the same process be led on to a like exhaustive examination of the things it picks up in its daily walks, the less complex facts they present being alone noticed at first: in plants, the color, number, and forms of the petals and shapes of the stalks and leaves; in insects, the numbers of the wings, legs, and antennæ, and their colors. As these become fully appreciated and invariably observed, further facts may be successively introduced: in the one case, the numbers of stamens and pistils, the forms of the flowers, whether radial or bilateral in symmetry, the arrangement and character of the leaves, whether opposite or alternate, stalked or sessile, smooth or hairy, serrated, toothed, or crenate; in the other, the divisions of the body, the segments of the abdomen, the markings of the wings, the number of joints in the legs, and the forms of the smaller organs—the system pursued throughout being that of making it the child's ambition to say respecting everything it finds all that can be said. Then when a fit age has been reached, the means of preserving these plants, which have become so interesting in virtue of the knowledge obtained of them, may as a great favor be supplied; and eventually, as a still greater favor, may also be supplied the apparatus needful for keeping the larvæ of our common butterflies and moths through their transformations—a practice which, as we can personally testify, yields the highest gratification; is continued with ardor for years; when joined with the formation of an entomological collection adds immense interest to Saturday afternoon rambles, and forms an admirable introduction to the study of physiology.

We are quite prepared to hear from many that all this is throwing away time and energy, and that children would be much better occupied in writing their copies or learning their pence-tables, and so fitting themselves for the business of life. We regret that such crude ideas of what constitutes education and such a narrow conception of utility should still be generally prevalent. Saying nothing on the need for a systematic culture of the perceptions and the value of the practices above inculcated as subserving that need, we are prepared to defend them even on the score of the knowledge gained. If men are to be mere cits, mere porers over ledgers, with no ideas beyond their trades—if it is well that they should be as the cockney whose conception of rural pleasures extends no farther than sitting in a tea-garden smoking pipes and drinking porter; or as the squire who thinks of woods as places for shooting in, of uncultivated plants as nothing but weeds, and who classifies animals into game, vermin, and stock—then indeed it is needless for men to learn anything that does not directly help to replenish the till and fill the larder. But if there is a more worthy aim for us than to be drudges—if there are other uses in the things around us than their power to bring money—if there are higher faculties to be exercised than acquisitive and sensual ones—if the pleasures which poetry and art and science and philosophy can bring are of any moment—then is it desirable that the instinctive inclination which every child shows to observe natural beauties and investigate natural phenomena should be encouraged. But this gross utilitarianism, which is content to come into the world and

quit it again without knowing what kind of a world it is or what it contains, may be met on its own ground. It will by and by be found that a knowledge of the laws of life is more important than any other knowledge whatever—that the laws of life include not only all bodily and mental processes, but by implication all the transactions of the house and the street, all commerce, all politics, all morals—and that therefore, without a due acquaintance with them, neither personal nor social conduct can be rightly regulated. It will eventually be seen, too, that the laws of life are essentially the same throughout the whole organic creation; and further, that they cannot be properly understood in their complex manifestations until they have been studied in their simpler ones. And when this is seen, it will be also seen that in aiding the child to acquire the out-of-door information for which it shows so great an avidity, and in encouraging the acquisition of such information throughout youth, we are simply inducing it to store up the raw material for future organization—the facts that will one day bring home to it with due force those great generalizations of science by which actions may be rightly guided.

The spreading recognition of drawing as an element of education is one among many signs of the more rational views on mental culture now beginning to prevail. Once more it may be remarked that teachers are at length adopting the course which nature has for ages been pressing upon their notice. The spontaneous efforts made by children to represent the men, houses, trees, and animals around them—on a slate if they can get nothing better, or with lead-pencil on paper, if they can beg them—are familiar to all. To be shown through a picture-book is one of their highest gratifications; and as usual, their strong imitative tendency presently generates in them the ambition to make pictures themselves also. This attempt to depict the striking things they see is a further instinctive exercise of the perceptions—a means whereby still greater accuracy and completeness of observation 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 solicit from us just that kind of culture which they most need.

Had teachers been guided by nature's hints not only in the making of drawing a part of education, but in the choice of their 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 large, things that are attractive 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 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 processes of representation gives it most delight? Coloring. Paper and pencil are good in default of something better, but a box of paints and a brush—these are the treasures. The drawing of outlines immediately becomes secondary to coloring — is gone through mainly with a view to the coloring; and if leave can be got to color a book of prints, how great is the favor! Now, ridiculous as such a position will seem to drawing-masters, who postpone coloring and who teach form by a dreary discipline of copying lines, we believe that the course of culture thus indicated is the right one. That priority of color to form, which, as already pointed out, has a psychological basis, and in virtue of which psychological basis arises this strong preference in the child, should be recognized from the very beginning; and from the very beginning also the things imitated should be real. That greater delight in color which is not only conspicuous in children but persists in most persons throughout life, should be continuously employed as the natural stimulus to the mastery of the comparatively difficult and unattractive form—should be the prospective reward for the achievement of form. And these instinctive attempts to represent interesting actualities should be all along encouraged, in the conviction that as, by a widening experience, smaller and more practicable objects become interesting, 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 grotesque the shapes produced, no matter how daubed and glaring the colors. The question is not whether the child is producing good drawings: the question is, whether it is developing its faculties. It has first to gain some command over its fingers, some crude notions of likeness; and this practice is better than any other for these ends, seeing that it is the spontaneous and the interesting one. During these early years, be it remembered, no formal drawing-lessons are possible; shall we therefore repress, or neglect to aid, these efforts at self-culture? or shall we encourage and guide them as normal exercises of the perceptions and the powers of manipulation? If by the supply of cheap woodcuts to be colored, and simple contour-maps to have their boundary lines tinted, we cannot only pleasurably draw out the faculty of color, but can incidentally produce some familiarity with the outlines of things and countries, and some ability to move the brush steadily, and if by the supply of temptingly-painted objects we can keep up the instinctive practice of making representations, however rough, it must happen that by the time drawing is commonly commenced there will exist a facility that would else have been absent. Time will have been gained, and trouble both to teacher and pupil saved.

From all that has been said, it may be readily inferred that we wholly disapprove of the practice of drawing from copies, and still more so of that formal discipline in making straight lines and curved lines and compound lines, with which it is the fashion of some teachers to begin. We regret to find that the Society of Arts has recently, in its series of manuals on "Rudimentary Art-Instruction," given its countenance to an elementary drawing-book which is the most vicious in principle that we have seen. We refer to the "Outline from Outline, or from the Flat," by John Bell, sculptor. As expressed in the prefatory note, this publication proposes "to place before the student a simple yet logical mode of instruction;" and to this end sets out with a number of definitions thus:

"A simple line in drawing is a thin mark drawn from one point to another.

"Lines may be divided, as to their nature in drawing, into two classes:

"1. *Straight*, which are marks that go the shortest road between two points, as A B.

"2. Or *Curved*, which are marks which do not go the shortest road between two points, as C D."

And so the introduction progresses to horizontal lines, perpendicular lines, oblique lines, angles of the several kinds, and the various figures which lines and angles make up. The work is, in short, a grammar of form, with exercises. And thus the system of commencing with a dry analysis of elements, which, in the teaching of language, has been exploded, is to be reinstituted in the teaching of drawing. The abstract is to be preliminary to the concrete. Scientific conceptions are to precede empirical experiences. That this is an inversion of the normal order we need scarcely repeat. It has been well said concerning the custom of prefacing 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 proposal to preface the art of representing objects by a nomenclature and definitions of the lines which they yield on analysis. These technicalities are alike repulsive and needless. They render the study distasteful at the very outset; and all with the view of teaching that which, in the course of practice, will be learned unconsciously. Just as the child incidentally gathers the meanings of ordinary words from the conversations going on around it, without the help of dictionaries, so, from the remarks on objects, pictures, and its own drawings, will it presently acquire, not only without effort, but even pleasurably, those same scientific terms which, if presented at first, are a mystery and a weariness.

If any dependence is to be placed upon the general principles of education that have been laid down, the process of learning to draw should be throughout continuous with 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. And when, after sundry abortive, Chinese-like attempts to render this appearance on paper, there has grown up a pretty clear perception of the thing to be achieved and a desire to achieve it, a first lesson in empirical perspective may be given by means of the apparatus occasionally used in explaining perspective as a science. This sounds formidable; but the experiment 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, being placed before the pupil, and 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 upon the glass, so that they may coincide with or hide the corners of this object. He is then told to join these dots by lines; on doing which he perceives that the lines he makes hide or coincide with the outlines of the object. And then, on being asked to put a sheet of paper on the other side of the glass, he discovers that the lines he has thus drawn represent the object as he saw it. They not only look like it, but he perceives that they must be like it, because he made them agree with its outlines; and by removing the paper he can repeatedly convince himself that they do agree with its outlines. The fact is new and striking, and serves him as an experimental demonstration, that 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 changing the position of the object, he may be led to observe how some lines shorten and disappear, while others come into sight and lengthen. The convergence of parallel lines, and, indeed, all the leading facts of perspective may from time to time be similarly illustrated to him. If he has been duly accustomed to self-help, he will gladly, when it is suggested, make the attempt to draw one of these outlines upon paper by the eye only; and it may soon be made an exciting aim to produce, unassisted, a representation, as like as he can to one subsequently sketched on the glass. Thus, without the unintelligent, mechanical practice of copying other drawings, but by a method at once simple and attractive—rational, yet not abstract, a familiarity with the linear appearances of things, and a faculty of rendering them, may be step by step acquired. To which advantages add these: that even thus early the pupil learns, almost unconsciously, the true theory of a picture—namely, that it is a delineation of objects as they appear when projected on a plane placed between them and the eye; and that when he reaches a fit age for commencing scientific perspective he is already thor-

oughly acquainted with the facts which form its logical basis.

As exhibiting a rational mode of communicating primary conceptions in geometry, we cannot do better than quote the following passage from Mr. Wyse:

"A child has been in the habit of using cubes for arithmetic; let him use them also for the elements of geometry. I would begin with solids, the reverse of the usual plan. It saves all the difficulty of absurd definitions, and bad explanations on points, lines, and surfaces, which are nothing but abstractions. . . . A cube presents many of the principal elements of geometry; it at once exhibits points, straight lines, parallel lines, angles, parallelograms, etc., etc. These cubes are divisible into various parts. The pupil has already been familiarized with such divisions in numeration, and he now proceeds to a comparison of their several parts, and of the relation of these parts to each other. . . . From thence he advances to globes, which furnish him with elementary notions of the circle, of curves generally, etc., etc.

"Being tolerably familiar with solids, he may now substitute planes. The transition may be made very easy. Let the cube, for instance, be cut into thin divisions, and placed on paper; he will then see as many plane rectangles as he has divisions; so with all the others. Globes may be treated in the same manner; he will thus see how surfaces really are generated, and be enabled to abstract them with facility in every solid.

"He has thus acquired the alphabet and reading of geometry. He now proceeds to write it.

"The simplest operation, and therefore the first, is merely to place these planes on a piece of paper, and pass the pencil round them. When this has been frequently done, the plane may be put at a little distance, and the child required to copy it, and so on."

A stock of geometrical conceptions having been obtained, in some such manner as this recommended by Mr. Wyse, a further step may, in course of time, be taken, by introducing the practice of testing the correctness of all figures drawn by the eye; thus alike exciting an ambition to make them exact, and continually illustrating the difficulty of fulfilling that ambition. There can be little doubt that geometry had its origin (as, indeed, the word implies) in the methods discovered by artisans and others, of making accurate measurement for the foundations of buildings, areas of inclosures, and the like; and that its truths came to be treasured up 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 lead him into, he may be for a length of time advantageously left, like the primitive builder, to tentative processes, and will so gain an abundant experience of the difficulty of achieving his aims by the unaided senses. When, having meanwhile undergone a valuable discipline of the perceptions, he has reached a fit age for using a pair of compasses, he will, while duly appreciating these as enabling him to verify his ocular guesses, be still hindered by the difficulties of the approximative method. In this stage he may be left for a further period: partly as being yet too young for anything higher, partly because it is desirable that he should be made to feel still more strongly the want of systematic contrivances. If the acquisition of knowledge is to be made continuously interesting, and if, in the early civilization of the child, as in the early civilization of the race, science becomes attractive only as ministering to art, it is manifest that the proper preliminary to geometry is a long practice in those constructive processes which geometry will facilitate. Observe that here, too, nature points the way. Almost invariably, children show a strong propensity to cut out things in paper, to make, to build—a propensity which, if duly encouraged and directed, will not only prepare the way for scientific conceptions, but will develop those powers of manipulation in which most people are so deficient.

When the observing and inventive faculties have attained the requisite power, the pupil may be introduced to empirical geometry; that is, geometry dealing with methodical solutions, but not with the demonstrations of them. Like all other transitions in education, this should be made not formally but incidentally, and the relationship to constructive art should still be maintained. To make a tetrahedron in card-board like one given to him is a problem which will alike interest the pupil and serve as a convenient starting-point. In attempting this, he finds it needful to draw four equilateral triangles arranged in special positions. Being unable in the absence of an exact method to do this accurately, he discovers, on putting the triangles into their respective positions, that he cannot make their sides fit, and that their 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 drawn with perfect correctness and without guessing; and after his failure he will duly value the information. Having thus helped him to the solution of his first problem, with the view of illustrating the nature of geometrical methods, he is in future to be left altogether to his own ingenuity in solving the questions put to him. To bisect a line, to erect a perpendicular, to describe a square, to bisect an angle, to draw a line parallel to a given line, to describe a hexagon, are problems which a little patience will enable him to find out. And from these he may be led on step by step to questions of a more complex kind, all of which, under judicious management, he will puzzle through unhelped. Doubtless many of those brought up under the old regime will look upon this assertion sceptically. We speak from facts, however, and those neither few nor special. We have seen a class of boys 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. Within the last month we have been told of one girls' school in which some of the young ladies voluntarily occupy themselves with geometrical questions out of school-hours; and of another in which they not only do this, but in which one of them is begging for problems to find out during the holidays—both which facts we state on the authority of the teacher. There could indeed be no stronger proofs than are thus afforded of the practicability and the immense advantage of self-development. A branch of knowledge which as commonly taught is dry and even repulsive, may, by following the method of nature, be made extremely interesting and profoundly beneficial. We say profoundly beneficial, because the effects are not confined to the gaining of geometrical facts, but often revolutionize the whole state of mind. It has repeatedly occurred that those who have been stupefied by the ordinary school-drill—by its abstract formulas, by its wearisome tasks, by its cramming—have suddenly had their intellects roused, by thus ceasing to make them passive recipients, and inducing them to become active discoverers. The discouragement brought about by bad teaching having been diminished by a little sympathy, and sufficient perseverance induced to achieve a first success, there arises a revulsion of feeling affecting the whole nature. They no longer find themselves incompetent; they too can do something. And gradually, as success follows success, the incubus of despair disappears, and they attack the difficulties of their other studies with a courage that insures conquest.

This empirical geometry which presents an endless series of problems, and should be continued along with other studies for years, may throughout be advantageously accompanied by those concrete applications of its principles which serve as its preliminary. After the cube, the octahedron, and the various forms of pyramid and prism have been mastered, may come the more complex regular bodies—the dodecahedron, and the icosahedron—to construct which out of single pieces of card-board requires considerable ingenuity. From these the transition may naturally be made to such modified forms of the regular bodies as are met with in crystals—the truncated cube, the cube with its dihedral as well as its solid angles truncated, the octahedron, and the various prisms as similarly modified; in imitating which numerous forms assumed by different metals and salts, an acquaintance with the leading facts of mineralogy will be incidentally gained. After long continuance in exercises of this kind, rational geometry, as may be supposed, presents no obstacles. Constantly habituated to contemplate relationships of form and quantity, and vaguely perceiving from time to time the necessity of certain results as reached by certain means, the pupil comes to regard the demonstrations of Euclid as the missing supplements to his familiar problems. His well-disciplined faculties enable him easily to master its successive propositions, and to appreciate their value; and he has the occasional gratification of finding some of his own methods proved to be true. Thus he enjoys what is to the unprepared a dreary task. It only remains to add that his mind will presently arrive at a fit condition for that most valuable of all exercises for the reflective faculties—the making of original demonstrations. Such theorems as those appended to the successive books of the Messrs. Chambers' Euclid will soon become practicable to him; and in proving them the process of self-development will be not intellectual only, but moral.

To continue much farther these suggestions would be to write a detailed treatise on education, which we do not purpose. The foregoing outlines of plans for exercising the perceptions in early childhood for conducting object-lessons for teaching drawing and geometry, must be considered as roughly-sketched illustrations of the method dictated by the general principles previously specified. We believe that on examination they will be found not only to progress from the simple to the complex, from the concrete to the abstract, from the empirical to the rational, but to satisfy the further requirements 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 one type of method capable of satisfying all these conditions tends alike to verify the conditions and to prove that type of method the right one. And when we add that this method is the logical outcome of the tendency characterizing all modern systems of instruction—that it is but an adoption in full of the method of nature which they adopt partially—that it displays this complete adoption of the method of nature, not only by conforming to the above principles, but by following 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 conclude that the mode of procedure above exemplified closely approximates to the true one.

A few paragraphs must be appended in further inculcation of the two general principles, alike the most important and the least attended to: we mean the principle that throughout youth, as in early childhood and in maturity, the process shall be one of self-instruction; and the obverse principle, that the mental action induced by this process shall be throughout intrinsically grateful. If progression from simple to complex, and from concrete to abstract, be considered the essential requirements as dictated by abstract psychology, then do these requirements that knowledge shall be self-mastered, and pleasurably mastered, become the tests by which we may judge whether the dictates of abstract 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 the steps in our *curriculum* are so arranged that they can be successively ascended by the pupil himself with little or no help, they must correspond with the stages of evolution in his faculties; and manifestly if the successive achievements of these steps are intrinsically gratifying to him, it follows that they require no more than a normal exercise of his powers.

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 guarantees a vividness and permanency of impression which the usual methods can never produce. Any piece of knowledge which the pupil has himself acquired, any problem which he has himself 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 no mere information heard from a teacher or read in a school-book can be registered. Even if he fails, the tension to which his faculties have been wound up insures his remembrance of the solution when given to him, better than half a dozen repetitions would Observe again, that this discipline necessitates a continuous organization of the knowledge he acquires. It is in the very nature of facts and inferences, assimilated in this normal manner, that they successively become the premises of further conclusions, the means of solving still further 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 taken in, and forthwith aids in the general function of thinking—does not lie merely written in the pages of an internal library, as when rote-learned. Mark further the importance of the moral culture which 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. That it is thoroughly practicable to carry out instruction after this fashion we can ourselves testify, having been in youth thus led to successively solve the comparatively complex problems of perspective. And that 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 officiousness 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. Marcel, that "what the learner discovers by mental exertion is better known than what is told to him."

Similarly with the correlative requirement, that the method of culture pursued shall be one productive of an intrinsically happy activity—an activity not happy in virtue of extrinsic rewards to be obtained, but in virtue of its own healthfulness. Conformity to this requirement not only guards us against thwarting the normal process of evolution, but incidentally secures positive benefits of importance. Unless we are to return to an ascetic morality, the maintenance of youthful happiness must be considered as in itself a worthy aim. Not to dwell upon this, however, we go on to remark that a pleasurable state of feeling is far more favorable to intellectual action than one of indifference or disgust. Every one knows that things read, heard, or seen with interest are better remembered than those read, heard, or seen with apathy. In the one case the faculties appealed to are actively occupied with the subject presented; in the other they are inactively occupied with it, and the attention is continually drawn away after more attractive thoughts. Hence the impressions are respectively strong and weak. Moreover, the intellectual listlessness which a pupil's lack of interest in any study involves is further complicated by his anxiety, by his fear of consequences, which distract his attention, and increase the difficulty he finds in bringing his faculties to bear upon these facts that are repugnant to them. Clearly, therefore, the efficiency of any intellectual action will, other things equal, be proportionate to the gratification with which it is performed.

It should be considered also that important moral consequences depend upon the habitual pleasure or pain which daily lessons produce. No one can compare the faces and manners of two boys—the one made happy by mastering interesting subjects, and the other made miserable by disgust with his studies, by consequent failure, by cold looks, by threats, by punishment—without seeing that the disposition of the one is being benefited, and that of the other greatly injured. Whoever has marked the effect of intellectual success upon the mind, and the power of the mind over the body, will see that in the one case both temper and health are favorably affected, while in the other there is danger of permanent moroseness, of permanent timidity, and even of permanent constitutional depression. To all which considerations we must add the further one, that the relationship between teachers and their pupils is, other things equal, rendered friendly and influential, or antagonistic and powerless, according as the system of culture produces happiness or misery. Human beings are at the mercy of their associated ideas. A daily minister of pain cannot fail to be regarded with a secret dislike, and if he causes no emotions but painful ones, will inevitably be hated. Conversely, he who constantly aids children to their ends, hourly provides them with the satisfactions of conquest, hourly encourages them through their difficulties and sympathizes in their successes, cannot fail to be liked; nay, if his behavior is consistent throughout, must be loved. And when we remember how efficient and benign is the control of a master who is felt to be a friend, when compared with the control of one who is looked upon with aversion, or at best indifference, we may infer that the indirect advantages of conducting education on the happiness principle do not fall far short of the direct ones. To all who question the possibility of acting out the system here advocated, we reply as before, that not only does theory point to it, but experience commends it. To the many verdicts of distinguished teachers who since Pestalozzi's time have testified this, may be here added that of Professor Pillans, who asserts that "where young people are taught as they ought to be, they are quite as happy in school as at play, seldom less delighted, nay, often more, with the well-directed exercise of their mental energies, than with that of their muscular powers."

As suggesting a final 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 proportion as it is made so is there a probability that education will not cease when school-days end. As long as the acquisition of knowledge is rendered habitually repugnant, so long will there be a prevailing tendency to discontinue it when free from the coercion of parents and masters. And when the acquisition of knowledge has been rendered habitually gratifying, then 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 those which call to mind bygone pleasures—painful lessons will make knowledge repulsive, and pleasurable lessons will make it attractive. The men to whom in boyhood information came in dreary tasks along with threats of punishment, and who were never led into habits of independent inquiry, are unlikely to be students in after years; while those to whom it came in the natural forms, 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 successes, are likely to continue 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 is being done in the detailed improvement of our systems in respect both of matter and manner, the most pressing desideratum has not yet been even recognized as a desideratum. To prepare the young for the duties of life is tacitly admitted by all to be the end which parents and schoolmasters should have in view; and happily the value of the things taught, and the goodness of the method followed in teaching them, are now ostensibly judged by their fitness to this end. The propriety of substituting for an exclusively classical training a training in which the modern 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 an elaborate preparation is needed, it appears to be thought that for 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 decorative acquirements which fit her for evening parties, not an hour is spent by either of them in preparation for that gravest of all responsibilities—the management of a family. Is it that this responsibility is but a remote 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: of all functions which the adult has to fulfil 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 the need for such self-instruction unrecognized, but the complexity of the subject renders it the one of all others in which self-instruction is least likely to succeed. No rational plea can be put forward for leaving the art of education out of our *curriculum*. Whether as bearing upon the happiness of parents themselves, or whether as affecting the characters and lives of their children and remote descendants, we must admit that a knowledge of the right methods of juvenile culture, physical, intellectual, and moral, is a knowledge second to none in importance. This topic should occupy the highest and last place in the course of instruction passed through by each man and woman. As physical maturity is marked by the ability to produce 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, and more especially

the moral management, is lamentably bad. Parents either never think about the matter at all, or else their conclusions are crude and inconsistent. In most cases, and especially on the part of mothers, the treatment adopted on every occasion is that which the impulse of the moment prompts: it springs not from any reasoned-out conviction as to what will most conduce to the child's welfare, but merely expresses the passing parental feelings, whether good or ill, and varies from hour to hour as these feelings vary. Or if these blind dictates of passion are supplemented by any definite doctrines and methods, they are those that have been handed down from the past, or those suggested by the remembrances of childhood, or those adopted from nurses and servants—methods devised not by the enlightenment, but by the ignorance of the time. Commenting on the chaotic state of opinion and practice relative to family government, Richter writes:

"If the secret variances of a large class of ordinary fathers were brought to light, and laid down as a plan of studies, and reading catalogued for a moral education, they would run somewhat after this fashion: In the first hour 'pure morality must be read to the child, either by myself or the tutor;' in the second, 'mixed morality, or that which may be applied to one's own advantage;' in the third, 'do you not see that your father does so and so?' in the fourth, 'you are little, and this is only fit for grown-up people;' in the fifth, 'the chief matter is that you should succeed in the world, and become something in the state;' in the sixth, 'not the temporary, but the eternal, determines the worth of a man;' in the seventh, 'therefore rather suffer injustice, and be kind;' in the eighth, 'but defend yourself bravely if any one attack you;' in the ninth, 'do not make a noise, dear child;' in the tenth, 'a boy must not sit so quiet;' in the eleventh, 'you must obey your parents better;' in the twelfth, 'and educate yourself.' So, by the hourly change of his principles, the father conceals their untenableness and one-sidedness. As for his wife, she is neither like him, nor yet like that harlequin who came on to the stage with a bundle of papers under each arm, and answered to the inquiry what he had under his right arm, 'orders,' and to what he had under his left arm, 'counter-orders.' But the mother might be much better compared to a giant Briareus, who had a hundred arms, and a bundle of papers under each."

This state of things is not to be readily changed. Generations must pass before any great amelioration of it can be expected. Like political constitutions, educational systems are not made, but grow; and within brief periods growth is insensible. Slow, however, as must be any improvement, even that improvement implies the use of means; and among the means is discussion.

We are not among those who believe in Lord Palmerston's dogma, that "all children are born good." On the whole, the opposite dogma, untenable as it is, seems to us less wide of the truth. Nor do we agree with those who think that, by skilful discipline, children may be made altogether what they should be. Contrariwise, we are satisfied that though imperfections of nature may be diminished by wise management, they cannot be removed by it. The notion that an ideal humanity might be forthwith produced by a perfect system of education is near akin to that shadowed forth in the poems of Shelley, that would mankind give up their old institutions, prejudices, and errors, all the evils in the world would at once disappear; neither notion being acceptable to such as have dispassionately studied human affairs.

Not that we are without sympathy with those who entertain these too sanguine hopes. Enthusiasm, pushed even to fanaticism, is a useful motive power—perhaps an indispensable one. It is clear that the ardent politician would never undergo the labors and make the sacrifices he does, did he not believe that the reform he fights for is the one thing needful. But for his conviction that drunkenness is the root of almost all social evils, the teetotaller would agitate far less energetically. In philanthropy as in other things great advantage results from division of labor; and that there may be division of labor, each class of philanthropists must be more or less subordinated to its function—must have an exaggerated faith in its work. Hence, of those who regard education, intellectual or moral, as the panacea, we may say that their undue expectations are not without use; and that perhaps it is part of the beneficent order of things that their confidence cannot be shaken.

Even were it true, however, that by some possible system of moral government children could be moulded into the desired form, and even could every parent be duly indoctrinated with this system, we should still be far from achieving the object in view. It is forgotten that the carrying out of any such system presupposes, on the part of adults, a degree of intelligence, of goodness, of self-control, possessed by no one. The great error made by those who discuss questions of juvenile discipline is in ascribing all the faults and difficulties to the children, and none to the parents. The current assumption respecting family government, as respecting national government, is, that the virtues are with the rulers and the vices with the ruled. Judging by educational theories, men and women are entirely transfigured in the domestic relation. The citizens we do business with, the people we meet in the world, we all know to be very imperfect creatures. In the daily scandals, in the quarrels of friends, in bankruptcy disclosures, in lawsuits, in police reports, we have constantly thrust before us the pervading selfishness, dishonesty, brutality. Yet when we criticise nursery management, and canvass the misbehavior of juveniles, we habitually take for granted that these culpable men and women are free from moral delinquency in the treatment of their offspring! So far is this from the truth that we do not hesitate to say that to parental misconduct is traceable a great part of the domestic disorder commonly ascribed to the perversity of children. We do not assert this of the more sympathetic and self-restrained, among whom we hope most of our readers may be classed, but we assert it of the mass. What kind of moral discipline is to be expected from a mother who, time after time, angrily shakes her infant because it will not suckle her, which we once saw a mother do? How much love of justice and generosity is likely to be instilled by a father who, on having his attention drawn by his child's scream to the fact that its finger is jammed between the window sash and the sill, forthwith begins to beat the child instead of releasing it? Yet that there are such fathers is testified to us by an eye-witness. Or, to take a still stronger case, also vouched for by direct testimony—what are the educational prospects of the boy who, on being taken home with a dislocated thigh, is saluted with a castigation? It is true that these are extreme instances—instances exhibiting in human beings that blind instinct which impels brutes to destroy the weakly and injured of their own race. But extreme though they are, they typify feelings and conduct daily observable in many families. Who has not repeatedly seen a child slapped by nurse or parent, for a fretfulness probably resulting from bodily derangement? Who, when watching a mother snatch up a fallen little one, has not often traced, both in the rough manner and in the sharply-uttered exclamation, "You stupid little thing!" an irascibility foretelling endless future squabbles? Is there not in the harsh tones in which a father bids his children be quiet, evidence of a deficient fellow-feeling with them? Are not the constant, and often quite needless thwartings that the young experience—the injunctions to sit still, which an active child cannot obey without suffering great nervous irritation, the commands not to look out of the window when travelling by railway, which on a child of any intelligence entails serious deprivation—are not these thwartings, we ask, signs of a terrible lack of sympathy? The truth is, that the difficulties of moral education are necessarily of dual origin—necessarily result from the combined faults of parents and children. If hereditary transmission is a law of nature, as every naturalist knows it to be, and as our daily remarks and current proverbs admit it to be, then, on the average of cases, the defects of children mirror the defects of their parents; on the average of cases, we say, because, complicated as the results are by the transmitted traits of remoter ancestors, the correspondence is not special but only general. And if, on the average of cases, this inheritance of defects exists, then the evil passions which parents have to check in their children imply like evil passions in themselves: hidden, it may be, from the public eye, or perhaps obscured by other feelings, but still there. Evidently, therefore, the general practice of any ideal system of discipline is hopeless: parents are not good enough.

Moreover, even were there methods by which the desired end could be at once effected, and even had fathers and mothers sufficient insight, sympathy, and self-command to employ these methods consistently, it might still be contended that it would be of no use to reform family discipline faster than other things are reformed. What is it that we aim to do? Is it not that education of whatever kind has for its proximate end to prepare a child for the business of life—to produce a citizen who, at the same time that he is well conducted, is also able to make his way in the world? And does not making his way in the world (by which we mean, not the acquirement of wealth, but of the means requisite for properly bringing up a family)—does not this imply a certain fitness for the world as it now is? And if by any system of culture an ideal human being could be produced, is it not doubtful whether he would be fit for the world as it now is? May we not, on the contrary, suspect that his too keen sense of rectitude, and too elevated standard of conduct, would make life alike intolerable and impossible? And however admirable the results might be, considered individually, would it not be self-defeating in so far as society and posterity are concerned? It may, we think, be argued with much reason, that as in a nation, so in a family, the kind of government is, on the whole, about as good as the general state of human nature permits it to be. It may be said that in the one case, as in the other, the average character of the people determines the quality of the control exercised. It may be inferred that in both cases amelioration of the average character leads to an amelioration of system; and further, that were it possible to ameliorate the system without the average character being first ameliorated, evil, rather than good, would follow. It may be urged that such degree of harshness as children now experience from their parents and teachers, is but a preparation for that greater harshness which they will meet with on entering the world; and that were it possible for parents and teachers to behave toward them with perfect equity and entire sympathy, it would but intensify the sufferings which the selfishness of men must, in after life, inflict on them.*

* This is the plea put in by some for the rough treatment experienced by boys at our public schools, where, as it is said, they are introduced to a miniature world whose imperfections and hardships prepare them for those of the real world; and it must be admitted that the plea has some force. But it is a very insufficient plea. For whereas domestic and school discipline, though they should not be very much better than the discipline of adult life, should at any rate be somewhat better; the discipline which boys meet with at Eton, Winchester, Harrow, etc., is much worse than that of adult life—much more unjust, cruel, brutal. Instead of being an aid to human progress, which all culture should be, the culture of our public schools, by accustoming boys to a despotic form of government, and an intercourse regulated by brute force, tends to fit them for a lower state of society than that which exists. And chiefly recruited as our legislature is from among those who are brought up at these schools, this barbarizing influence becomes a serious hindrance to national progress.

"But does not this prove too much?" some one will ask. "If no system of moral culture can forthwith make children altogether 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 even could such a system be successfully carried out, its results would be disastrously incongruous with the present state of society; does it not follow that a reform in the system now in use is neither practicable nor desirable?" No. It merely follows that reform in domestic government must go on, *pari passu*, with other reforms. It merely follows that methods of discipline neither can be nor should be ameliorated, except by instalments. It merely follows that the dictates of abstract rectitude will, in practice, inevitably be subordinated by the present state of human nature—by the imperfections alike of children, of parents, and of society; and can only be better fulfilled as the general character becomes better.

"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 advantage in elaborating and recommending methods that are in advance of the time." Again we must contend for the contrary. Just as in the case of political government, though pure rectitude may be at present impracticable, it is requisite to know where the right lies, so that the changes we make may be *toward* the right instead of *away* from it; so in the case of domestic government, an ideal must be upheld, that there may be gradual approximations to it. We need fear no evil consequences from the maintenance of such an ideal. On the average the constitutional conservatism of mankind is always strong enough to prevent a too rapid change. So admirable are the arrangements of things, that until men 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.

With these preliminary 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 propose to enter upon the question of religious 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 methods of parental behavior in the hourly-occurring difficulties of family government.

When a child falls, or runs its head against the table, it suffers a pain, the remembrance of which tends to make it more careful for the future; and by an occasional repetition of like experiences it is eventually disciplined into a proper guidance of its movements. If it lays hold of the fire-bars, thrusts its finger into the candle-flame, or spills boiling water on any part of its skin, the resulting burn or scald is a lesson not easily forgotten. So deep an impression is produced by one or two such events that afterward no persuasion will induce it again to disregard the laws of its constitution in these ways.

Now in these and like cases, nature illustrates to us in the simplest way the true theory and practice of moral discipline—a theory and practice which, however much they may seem to the superficial like those commonly received, we shall find on examination to differ from them very widely.

Observe, in the first place, that in bodily injuries and their penalties we have misconduct and its consequences reduced to their simplest forms. Though, according to their popular acceptations, *right* and *wrong* are words scarcely applicable to actions that have none but direct bodily effects, yet whoever considers the matter will see that such actions must be as much classifiable under these heads as any other actions. From whatever basis they start, all theories of morality agree in considering that conduct whose total results, immediate and remote, are beneficial, is good conduct; while conduct whose total results, immediate and remote, are injurious, is bad conduct. The happiness or misery caused by it are the *ultimate* standards by which all men judge of behavior. We consider drunkenness wrong because of the physical degeneracy and accompanying moral evils entailed on the transgressor and his dependants. Did theft uniformly give pleasure both to taker and loser, we should not find it in our catalogue of sins. Were it conceivable that benevolent actions multiplied human pains, we should condemn them—should not consider them benevolent. It needs but to read the first newspaper leader, or listen to any conversation touching social affairs, to see that acts of parliament, political movements, philanthropic agitations, in common with the doings of individuals, are judged by their anticipated results in multiplying the pleasures or pains of men. And if, on looking on all secondary superinduced ideas, we find these to be our ultimate tests of right and wrong, we cannot refuse to class purely physical actions as right or wrong according to the beneficial or detrimental results they produce.

Note, in the second place, the character of the punishments by which these physical transgressions are prevented. Punishments we call them in the absence of a better word, for they are not punishments in the literal sense. They are not artificial and unnecessary inflictions of pain, but are simply the beneficent checks to actions that are essentially at variance with bodily welfare—checks in the absence of which life would quickly be destroyed by bodily injuries. It is the peculiarity of these penalties, if we must so call them, that they are nothing more than the *unavoidable consequences* of the deeds which they follow; they are nothing more than the *inevitable reactions* entailed by the child's actions.

Let it be further borne in mind that these painful reactions are proportionate to the degree in which the organic laws have been transgressed. A slight accident brings a slight pain, a more serious one a greater pain. When a child tumbles over the door-step, 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 not to be escaped. No threats, but a silent, 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 perpetually. In all its dealings with surrounding inorganic nature it finds this unswerving persistence, which listens to no excuse, and from which there is no appeal; and very soon recognizing this stern though beneficent discipline, it becomes extremely careful not to transgress.

Still more significant will these general truths appear when we remember that they hold throughout adult life as well as throughout infantine life. It is by an experimentally gained knowledge of the natural consequences that men and women are checked when they go wrong. After home education has ceased, and when there are no longer parents and teachers to forbid this or that kind of conduct, there comes into play a discipline like that by which the young child is taught its first lessons in self-guidance. If the youth entering upon the business of life idles away his time and fulfils slowly or unskilfully the duties intrusted to him, there by and by follows the natural penalty: he is discharged, and left to suffer for a while the evils of relative poverty. On the unpunctual man, failing alike his appointments of business and pleasure, there continually fall the consequent inconveniences, losses, and deprivations. The avaricious tradesman who charges too high a rate of profit loses his customers, and so is checked in his greediness. Diminishing practice teaches the inattentive doctor to bestow more trouble on his patients. The too credulous creditor and the over-sanguine speculator alike learn by the difficulties which rashness entails on them the necessity of being more cautious in their engagements. And so throughout the life of every citizen. In the quotation so often made *à propos* of these cases—"The burned child dreads the fire"—we see not only that the analogy between this social discipline and nature's early discipline of infants is universally recognized, but we also see an implied conviction that this discipline is of the most efficient kind. Nay more, this conviction is not only implied, but distinctly stated. Every one has heard others confess that only by "dearly bought experience" had they been induced to give up some bad or foolish course of conduct formerly pursued. Every one has heard, in the criticisms passed on the doings of this spendthrift or the other speculator, the remark that advice was useless, and that nothing but "bitter experience" would produce any effect—nothing, that is, but suffering the unavoidable consequences. And if further proof be needed that the penalty of the natural reaction is not only the most efficient, but that no humanly devised penalty can replace it, we have such further proof in the notorious ill-success of our various penal systems. Out of the many methods of criminal discipline that have been proposed and legally enforced, none have answered the expectations of their advocates. Not only have artificial punishments failed to produce reformation, but they have in many cases increased the criminality. The only successful reformatories are those privately established ones which have approximated their regime to the method of nature—which have done little more than administer the natural consequences of criminal conduct; the natural consequences being that, by imprisonment or other restraint, the criminal shall have his liberty of action diminished as much as is needful for the safety of society, and that he shall be made to maintain himself while living under this restraint. Thus we see not only that the discipline by which the young child is so successfully taught to regulate its movements is also the discipline by which the great mass of adults are kept in order, and more or less improved, but that the discipline humanly devised for the worst adults fails when it diverges from this divinely ordained discipline, and begins to succeed when it approximates to it.

Have we not here, then, the guiding principle of moral education? Must we not infer that the system so beneficent in its effects, alike during infancy and maturity, will be equally beneficent throughout youth? Can any one believe that the method which answers so well in the first and the last divisions of life will not answer in the intermediate division? Is it not manifest that, as "ministers and interpreters of nature," it is the function of parents to see that their children habitually experience the true consequences of their conduct—the natural reactions; neither warding them off, nor intensifying them, nor putting artificial conse-

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

Probably, however, not a few 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—that parental anger, venting itself in harsh words and deeds, is the result of a child's transgression, and that, in the suffering, physical or moral, which the child is subject to, it experiences the natural reaction of its misbehavior. Along with much error this assertion doubtless contains some truth. It is unquestionable that the displeasure of fathers and mothers is a true consequence of juvenile delinquency, and that the manifestation of it is a normal check upon such delinquency. It is unquestionable that the scoldings and threats and blows which a passionate parent visits on offending little ones are effects actually produced in such a parent by their offences, and so are, in some sort, to be considered as among the natural reactions of their wrong actions. And we are by no means prepared to say that these modes of treatment are not relatively right—right, that is, in relation to the uncontrollable children of ill-controlled adults, and right in relation to a state of society in which such ill-controlled adults make up the mass of the people. As already suggested, educational systems, like political and other institutions, are generally as good as the state of human nature permits. The barbarous children of barbarous parents are probably only to be restrained by the barbarous methods which such parents spontaneously employ; while submission to these barbarous methods is perhaps the best preparation such children can have for the barbarous society in which they are presently to play a part. Conversely, the civilized members of a civilized society will spontaneously manifest their displeasure in less violent ways—will spontaneously use milder measures—measures strong enough for their better-natured children. Thus it is doubtless true that, in so far as the expression of parental feeling is concerned, the principle of the natural reaction is always more or less followed. The system of domestic government ever gravitates toward its right form.

But now observe two important facts. In the first place, observe that, in states of rapid transition like ours, which witness a long-drawn battle between old and new theories and old and new practices, the educational methods in use are apt to be considerably out of harmony with the times. In deference to dogmas fit only for the ages that uttered them, many parents inflict punishments that do violence to their own feelings, and so visit on their children *un*natural reactions; while other parents, enthusiastic in their hopes of immediate perfection, rush to the opposite extreme. And then observe, in the second place, that the discipline on which we are insisting is not so much the experience of parental approbation or disapprobation, which, in most cases, is only a secondary consequence of a child's conduct, but it is the experience of those results which would naturally flow from the conduct in the absence of parental opinion or interference. The truly instructive and salutary consequences are not those inflicted by parents when they take upon themselves to be nature's proxies, but they are those inflicted by nature herself. We will endeavor to make this distinction clear by a few illustrations, which, while they show what we mean by natural reactions as contrasted with artificial ones, will afford some directly practical suggestions.

In every family where there are young children there almost daily occur cases of what mothers and servants call "making a litter." A child has had out its box of toys, and leaves them scattered about the floor; or a handful of flowers, brought in from a morning walk, is presently seen dispersed over tables and chairs; or a little girl, making doll's-clothes, disfigures the room with shreds. In most cases the trouble of rectifying this disorder falls anywhere but in the right place: if in the nursery, the nurse herself, with many grumblings about "tiresome little things," etc., undertakes the task; if below stairs, the task usually devolves either on one of the elder children or on the housemaid, the transgressor being visited with nothing more than a scolding. In this very simple case, however, there are many parents wise enough to follow out, more or less consistently, the normal course—that of making the child itself collect the toys or shreds. The labor of putting things in order is the true consequence of having put them in disorder. Every trader in his office, every wife in her household, has daily experience of this fact. And if education be a preparation for the business of life, then every child should also, from the beginning, have daily experience of this fact. If the natural penalty be met by any refractory behavior (which it may perhaps be where the general system of moral discipline previously pursued has been bad), then the proper course is to let the child feel the ulterior reaction consequent on its disobedience. Having refused or neglected to pick up and put away the things it has scattered about, and having thereby entailed the trouble of doing this on some one else, the child should, on subsequent occasions, be denied the means of giving this trouble. When next it petitions for its toy-box, the reply of its mamma should be, "The last time you had your toys you left them lying on the floor, and Jane had to pick them up. Jane is too busy to pick up every day the things you leave about, and I cannot do it myself. So that, as you will not put away your toys when you have done with them, I cannot let you have them." This is obviously a natural consequence, neither increased nor lessened, and must be so recognized by a child. The penalty comes, too, at the moment when it is most keenly felt. A new-born desire is balked at the moment of anticipated gratification, and the strong impression so produced can scarcely fail to have an effect on the future conduct—an effect which, by consistent repetition, will do whatever can be done in curing the fault. Add to which that, by this method, a child is early taught the lesson which cannot be learned too soon, that in this world of ours pleasures are rightly to be obtained only by labor.

Take another case. Not long since we had frequently to listen to the reprimands visited on a little girl who was scarcely ever ready in time for the daily walk. Of eager disposition, and apt to become thoroughly absorbed in the occupation of the moment, Constance never thought of putting on her things until the rest were ready. The governess and the other children had almost invariably to wait, and from the mamma there almost invariably came the same scolding. Utterly as this system failed it never occurred to the mamma to let Constance experience the natural penalty; nor, indeed, would she try it when it was suggested to her. In the world the penalty of being behindtime is the loss of some advantage that would else have been gained: the train is gone, or the steamboat is just leaving its moorings, or the best things in the market are sold, or all the good seats in the concert-room are filled. And every one, in cases perpetually occurring, may see that it is the prospective deprivations entailed by being too late which prevent people from being too late. Is not the inference obvious? Should not these prospective deprivations control the child's conduct also? If Constance is not ready at the appointed time, the natural result is that of being left behind, and losing her walk. And no one can, we think, doubt that after having once or twice remained at home while the rest were enjoying themselves in the fields, and after having felt that this loss of a much-prized gratification was solely due to want of promptitude, some amendment would take place. At any rate, the measure would be more effective than that perpetual scolding which ends only in producing callousness.

Again, when children, with more than usual carelessness, break or lose the things given to them, the natural penalty—the penalty which makes grown-up persons more careful—is the consequent inconvenience. The want of the lost or damaged article and the cost of supplying its place are the experiences by which men and women are disciplined in these matters; and the experience of children should be as much as possible assimilated to theirs. We do not refer to that early period at which toys are pulled to pieces in the process of learning their physical properties, and at which the results of carelessness cannot be understood, but to a later period, when the meaning and advantages of property are perceived. When a boy old enough to possess a penknife uses it so roughly as to snap the blade, or leaves it in the grass by some hedge-side, where he was cutting a stick, a thoughtless parent or some indulgent relative will commonly forthwith buy him another, not seeing that, by doing this, a valuable lesson is lost. In such a case a father may properly explain that penknives cost money, and that to get money requires labor; that he cannot afford to purchase new penknives for one who loses or breaks them, and that until he sees evidence of greater carefulness he must decline to make good the loss. A parallel discipline may be used as a means of checking extravagance.

These few familiar instances, here chosen because of the simplicity with which they illustrate our point, will make clear to every one the distinction between those natural penalties, which we contend are the truly efficient ones, and those artificial penalties which parents commonly substitute for them. Before going on to exhibit the higher and subtler applications of this principle, let us note its many and great superiorities over the principle, or rather the empirical practice, which prevails in most families.

In the first place, right conceptions of cause and effect are early formed, and by frequent and consistent experience are eventually rendered definite and complete. Proper conduct in life is much better guaranteed when the good and evil consequences of actions are rationally understood than when they are merely believed on authority. A child who finds that disorderliness entails the subsequent trouble of putting things in order, or who misses a gratification from dilatoriness, or whose want of care is followed by the loss or breakage of some much-prized possession, not only experiences a keenly-felt consequence, but gains a knowledge of causation—both the one and the other being just like those which adult life will bring; whereas a child who in such cases receives some reprimand or some factitious penalty not only experiences a consequence for which it often cares very little, but lacks that instruction respecting the essential natures of good and evil conduct which it would else have gathered. It is a vice of the common system of artificial rewards and punishments long since noticed by the clear-sighted, that by substituting for the natural results of misbehavior certain threatened tasks or castigations, it produces a radically wrong standard of moral guidance. Having throughout infancy and boyhood always regarded parental or tutorial displeasure as the result of a forbidden action, the youth has gained an established association of ideas between such action and such displeasure as cause and effect; and consequently when parents and tutors have abdicated, and their displeasure is not to be feared, the restraint on a forbidden action is in great measure removed, the true restraints, the natural reactions, having yet to be learned by sad experience. As

writes one who has had personal knowledge of this short-sighted system: "Young men let loose from school, particularly those whose parents have neglected to exert their influence, plunge into every descriptiou of extravagance; they know no rule of action—they are ignorant of the reasons for moral conduct—they have no fouudatiou to rest upon, and uutil they have been severely disciplined by the world are extremely dangerous members of society."

Another great advantage of this natural system of discipline is, that it is a system of pure justice, and will be recognized by every child as such. Whoso suffers nothing more than the evil which obviously follows naturally from his own misbehavior is much less likely to think himself wrongly treated than if he suffers an evil artificially iuflicted on him; and this will be trne of children as of men. Take the case of a boy who is habitually 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 occupied by thinking over his injuries than repenting of his transgressions. But suppose he is required to rectify as far as he ean the harm he has done—to clean off the mud with 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 while paying this penalty be continuously conscious of the connection between it aud its cause? And will he not, spite his irritation, recognize more or less clearly tbe justiee of the arrangement? If several lessous of this kind fail to produce amendment; if suits of clothes are prematurely spoiled; if, pursuing this same system of diseipline, a father declines to spend money for new ones until the ordinary time has elapsed, and if meanwhile there occur occasions on which, having no decent clothes to go in, the boy is debarred from joining the rest of the family on holiday excursions and *fête* days, it is manifest that while he will keenly feel the puuishment he can scarcely fail to trace the chain of causation, aud to perceive that his own carelessness is the origin of it; and seeing this, he will not have that same sense of injustice as when there is no obvious connection between the transgression and its penalty.

Again, the tempers both of pareuts and children are much less liable to be ruffled under this system than under the ordinary system. Instead of letting children experience the painful results which naturally follow from wrong conduct, the usual course pursued by parents is to inflict themselves certaiu 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. Add to which the further irritations which result from taking upon themselves, in the shape of extra labor or cost, those evil consequences which should have been allowed to fall on the wrong-doers. Similarly with the childreu. Penalties which the necessary reaction of things brings round upon them—penalties which are inflicted by impersonal ageucy—produce an irritation that is comparatively slight and transient; whereas penalties which are voluntarily iuflicted by a parent, and are afterward remembered as caused by him or her, produce an irritation both greater and more continued. Just consider how disastrous would be the result if this empirical method were pursued from the beginning. Suppose it were possible for parents to take upou themselves the physical sufferings entailed on their children by ignorance and awkwardness, and that while bearing these evil consequences they visited on their children certain other evil consequences, with the view of teaching them the impropriety of their conduct. Suppose that when a child, who had been forbidden to meddle with the kettle, spilled some boiling water on its foot, the mother viearious ly assumed the scald and gave a blow in place of it; and similarly iu all other cases. Would not the daily mishaps be sources of far more anger than now? Would there not be chronic ill-temper on both sides? Yet au exactly parallel policy is pursued in after years. A father who punishes his boy for carelessly or wilfully breaking a sister's toy, and then himself pays for a new toy, does substantially this same thing—inflicts an artificial penalty on the transgressor, and takes the natural penalty on himself—his own feelings and those of the trausgressor being alike 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 at his, the boy's, cost, and that his supply of pocket-money must be withheld to the needful extent, there would be much less eause for ebullition of temper on either side; while iu the deprivation afterward felt the boy would experienee the equitable and salutary consequenee. In brief, the system of discipline by natural reactions is less injurious to temper, alike because it is perceived on both sides to be nothing more than pure justice, and because it more or less substitutes the impersonal ageucy of nature for the personal agency of parents.

Whence also follows the manifest corollary, that under this system the parental aud filial relation will be a more friendly and therefore a more influential one. Whether in pareut or child, anger, however caused, and to whomsoever directed, is more or less detrimental. But anger in a parent toward a child and in a child toward a parent is especially detrimental, because it weakens that bond of sympathy which is essential to a beneficent control. In virtue of the general law of association of ideas, it inevitably results, both in young and old, that dislike is contracted toward things which in our experience are habitually connected with disagreeable feelings; or where attachment originally existed, it is weakened, or destroyed, or turned into repugnance, according to the quantity of painful impressions received. Parental wrath, with its accompanying reprimands and castigatious, cannot fail, if often repeated, to produce filial alienation; while the resentment and sulkiness of children cannot fail to weakeu the affection felt for them, and may even end in destroying it. Hence the numerous cases in which parents (and especially fathers, who are eommonly deputed 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 looked upon as inflictions. Seeing, then, as all must do, that estrangement of this kind is fatal to a salutary moral culture, it follows that parents cannot be too solicitous in avoiding occasions of direct antagonism with their children—occasions of personal resentment; and therefore they cannot too anxiously avail themselves of this discipline of natural consequences—this system of letting the penalty be inflicted by the laws of things, which, by saving the parent from the function of a penal agent, prevents these mutual exasperations aud estrangements.

Thus we see that this method of moral culture by experience of the normal reactions, which is the divinely-ordained method alike for infancy and for adult life, is equally applicable duriug the intermediate childhood and youth. And among the advantages of this method we see, first, that it gives that rational comprehension of right and wrong conduct which results from actual experience of the good and bad consequeuces caused by them; second, that the child, suffering nothiug more than the paiuful effects brought upon it by its owu wrong actions, must recognize more or less clearly the justice of the penalties; third, that, recogniziug the justice of the penalties, and receiving those penalties through the working of things, rather than at the hands of an individual, its temper will be less disturbed; while the parent, occupying the comparatively passive position of taking care that the natural penalties are felt, will preserve a comparative equanimity; and, fourth, that mutual exasperation being thus in great measure prevented, a much happier aud a more influential state of feeling will exist between parent and child.

"But what is to be done with more serious miseonduet?" some will ask. "How is this plau to be carried out when a petty theft has been committed? or wheu a lie has been told? or when some younger brother or sister has been ill-used?"

Before replying 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 education of his little nephew and niece. This he had couducted, more perhaps from natural sympathy than from reasoned-out conclusions, in the spirit of the method above set forth. The two children were in doors his pupils and out of doors his companions. They daily joined him in walks and botanizing excursions, eagerly sought out plants for him, looked on while he examined and identified them, and in this and other ways were ever gaining both pleasure and instruction in his society. In short, morally considered, he stood to them much more in the position of parent than either their father or mother did. Describing to us the results of this policy, he gave, among other instances, the following: One evening, having need for some article lying in another part of the house, he asked his nephew to fetch it for him. Deeply interested as the boy was in some amusement 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 annoyanee this ill-behavior gave him. And when, later in the evening, the boy made overtures for the usual play, they were gravely repelled—the uncle manifested just that eoldness of feeling naturally produced in him, and so let the boy experience the neeessary consequences of his conduct. Next morning, at the usual time for rising, our frieud heard a new voice outside the door, and in walked his little nephew with the hot water; and then the boy, peering about the room to see what else could be done, exclaimed, "Oh, you want your boots," and forthwith rushed downstairs to fetch them. In this and other ways he showed a true peuitence for his misconduct; he endeavored by unusual services to make up for the service he had refused; his higher feelings had of themselves conquered his lower ones, and acquired strength by the conquest; aud he valued more thau before the friendship he thus regained.

This gentlemau is now himself a father; acts on the same system, and finds it auswer completely. He makes himself thoroughly his childreu's friend. The evening is longed for by them because he will be at home, and they especially enjoy the Sunday because he is with them all day. Thus possessiug their perfect coufidence aud affectiou, he finds that the simple display of his approbation or disapprobation gives him abundaut power of control. If, on his return home, he hears that one of his boys has been naughty, he behaves toward him with that comparative coldness which the consciousness of the boy's miscouduct naturally produces, and he finds this a most efficieut punishment. The mere withholding of the usual caresses is a source of the keeuest distress—produces a much more prolouged fit of cryiug 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 mamma how they have behaved, and whether the report will be good. Recently the eldest, an active urchin of five, in one of those bursts of animal spirits common in healthy children, committed sundry extravagances during his mamma's absence—cut off part of his brother's hair and wounded himself with a razor taken from his father's dressing-case. Hearing of these occurrences on his return, the father did not speak to the boy either that night or next morning. Not only was the tribulation great, but the subsequent 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 inquiry, it appeared his fear was that he might again transgress in her absence.

We have introduced these facts before replying to the question, "What is to be done with the graver 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 successful treatment of these graver offences. And as a further preliminary, we must now point out that the establishment of this relation will result from adopting the system we advocate. Already we have shown that by letting a child experience simply the painful reactions of its own wrong actions, a parent in great measure avoids assuming the attitude of an enemy, and escapes being regarded as one; but it still remains to be shown that where this course has been consistently pursued from the beginning, a strong feeling of active friendship will be generated.

At present mothers and fathers are mostly considered by their offspring as friend-enemies. Determined as their impressions inevitably are by the treatment they receive, and oscillating as that treatment does between bribery and thwarting, between petting and scolding, between gentleness and castigation, children necessarily acquire conflicting beliefs respecting the parental character. A mother commonly thinks it quite sufficient to tell her little boy that she is his 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 know what is proper for you better than you do yourself;" "You are not old enough to understand it now, but when you grow up you will thank me for doing what I do"—these and like assertions are daily reiterated. 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 understand that future which his mother has in view, or how this treatment conduces to the happiness of that future, he judges by such results as he feels; and finding these results anything but pleasurable, he becomes sceptical respecting these professions of friendship. And is it not folly to expect any other issue? Must not the child judge by such evidence as he has got? 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 found some one who was constantly thwarting her wishes, uttering sharp reprimands, and occasionally inflicting actual penalties on her, she would pay but little attention to any professions of anxiety for her welfare which accompanied these acts. Why, then, does she suppose that her boy will conclude 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 punishment, but plays the part of a friend, by warning her boy of the punishments which nature will inflict. Take a case, and that it may illustrate the mode in which this policy is to be early initiated, let it be one of the simplest cases. Suppose that, prompted by the experimental spirit so conspicuous in children, whose proceedings instinctively conform to the inductive method of inquiry—suppose that, so prompted, the child is amusing himself by lighting pieces of paper in the candle and watching them burn. If his mother is of the ordinary unreflective stamp, she will either, on the plea of keeping the child "out of mischief," or from fear that he will burn himself, command him to desist, and in case of non-compliance will snatch the paper from him. On the other hand, should he be so fortunate as to have a mother of sufficient rationality, who knows that this interest with which the child is watching the paper burn results from a healthy inquisitiveness, without which he would never have emerged out of infantine stupidity, and who is also wise enough to consider the moral results of interference, she will reason thus: "If I put a stop to this I shall prevent the acquirement of a certain amount of knowledge. It is true that I may save the child from a burn; but what then? He is sure to burn himself some time; and it is quite essential to his safety in life that he should learn by experience the properties of flame. Moreover, if I forbid him from running this present risk, he is sure hereafter to run the same or a greater risk when no one is present to prevent him; whereas, if he should have any accident now that I am by, I can save him from any great injury; add to which the advantage that he will have in future some dread of fire, and will be less likely to burn himself to death, or set the house in a flame when others are absent. Furthermore, were I to make him desist, I should thwart him in the pursuit of what is in itself a purely harmless and, indeed, instructive gratification; and he would be sure to regard me with more or less ill-feeling. Ignorant as he is of the pain from which I would save him, and feeling only the pain of a balked desire, he could not fail to look upon me as the cause of that pain. To save him from a hurt which he cannot conceive, and which has therefore no existence for him, I inflict upon him a hurt which he feels keenly enough, and so become, from his point of view, a minister of evil. My best course then is simply to warn him of the danger, and to be ready to prevent any serious damage." And following out this conclusion, she says to the child, "I fear you will hurt yourself if you do that." Suppose, now, that the child perseveres, as he will very probably do, and suppose that he ends by burning himself. What are the results? In the first place he has gained an experience which he must gain eventually, and which, for his own safety, he cannot gain too soon; and, in the second place, he has found that his mother's disapproval or warning was meant for his welfare: he has a further positive experience of her benevolence—a further reason for placing confidence in her judgment and her kindness—a further reason for loving her.

Of course, in those occasional hazards where there is a risk of broken limbs or other serious bodily injury, forcible prevention is called for. But leaving out these extreme cases, the system pursued should be not that of guarding a child against the small dangers into which it daily runs, but that of advising and warning it against them. And by consistently pursuing this course, a much stronger filial affection will be generated than commonly exists. If here, as elsewhere, the discipline of the natural reactions is allowed to come into play—if in all those out-of-door scramblings and in-door experiments, by which children are liable to hurt themselves, they are allowed to persevere, subject only to dissuasion more or less earnest according to the risk, there cannot fail to arise an ever-increasing faith in the parental friendship and guidance. Not only, as before shown, does the adoption of this principle enable fathers and mothers to avoid the chief part of that odium which attaches to the infliction of positive punishment; but, as we here see, it enables them further to avoid the odium that attaches to constant thwartings, and even to turn each of those incidents which commonly cause squabbles into a means of strengthening the mutual good feeling. Instead of being told in words, which deeds seem to contradict, that their parents are their best friends, children will learn this truth by a consistent daily experience; and so learning it, will acquire a degree of trust and attachment which nothing else can give. And now having indicated the much more sympathetic relation which must result from the habitual use of this method, let us return to the question above put, How is this method to be applied to the graver offences?

Note, in the first place, that these graver offences are likely to be both less frequent and less grave under the regime we have described than under the ordinary regime. The perpetual ill-behavior of many children is itself the consequence of that chronic irritation in which they are kept by bad management. The state of isolation and antagonism produced by frequent punishment necessarily deadens the sympathies; necessarily, therefore, opens the way to those transgressions which the sympathies should check. That harsh treatment which children of the same family inflict on each other is often, in great measure, a reflex of the harsh treatment they receive from adults—partly suggested by direct example, and partly generated by the ill-temper and the tendency to vicarious retaliation which follow chastisements and scoldings. It cannot be questioned that the greater activity of the affections and happier state of feeling, maintained in children by the discipline we have described, must prevent their sins against each other from being either so great or so frequent. Moreover, the still more reprehensible offences, as lies and petty thefts, will, by the same causes, be diminished. Domestic estraugement is a fruitful source of such transgressions. It is a law of human nature, visible enough to all who observe, that those who are debarred the higher gratifications fall back upon the lower; those who have no sympathetic pleasures seek selfish ones; and hence, conversely, the maintenance of happier relations between parents and children is calculated to diminish the number of those offences of which selfishness is the origin.

When, however, such offences are committed, as they will occasionally be, even under the best system, the discipline of consequences may still be resorted to; and if there exist that bond of confidence and affection which we have described, this discipline will be found efficient. For what are the natural consequences, say, of a theft? They are of two kinds—direct and indirect. The direct consequence, as dictated by pure equity, is that of making restitution. An absolutely just ruler (and every parent should aim to be one) will demand that, wherever it is possible, a wrong act shall be undone by a right one; and in the case of theft this implies either the restoration of the thing stolen, or, if it is consumed, then the giving of an equivalent; which, in the case of a child, may be effected out of its pocket-money. The indirect and more serious consequence is the grave displeasure of parents—a consequence which inevitably follows among all peoples sufficiently civilized to regard theft as a crime; and the manifestation of this displeasure is, in this instance, the most severe of the natural reactions produced by the wrong action. "But," it will be said, "the manifestation of parental displeasure, either in words or blows, is the ordinary course in

these cases: the method leads here to nothing new." Very true. Already we have admitted that, in some directions, this method is spontaneously pursued. Already we have shown that there is a more or less manifest tendency for educational systems to gravitate toward the true system. And here we may remark, as before, that the intensity of this natural reaction will, in the beneficent order of things, adjust itself to the requirements—that this parental displeasure will vent itself in violent measures during comparatively barbarous times, when the children are also comparatively barbarous, and will express itself less cruelly in those more advanced social states in which, by implication, the children are amenable to milder treatment. But what it chiefly concerns us here to observe is, that the manifestation of strong parental displeasure, produced by one of these graver offences, will be potent for good just in proportion to the warmth of the attachment existing between parent and child. Just in proportion as the discipline of the natural consequences has been consistently pursued in other cases, will it be efficient in this case. Proof is within the experience of all, if they will look for it.

For does not every man know that when he has offended another person, the amount of genuine regret he feels (of course, leaving worldly considerations out of the question) varies with the degree of sympathy he has for that person? Is he not conscious that when the person offended stands to him in the position of an enemy, the having given him annoyance is apt to be a source rather of secret satisfaction than of sorrow? Does he not remember that where umbrage has been taken by some total stranger, he has felt much less concern than he would have done had such umbrage been taken by one with whom he was intimate? While, conversely, has not the anger of an admired and cherished friend been regarded by him as a serious misfortune, long and keenly regretted? Clearly, then, the effects of parental displeasure upon children must similarly depend upon the pre-existing relationship. Where there is an established alienation, the feeling of a child who has transgressed is a purely selfish fear of the evil consequences likely to fall upon it in the shape of physical penalties or deprivations; and after these evil consequences have been inflicted, there are aroused an antagonism and dislike which are morally injurious, and tend further to increase the alienation. On the contrary, where there exists a warm filial affection produced by a consistent parental friendship—a friendship not dogmatically asserted as an excuse for punishments and denials, but daily exhibited in ways that a child can comprehend—a friendship which avoids needless thwartings, which warns against impending evil consequences, and which sympathizes with juvenile pursuits — there the state of mind caused by parental displeasure will not only be salutary as a check to future misconduct of like kind, but will also be intrinsically salutary. The moral pain consequent upon having, for the time being, lost so loved a friend, will stand in place of the physical pain usually inflicted; and where this attachment exists, will prove equally if not more efficient. While instead of the fear and vindictiveness excited by the one course, there will be excited by the other more or less of sympathy with parental sorrow, a genuine regret for having caused it, and a desire, by some atonement, to re-establish the habitual friendly relationship. Instead of bringing into play those purely egoistic feelings whose predominance is the cause of criminal acts, there will be brought into play those altruistic feelings which check criminal acts. Thus the discipline of the natural consequences is applicable to grave as well as trivial faults; and the practice of it conduces not simply to the repression, but to the eradication of such faults.

In brief, the truth is that savageness begets savageness, and gentleness begets gentleness. Children who are unsympathetically treated become relatively unsympathetic; whereas treating them with due fellow-feeling is a means of cultivating their fellow-feeling. With family governments as with political ones, a harsh despotism itself generates a great part of the crimes it has to repress; while conversely a mild and liberal rule not only avoids many causes of dissension, but so ameliorates the tone of feeling as to diminish the tendency to transgression. As John Locke long since remarked, "Great severity of punishment does but very little good, nay, great harm, in education; and I believe it will be found that, *cæteris paribus*, those children who have been most chastised seldom make the best men." In confirmation of which opinion we may cite the fact not long since made public by Mr. Rogers, Chaplain of the Penitonville Prison, that those juvenile criminals who have been whipped are those who most frequently return to prison. On the other hand, as exhibiting the beneficial effects of a kinder treatment, we will instance the fact stated to us by a French lady, in whose house we recently stayed in Paris. Apologizing for the disturbance daily caused by a little boy who was unmanageable both at home and at school, she expressed her fear that there was no remedy save that which had succeeded in the case of an elder brother—namely, sending him to an English school. She explained that at various schools in Paris this elder brother had proved utterly untractable; that in despair they had followed the advice to send him to England; and that on his return home he was as good as he had before been bad. And this remarkable change she ascribed entirely to the comparative mildness of the English discipline.

After this exposition of principles, our remaining space may best be occupied by a few of the chief maxims and rules deducible from them; and with a view to brevity we will put these in a more or less hortatory form.

Do not expect from a child any great amount of moral goodness. During early years every civilized man passes through that phase of character exhibited by the barbarous race from which he is descended. As the child's features—flat nose, forward-opening nostrils, large lips, wide-apart eyes, absent frontal sinus, etc.—resemble for a time those of the savage, so, too, do his instincts. Hence the tendencies to cruelty, to thieving, to lying, so general among children—tendencies which, even without the aid of discipline, will become more or less modified just as the features do. The popular idea that children are "innocent," while it may be true in so far as it refers to evil *knowledge*, is totally false in so far as it refers to evil *impulses*, as half an hour's observation in the nursery will prove to any one. Boys when left to themselves, as at a public school, treat each other far more brutally than men do; and were they left to themselves at an earlier age their brutality would be still more conspicuous.

Not only is it unwise to set up a high standard for juvenile good conduct, but it is even unwise to use very urgent incitements to such good conduct. Already most people recognize the detrimental results of intellectual precocity; but there remains to be recognized the truth that there is a *moral precocity* which is also detrimental. Our higher moral faculties, like our higher intellectual ones, are comparatively complex. By consequence they are both comparatively late in their evolution. And with the one as with the other, a very early activity produced by stimulation will be at the expense of the future character. Hence the not uncommon fact that those who during childhood were instanced as models of juvenile goodness by and by undergo some disastrous and seemingly inexplicable change, and end by being not above but below par; while relatively exemplary men are often the issue of a childhood by no means so promising.

Be content, therefore, with moderate measures and moderate results. Constantly bear in mind the fact that a higher morality, like a higher intelligence, must be reached by a slow growth, and you will then have more patience with those imperfections of nature which your child hourly displays. You will be less prone to that constant scolding, and threatening, and forbidding, by which many parents induce a chronic domestic irritation, in the foolish hope that they will thus make their children what they should be.

This comparatively liberal form of domestic government, which does not seek despotically to regulate all the details of a child's conduct, necessarily results from the system for which we have been contending. Satisfy yourself with seeing that your child always suffers the natural consequences of his actions, and you will avoid that excess of control in which so many parents err. Leave him wherever you can to the discipline of experience, and you will so save him from that hothouse virtue which over-regulation produces in yielding natures, or that demoralizing antagonism which it produces in independent ones.

By aiming in all cases to administer the natural reactions to your child's actions, you will put an advantageous check upon your own temper. The method of moral education pursued by many, we fear by most, parents, is little else than that of venting their anger in the way that first suggests itself. The slaps, and rough shakings, and sharp words, with which a mother commonly visits her offspring's small offences (many of them not offences considered intrinsically), are very generally but the manifestations of her own ill-controlled feelings—result much more from the promptings of those feelings than from a wish to benefit the offenders. While they are injurious to her own character, these ebullitions tend, by alienating her children and by decreasing their respect for her, to diminish her influence over them. But by pausing in each case of transgression to consider what is the natural consequence, and how that natural consequence may best be brought home to the transgressor, some little time is necessarily obtained for the mastery of yourself; the mere blind anger first aroused in you settles down into a less vehement feeling, and one not so likely to mislead you.

Do not, however, seek to behave as an utterly passionless instrument. Remember that besides the natural consequences of your child's conduct which the working of things tends to bring round on him, your own approbation or disapprobation is also a natural consequence, and one of the ordained agencies for guiding him. The error which we have been combating is that of *substituting* parental displeasure and its artificial penalties for the penalties which nature has established. But while it should not be *substituted* for these natural penalties, it by no means follows that it should not, in some form, *accompany* them. The *secondary* kind of punishment should not usurp the place of the *primary* kind; but, in moderation, it may rightly supplement the primary kind. Such amount of disapproval, or sorrow, or indignation, as you feel, should be expressed in words or manner or otherwise; subject, of course, to the approval of your judgment. The degree and kind of feeling produced in you will necessarily depend upon your own character, and it is therefore useless to say it should be this or that. All that can be recommended is, that you should aim to modify the feeling into that which you believe ought to be entertained. Beware, however, of the two extremes, not only in respect of the intensity, but in respect of the duration of your displeasure. On the one hand, anxiously avoid that weak

impulsiveness, so general among mothers, which scolds and forgives almost in the same breath. On the other hand, do not unduly continue to show estrangement of feeling, lest you accustom your child to do without your 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 assimilate to those which you conceive would be called forth from a parent of perfect nature.

Be sparing of commands. Command only in those cases in which other means are inapplicable, or have failed. "In frequent orders the parents' advantage is more considered than the child's," says Richter. As in primitive societies a breach of law is punished, not so much because it is intrinsically wrong as because it is a disregard of the king's authority—a rebellion against him; so, in many families, the penalty visited on a transgressor proceeds less from reprobation of the offence than from anger at the disobedience. Listen to the ordinary speeches—"How *dare* you disobey me?" "I tell you I'll *make* you do it, sir." "I'll soon teach you who is *master*"—and then consider what the words, the tone, and the manner imply. A determination to subjugate is much more conspicuous in them than an anxiety for the child's welfare. For the time being the attitude of mind differs but little from that of the despot bent on punishing a recalcitrant subject. The right-feeling parent, however, like the philanthropic legislator, will not rejoice in coercion, but will rejoice in dispensing with coercion. He will do without law in all cases where other modes of regulating conduct can be successfully employed; and he will regret the having recourse to law when it is necessary. As Richter remarks, "The best rule in politics is said to be '*pas trop gouverner;*' it is also true in education." And in spontaneous conformity with this maxim, parents whose lust of dominion is restrained by a true sense of duty will aim to make their children control themselves wherever it is possible, and will fall back upon absolutism only as a last resort.

But whenever you *do* command, command with decision and consistency. If the case is one which really cannot be otherwise dealt with, then issue your fiat, and having issued it, never afterward swerve from it. Consider well beforehand what you are going to do; weigh all the consequences, think whether your firmness of purpose will be sufficient, and then, if you finally make the law, enforce it uniformly at whatever cost. Let your penalties be like the penalties inflicted by inanimate nature—inevitable. The hot cinder burns a child the first time he seizes it; it burns him the second time; it burns him the third time; it burns him every time; and he very soon learns not to touch the hot cinder. If you are equally consistent—if the consequences which you tell your child will follow certain acts, follow with like uniformity, he will soon come to respect your laws as he does those of nature. And this respect once established will prevent endless domestic evils. Of errors in education one of the worst is that of inconsistency. As in a community, crimes multiply when there is no certain administration of justice, so in a family, an immense increase of transgressions results from a hesitating or irregular infliction of penalties. A weak mother, who perpetually threatens and rarely performs—who makes rules in haste and repents of them at leisure—who treats the same offence now with severity and now with leniency, according as the passing humor dictates, is laying up miseries both for herself and her children. She is making herself contemptible in their eyes; she is setting them an example of uncontrolled feelings; she is encouraging them to transgress by the prospect of probable impunity; she is entailing endless squabbles and accompanying damage to her own temper and the tempers of her little ones; she is reducing their minds to a moral chaos, which after-years of bitter experience will with difficulty bring into order. Better even a barbarous form of domestic government carried out consistently than a humane one inconsistently carried out. Again we say, avoid coercive measures whenever it is possible to do so; but when you find despotism really necessary, be despotic in good earnest.

Bear constantly in mind the truth that the aim of your discipline should be to produce a *self-governing* being, not to produce a being to be *governed by others*. Were your children fated to pass their lives as slaves, you could not too much accustom them to slavery during their childhood; but as they are by and by to be free men, with no one to control their daily conduct, you cannot too much accustom them to self-control while they are still under your eye. This it is which makes the system of discipline by natural consequences so especially appropriate to the social state which we in England have now reached. Under early tyrannical forms of society, when one of the chief evils the citizen had to fear was the anger of his superiors, it was well that during childhood parental vengeance should be a predominant means of government. But now that the citizen has little to fear from any one—now that the good or evil which he experiences throughout life is mainly that which in the nature of things results from his own conduct, it is desirable that from his first years he should begin to learn, experimentally, the good or evil consequences which naturally follow this or that conduct. Aim, therefore, to diminish the amount of parental government as fast as you can substitute for it in your child's mind that self-government arising from a foresight of results. In infancy a considerable amount of absolutism is necessary. A three-year-old urchin playing with an open razor cannot be allowed to learn by this discipline of consequences; for the consequences may, in such a case, be too serious. But as intelligence increases, the number of instances calling for peremptory interference may be, and should be, diminished, with the view of gradually ending them as maturity is approached. All periods of transition are dangerous; and the most dangerous is the transition from the restraint of the family circle to the non-restraint of the world. Hence the importance of pursuing the policy we advocate, which, alike by cultivating a child's faculty of self-restraint, by continually increasing the degree in which it is left to its self-constraint, 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 control, where control is really needful; by and by an incipient constitutionalism, in which the liberty of the subject gains some express recognition; successive extensions of this liberty of the subject, gradually ending in parental abdication.

Do not regret the exhibition of considerable self-will on the part of your children. It is the correlative of that diminished coerciveness so conspicuous in modern education. The greater tendency to assert freedom of action on the one side corresponds to the smaller tendency to tyrannize on the other. They both indicate an approach to the system of discipline we contend for, under which children will be more and more led to rule themselves by the experience of 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 manageableness of the German ones, and with it the submissiveness and political serfdom of adult Germans? Or shall we not rather tolerate in our boys those feelings which make them free men, and modify our methods accordingly?

Lastly, always remember that to educate rightly is not a simple and easy thing, but a complex and extremely difficult thing—the hardest task which devolves upon adult life. The rough and ready style of domestic government is indeed practicable by the meanest and most uncultivated intellects. Slaps and sharp words are penalties that suggest themselves alike to the least reclaimed barbarian and the most stolid peasant. Even brutes can use this method of discipline; as you may see in the growl and half-bite with which a bitch will check a too-exigeant puppy. But if you would carry out with 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 habitually to trace the consequences of conduct—to consider what are the results which in adult life follow certain kind of acts; and then you will have to devise methods by which parallel results shall be entailed on the parallel acts of your children. You will daily be called upon to analyze the motives of juvenile conduct; you must distinguish between acts that are really good and those which, though externally simulating them, proceed from inferior impulses; while you must be ever on your guard against the cruel mistake not unfrequently made, of translating neutral acts into transgressions, or ascribing worse feelings than were entertained. You must more or less modify your method to suit the disposition of each child, and must be prepared to make further modifications as each child's disposition enters on a new phase. Your faith will often be taxed to maintain the requisite perseverance in a course which seems to produce little or no effect. Especially if you are dealing with children who have been wrongly treated, you must be prepared for a lengthened trial of patience before succeeding with better methods; seeing that that which is not easy even where a right state of feeling has been established from the beginning becomes doubly difficult when a wrong state of feeling has to be set right. Not only will you have constantly to analyze the motives of your children, but you will have to analyze your own motives—to discriminate between those internal suggestions springing 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 that you are educating your children. Intellectually you must cultivate to good purpose that most complex of subjects—human nature and its laws, as exhibited in your children, in yourself, and in the world. 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 last stage in the mental development of each man and woman is to be reached only through the proper discharge of the parental duties. And when this truth is recognized, it will be seen how admirable is the ordination in virtue of which human beings are led by their strongest affections to subject themselves to a discipline which they would else elude.

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 demands

the higher attributes of human nature, they will see to be evidence of its fitness for the more advanced states of humanity. Though it calls for much labor and self-sacrifice, they will see that it promises an abundant return of happiness, immediate and remote. They 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—it blesses him that trains and him that's trained.

It will be seen that we have said nothing in this chapter about the transcendental distinction between right and wrong, of which wise men know so little, and children nothing. All thinkers are agreed that we may find the criterion of right in the effect of actions if we do not find the rule there; and that is sufficient for the purpose we have had in view. Nor have we introduced the religious element. We have confined our inquiries to a nearer, and a much more neglected field, though a very important one. 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 ordinary, and at the village alehouse, the topic which, after the political question of the day, excites perhaps the most general interest is the management of animals. Riding home from hunting, the conversation is pretty sure to gravitate toward horse-breeding, and pedigrees, and comments on this or that "good point;" while a day on the moors is very unlikely to pass without something being said on the treatment of dogs. When crossing the fields together from church, the tenants of adjacent farms are apt to pass from criticisms on the sermon to criticisms on the weather, the crops, 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 pig-styes, 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 this or that kind of treatment. Nor is it only among the rural population that the regulations of the kennel, the stable, the cow-shed, and the sheep-pen, are favorite subjects. In towns, too, the numerous artisans who keep dogs, the young men who are rich enough to now and then indulge their sporting tendencies, and their more staid 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 other.

But during after-dinner conversations, or at other times of like intercourse, who hears anything said about the rearing of children? When the country gentleman has paid his daily visit to the stable, and personally inspected 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 ventilation? On his library shelves may be found White's "Farriery," Stephen's "Book of the Farm," Nimrod on the "Condition of Hunters," and with the contents of these he is more or less familiar; but how many books has he read on the management of infancy and childhood? The fattening properties of oilcake, the relative values of hay and chopped straw, the dangers of unlimited clover, are points on which every landlord, farmer, and peasant has some knowledge; but what proportion of them know much about the qualities of the food they give their children, and its fitness to the constitutional needs of growing boys and girls? Perhaps the business interests of these classes will be assigned as accounting for this anomaly. The explanation is inadequate, however, seeing that the same contrast holds more or less among other classes. Of a score of townspeople few, if any, would prove ignorant 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 fathers, probably not one would be found who had considered whether the time elapsing between his children's dinner and their resumption of lessons was sufficient. Indeed, on cross-examination, nearly every man 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," would probably be the reply. And 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 bullocks is an occupation on which men of education willingly bestow much time, inquiry, and thought, the bringing up of fine human beings is an occupation tacitly voted unworthy of their attention. Mammas who have been taught little but languages, music, and accomplishments, aided by nurses full of antiquated prejudices, are held competent regulators of the food, clothing, and exercise of children. Meanwhile the fathers read books and periodicals, attend agricultural meetings, try experiments, and engage in discussions, all with the view of discovering how to fatten prize pigs! Infinite pains will be taken to produce a racer that shall win the Derby, none to produce a modern athlete. Had Gulliver narrated of the Laputans 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 is the antithesis, 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 animal;" and to be a nation of good animals is the first condition to national prosperity. Not only is it that the event of a war often turns on the strength and hardiness of soldiers; but it is that the contests of commerce are in part determined by the bodily endurance of producers. Thus far we have found no reason to fear trials of strength with 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 keen competition of modern life, the application required of almost every one is such as few can bear without more or less injury. Already thousands break down under the high pressure they are subject to. If this 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 to bear its excessive wear and tear.

Happily the matter is beginning to attract attention. The writings of Mr. Kingsley indicate a reaction against over-culture; carried, as reactions usually are, somewhat too far. Occasional letters and leaders in the newspapers have shown an awakening interest in physical training. And the formation of a school, significantly nicknamed that of "muscular Christianity," implies a growing opinion that our present methods of bringing up children do not sufficiently regard the welfare of the body. The topic is evidently ripe for discussion.

To conform the regimen of the nursery and the school to the established truths of modern science—this is the desideratum. It is time that the benefits which our sheep and oxen have for years past derived from the investigations of the laboratory should be participated in by our children. Without calling in question the great importance of horse-training and pig-feeding, we would suggest that, as the rearing of well-grown men and women is also of some moment, the conclusions indicated by theory and indorsed by practice ought to be acted on in the last case as in the first. Probably not a few will be startled, perhaps offended, by this collocation of ideas. But it is a fact not to be disputed, and to which we had best reconcile ourselves, that man is subject to the same organic laws as inferior creatures. No anatomist, no physiologist, no chemist, will for a moment hesitate to assert that the general principles which rule over the vital processes in animals equally rule over the vital processes in man. And a candid admission of this fact is not without its reward—namely, that the truths established by observation and experiment on brutes become more or less available for human guidance. Rudimentary as is the science of life, it has already attained to certain fundamental principles underlying the development of all organisms, the human included. That which has now to be done, and that which we shall endeavor in some measure to do, is to show the bearing of these fundamental principles upon the physical training of childhood and youth.

The rhythmical tendency which is traceable in all departments of social life—which is illustrated in the access of despotism after revolution, or, among ourselves, in the alternation of reforming epochs and conservative epochs—which, after a dissolute age, brings an age of asceticism, and conversely, which, in commerce produces the regularly recurring inflations and panics—which carries the devotees of fashion from one absurd extreme to the opposite one—this rhythmical tendency affects also our table-habits, and by implication the dietary of the young. After a period distinguished by hard drinking and hard eating has come a period of comparative sobriety, which, in teetotalism and vegetarianism, exhibits extreme forms of its protest against the riotous living of the past. And along with this change in the regimen of adults has come a parallel change in the regimen for boys and girls. In past generations the belief was that the more a child could be induced to eat the better; and even now, among farmers and in remote districts, where traditional ideas most linger, parents may be found who tempt their children to gorge themselves. But among the educated classes, who chiefly display this reaction toward abstemiousness, there may be seen a decided leaning to the underfeeding rather than the overfeeding of children. Indeed their disgust for bygone animalism is more clearly shown in the treatment of their offspring than in the treatment of themselves; seeing that while their disguised asceticism is, in so far as their personal conduct is concerned, kept in check by their appetites, it has full play in legislating for juveniles.

That overfeeding and underfeeding are both bad is a truism. Of the two, however, the last is the worst. As writes a high authority, "the effects of casual repletion are less prejudicial, and more easily corrected, than those of inanition."* Add to which, that where there has been no injudicious interference, repletion will seldom occur. "Excess is the vice rather of adults than of the young, who are rarely either gourmands or epicures, unless through the fault of those

* "Cyclopædia of Practical Medicine."

who rear them." * This system of restriction, which many parents think so necessary, is based upon very inadequate observation and very erroneous reasoning. There is an 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 the quantity of food.

"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 certainly will do?" As thus put, the 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 the lower creation—as it is a good guide to the infant—as it is a good guide to the invalid—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 relevancy of these facts; and yet the paradox is quite defensible. The truth is, that the instances of excess which such persons have in mind are usually the *consequences* of the restrictive system they seem to justify. They are the sensual reactions caused by a more or less ascetic regimen. They illustrate on a small scale that commonly-remarked fact, that those who during youth have been subject to the most rigorous discipline, are apt afterward to rush into the wildest extravagances. They are analogous to those frightful phenomena, once not uncommon in convents, where nuns suddenly lapsed from the extremest austerities into an almost demoniac wickedness. They simply exhibit the uncontrollable vehemence of a long-denied desire. 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 desires, it should be discouraged. The physiologist, however, whose discoveries lead him to an ever-increasing reverence for the arrangements of things, will suspect that there is something more in this love of sweets 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 vital processes. Both saccharine and fatty matters are eventually oxidized in the body, and there is an accompanying evolution of heat. Sugar is the form to 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 starch changed into sugar in the course of digestion, but it has been proved by M. Claude Bernard that the liver is a factory in which other constituents of food are transformed into sugar. Now, when to the fact 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—that the organism demands more sugar because it cannot deal with much fat. Again, children are usually very fond of vegetable acids. Fruits of all kinds are their delight; and, in the absence of anything better, they will devour unripe gooseberries and the sourest of crabs. Now, not only are vegetable acids, in common with mineral ones, very good tonics, and beneficial as such when taken in moderation, but they have, when administered in their natural forms, other advantages. "Ripe fruit," says Dr. Andrew Combe, "is more freely given on the Continent than in this country; and particularly when the bowels act imperfectly it is often very useful." See, then, the discord between the instinctive wants of children and their habitual treatment. Here are two dominant desires, which there is good reason to believe express certain needs of the juvenile constitution; and not only are they ignored in the nursery regimen, 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 dietary equally insipid, is rigidly adhered to; and any ministration to the palate is thought not only needless but wrong. What is the necessary consequence? When, on fête-days, 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 fruit-garden is obtained, then the long-denied and therefore intense desires lead to great excesses. There is an impromptu carnival, caused not only by the release from past restraints, but also 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 children must not be left to the guidance of their appetites! These disastrous results of artificial restrictions are themselves cited as proving the need for further restrictions! We contend, therefore, that the reasoning commonly used to justify this system of interference is vicious. We contend that, were children allowed daily to partake of these more sapid edibles, for which there is a physiological requirement, they would rarely exceed, as they now mostly do, when they have the opportunity: were fruit, as Dr. Combe recommends, "to constitute a part of the regular food" (given, as he advises, not between meals, but along with them), there would be none of that craving which prompts the devouring of such fruits as crabs and sloes. And similarly in other cases.

Not only is it that the *à priori* reasons for trusting the appetites of children are so strong, and that the reasons assigned for distrusting them are invalid, but it is that no other guidance is worthy of any confidence. What is the value of this parental judgment, set up as an alternative regulator? When to "Oliver asking for more," the mamma or the governess replies in the negative, on what data does she proceed? She *thinks* he has had enough. But where are her grounds for so thinking? Has she some secret understanding with the boy's stomach—some *clairvoyant* power enabling her to discern the needs of his body? If not, how can she safely decide? Does she not know that the demand of the system for food is determined by numerous and involved causes—varies with the temperature, with the hygrometric state of the air, with the electric state of the air—varies also according to the exercise taken, according to the kind and quality of food eaten at the last meal, and according to the rapidity with which the last meal was digested? How can she calculate the result of such a combination of causes? As we heard said by the father of a five-years-old boy, who stands a head taller than most of his age, and is proportionately robust, rosy, and active: "I can see no artificial standard by which to mete out his food. If I say, 'this much is enough,' it is a mere guess; and the guess is as likely to be wrong as right. Consequently, having no faith in guesses, I let him eat his fill." And certainly any one judging of his policy by its effects would be constrained to admit its wisdom. In truth, this confidence, with which most parents take upon themselves to legislate for the stomachs of their children, proves their unacquaintance with the principles of physiology: if they knew more they would be more modest. "The pride of science is humble when compared with the pride of ignorance." If any one would learn how little faith is to be placed in human judgments, and how much in the pre-established arrangements of things, let him compare the rashness of the inexperienced physician with the caution of the most advanced; or let him dip into Sir John Forbes' work, "On Nature and Art in the Cure of Disease;" and he will then see that, in proportion as men gain a greater knowledge of the laws of life, they come to have less confidence in themselves and more in nature.

Turning from the question of *quantity* of food to that of *quality*, we may discern the same ascetic tendency. Not simply a more or less restricted diet, but a comparatively low diet, is thought proper for children. The current opinion is that they should have but little animal food. Among the less wealthy classes economy seems to have dictated this opinion—the wish has been father to the 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 first, probably nothing but a convenient excuse, has by repetition grown into an article of faith; while the classes with whom cost is not a consideration have been swayed partly by the example of the majority, partly by the influence of nurses drawn from the lower classes, and in some measure by the reaction against past animalism.

If, however, we inquire for the basis of this opinion, we find little or none. It is a dogma repeated and received without proof, like that which, for thousands of years, insisted on the necessity of swaddling-clothes. It may indeed be true that, to the young child's stomach, not yet endowed with much muscular power, meat, which requires considerable trituration before it can be made into chyme, is an unfit aliment. But this objection does not tell against animal food from which the fibrous part has been extracted; nor does it apply when, after the lapse of two or three years, considerable muscular vigor has been acquired. And while the evidence in support of this dogma, partially valid in the case of very young children, is not valid in the case of older children, who are, nevertheless, ordinarily treated in conformity with the dogma, the adverse evidence is abundant and conclusive. The verdict of science is exactly opposite to the popular opinion. We have put the question to two of our leading physicians, and to several of the most distinguished physiologists, and they uniformly agree in the conclusion that children should have a diet not *less* nutritive, but, if anything, *more* nutritive than that of adults.

The grounds for this conclusion are obvious, and the reasoning simple. It needs but to compare the vital processes of a man with those of a boy to see at once that the demand for sustenance is relatively greater in the boy than in the man. What are the ends for which a man requires food? Each day his body undergoes more or less wear—wear through muscular exertion, wear of the nervous system through mental actions, wear of the viscera in carrying on the functions of life; and the tissue thus wasted has to be renewed. Each day, too, by perpetual radiation, his body loses a large amount of heat; and as, for the continuance of the vital actions, the temperature of the body must be maintained, this loss has to be compensated by a constant production of heat; to which end certain constituents of the food are unceasingly undergoing oxidation. To make up for the day's waste, and to supply fuel for the day's expenditure of heat, are, then, the sole purposes for which the adult requires food. Consider, now, the case of the boy. He, too, wastes the substance of his body by action; and it needs but to note his restless activity to see that, in proportion to

* "Cyclopædia of Practical Medicine."

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 its mass than does that of a man, 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 that even had the boy no other vital processes to carry on than the man has, he would need, relatively to his size, a somewhat larger supply of nutriment. But, besides repairing his body and maintaining its heat, the boy has to make new tissue—to grow. After waste and thermal loss have been provided for, such surplus of nutriment as remains goes to the further building up of the frame; and only in virtue of this surplus is normal growth possible—the growth that sometimes takes place in the absence of such surplus, causing a manifest prostration consequent upon defective repair. How peremptory is the demand of the unfolding organism for materials is seen alike in that "school-boy hunger" which after-life rarely parallels in intensity, and in the comparatively quick return of appetite. And if there needs further evidence of this extra necessity for nutriment, we have it in the fact that, during the famines following shipwrecks and other disasters, the children are the first to die.

This relatively greater need for nutriment being admitted, as it must perforce be, the question that remains is, Shall we meet it by giving an excessive quantity of what may be called dilute food, or a more moderate quantity of concentrated food? The nutriment obtainable from a given weight of meat is obtainable only from a larger weight of bread, or from a still larger weight of potatoes, and so on. To fulfil the requirement, the quantity must be increased as the nutritiveness is diminished. Shall we, then, respond to the extra wants of the growing child by giving an adequate quantity of food as good as that of 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 the more energy is left for the purposes of growth and action. The functions of the stomach and intestines cannot be performed without a large supply of blood and nervous power; and in the comparative lassitude that follows a hearty meal every adult has proof that this supply of blood and nervous power is at the expense of the system at large. If the requisite nutriment is furnished by a great quantity of innutritious food, more work is entailed on the viscera 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 in both. The inference is, then, that they should have a diet which combines, as much as possible, nutritiveness and digestibility.

It is doubtless true that 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 comparatively little meat is given; and who, nevertheless, grow and appear in good health. Animal food is scarcely tasted by the offspring of laboring people; and yet they reach a healthy maturity. But these seemingly adverse facts have by no means the weight commonly supposed. In the first place, it does not follow that those who in early years flourish on bread and potatoes will eventually reach a fine development; and a comparison between the agricultural laborers and the gentry in England, or between the middle and lower classes in France, is by no means in favor of vegetable feeders. In the second place, the question 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, flaccid tissue may appear the equal of one whose fibres are well toned, a trial of strength will prove the difference. Obesity in adults is often a sign of feebleness. Men lose weight in training. And hence the appearance of these low-fed children 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 those of the bread-and-potato-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 the better-fed son of a gentleman.

If we compare different classes of animals, or different races of men, or the same animals or men when differently fed, we find still more distinct proof that *the degree of energy essentially depends on the nutritiveness of the food.*

In a cow, subsisting on so innutritive a food as grass, we see that the immense quantity required to be eaten necessitates an enormous digestive system; that the limbs, small in comparison with the body, are burdened by its weight; that in carrying about this heavy body and digesting this excessive quantity of food, a great amount of force is expended; and that, having but little energy remaining, the creature is sluggish. Compare with the cow a horse—an animal of nearly allied structure but adapted to a more concentrated food. Here we see that the body, and more especially its abdominal region, bears a much smaller ratio to the limbs; that the powers are not taxed by the support of such massive viscera, nor the digestion of so bulky a food; and that, as a consequence, there is great locomotive energy and considerable vivacity. If, again, we contrast the stolid inactivity of the graminivorous sheep with the liveliness of the dog, 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 noting the restlessness with which the carnivorous animals pace up and down their cages, it needs but to remember that none of the herbivorous animals habitually display this superfluous energy, to see how clear is the relation between concentration of food and degree of activity.

That these differences are not directly consequent upon differences of constitution, as some may argue, but are directly consequent upon differences in the food which the creatures are constituted to subsist 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 larvæ of insects and the like meagre fare, are comparatively puny in stature, have large abdomens, soft and undeveloped muscles, and are quite unable to cope with Europeans, either in a struggle or in prolonged exertion. Count up the wild races who are well grown, strong and active, as the Kaffirs, North American Indians, and Patagonians, and you find them large consumers of flesh. The ill-fed Hindoo goes down before the Englishman fed on more nutritive food, to whom he is as inferior in mental as in physical energy. And generally, we think, the history of the world shows that the well-fed races have been the energetic and dominant races.

Still stronger, however, becomes the argument, when we find that the same individual animal becomes capable of more or less exertion according as its food is more or less nutritious. This has been clearly demonstrated in the case of the horse. Though 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 well known of old that, after passing the summer months in the fields, hunters required some months of stable-feeding before becoming able to follow the hounds, and that they did not get into good condition until the beginning of the next spring. And the modern practice is that insisted on by Mr. Apperley, "Never to give a hunter what is called 'a summer's run at grass,' and, except under particular and very favorable circumstances, never to turn him out at all." That is to say, never give him poor food: great energy and endurance are to be obtained only by the continuous use of very nutritive food. So true is this that, as proved by Mr. Apperley, prolonged high-feeding will enable a middling horse to 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, it is the practice to give him beans—a food containing a larger proportion of nitrogenous, or flesh-making material, than his habitual oats.

Once more, in the case of individual men the truth has been illustrated with equal or still greater clearness. We do not refer to men in training for feats of strength, whose regimen, however, thoroughly conforms to the doctrine. We refer to the experience of railway contractors and their laborers. It has been for years past a well-established fact that the English navvy, eating largely of flesh, is far more efficient than a continental navvy living on a less nutritive food: so much more efficient that English contractors for continental railways have habitually taken their laborers with them. That difference of diet and not difference of race caused this superiority has been of late distinctly shown. For it has turned out that when the continental navvies live in the same style as their English competitors they presently rise, more or less nearly, to a par with them 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 indorse our argument respecting the feeding of children? Do they not imply that, even supposing the same stature and bulk to be attained on an innutritive as on a nutritive diet, the quality of tissue is greatly inferior? Do they not establish the position that, where energy as well as growth has to be maintained, it can only be done by high feeding? Do they not confirm the *à priori* conclusion that, though a child of whom little is expected in the way of bodily or mental activity may thrive tolerably well on farinaceous substances, a child who is daily required, not only to form the due amount of new tissue, but to supply the waste consequent on great muscular action, and the further waste consequent on hard exercise of brain, must live on substances containing a larger ratio of nutritive matter? And is it not an obvious corollary that denial of this better food will be at the expense either of growth, or of bodily activity, or of mental activity, as constitution and circumstances may determine? We believe no logical intellect will question it. To think otherwise is to entertain in a disguised form the old fallacy of the perpetual-motion schemers—that it is possible to get power out of nothing.

Before leaving the question of food, a few words must be said on another requisite—*variety*. In this respect the dietary of the young is very faulty. If not, like our soldiers, condemned to "twenty years of boiled beef," our children have mostly to bear a monotony which, though less extreme and less lasting, is quite as clearly at variance with the laws of health. At dinner, it is

true, they usually have food that is more or less mixed, and that is changed day by day. But week after week, month after month, year after year, comes the same breakfast of bread-and-milk, or, it may be, oatmeal porridge. And with like persistence the day is closed, perhaps with a second edition of the bread-and-milk, perhaps with tea and bread-and-butter.

This practice is opposed to the dictates of physiology. The satiety produced by an often-repeated dish, and the gratification caused by one long a stranger to the palate, are *not* meaningless, as many carelessly assume; but they are the incentives to a wholesome diversity of diet. It is a fact, established by numerous experiments, that there is scarcely any one food, however good, which supplies in due proportions or right forms all the elements required for carrying on the vital processes in a normal manner: from whence it is to be inferred that frequent change of food is desirable to balance the supply 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 action of the heart, and so propelling the blood with increased vigor, aids in the subsequent digestion. And these truths are in harmony with the maxims of modern cattle-feeding, which dictate a rotation of diet.

Not only, however, is periodic change of food very desirable, but, for the same reasons, it is very desirable that a mixture of food should be taken at each meal. The better balance of ingredients and the greater nervous stimulation are advantages which hold here as before. If facts are asked for, we may name as one, the comparative ease with which the stomach disposes of a French dinner, enormous in quantity but extremely varied in material. Few will contend that an equal weight of one kind of food, however well cooked, could be digested with as much facility. If any desire further facts, they may find them in every modern book on the management of animals. Animals thrive best when each meal is made up of several things. And indeed, among men of science the truth has been long ago established. The experiments of Goss and Stark "afford the most decisive proof of the advantage, or rather the necessity, of a mixture of substances, in order to produce the compound which is the best adapted for the action of the stomach."*

Should any object, as probably many will, that a rotating dietary for children, and one which also requires a mixture of food at each 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 regimen indicated. The change must 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 liable to indigestion."† Hence, therefore, where the energies are low, the transition to a generous diet must be gradual, each increment of strength gained justifying a further increase of nutriment. Further, it should always be borne in mind that the concentration of nutriment may be carried too far. A bulk sufficient to fill the stomach is one requisite of a proper meal; and this requisite negatives a diet deficient in those waste matters which give adequate mass. Though the size of the digestive organs is less in the well-fed civilized races than in the ill-fed savage ones; and though their size may eventually diminish still further, yet for the time being the bulk of the ingesta must be determined by the existing capacity. But, paying due regard to these two qualifications, our conclusions are, that the food of children should be highly nutritive, that it should be varied at each meal and at successive meals, and that it should be abundant.

With clothing as with food, the established tendency is toward an improper scantiness. Here, too, asceticism peeps out. There is a current theory, vagnely entertained, if not put into a definite formula, that the sensations are to be disregarded. They do not exist for our guidance, but to mislead us, seems to be the prevalent belief reduced to its naked form. It is a grave error: we are much more beneficently constituted. It is not obedience to the sensations, but disobedience to them, which is the habitual cause of bodily evils. It is not the eating when hungry, but the eating in the absence of appetite which is bad. It is not the drinking when thirsty, but the continuing to drink when thirst has ceased that is the vice. Harm results not from breathing that fresh air which every healthy person enjoys, but from continuing to breathe foul air, spite of the protest of the lungs. Harm results not from taking that active exercise which, as every child shows us, nature strongly prompts, but from a persistent disregard of nature's promptings. Not that mental activity which is spontaneous and enjoyable does the mischief, but that which is persevered in after a hot or aching head commands desistance. Not that bodily exertion which is pleasant or indifferent does injury, but that which is continued when exhaustion forbids. It is true that, in those who have long led unhealthy lives, the sensations are not trustworthy guides. People who have for years been almost constantly indoors, who have exercised their brains very much, and their bodies scarcely at all, who in eating have obeyed their clocks without consulting their stomachs, may very likely be misled by their vitiated feelings. But their abnormal state is itself the result of transgressing their feelings. Had they from childhood up never disobeyed what we may term the physical conscience, it would not have been seared, but would have remained a faithful monitor.

Among the sensations serving for our guidance are those of heat and cold; and a clothing for children which does not carefully consult these sensations is to be condemned. The common notion about "hardening" is a grievous delusion. Children are not unfrequently "hardened" out of the world; and those who survive permanently suffer either in growth or constitution. "Their delicate appearance furnishes ample indication of the mischief thus produced, and their frequent attacks of illness might prove a warning even to unreflecting parents," says Dr. Combe. The reasoning on which this hardening theory rests is extremely superficial. Wealthy parents, seeing little peasant 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 is the result of the exposure, and resolve to keep their own offspring scantily covered! It is forgotten that these urchins who gambol upon village-greens are in many respects favorably circumstanced—that their days are spent in 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 subject.

For when, the constitution being sound enough to bear it, exposure does produce hardness, it does so at the expense of growth. This truth is displayed alike in animals and in man. The Shetland pony bears greater inclemencies than the horses of the south, but is dwarfed. Highland sheep and cattle, living in a colder climate, are stunted in comparison with English breeds. In both the arctic and antarctic regions the human race falls much below its ordinary height: the Laplander and Esquimaux are very short; and the Terra del Fuegians, who go naked in a cold latitude, are described by Darwin as so stunted and hideous that "one can hardly make one's self believe they are fellow-creatures."

Science clearly explains this dwarfishness 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, there must be a constant oxidation of certain matters which form part of the food. And in proportion as the thermal loss is great must the quantity of these matters required for oxidation be great. But the power of the digestive organs is limited. Hence it follows that when they have to prepare a large quantity of this material needful for maintaining the temperature, they can prepare but a small quantity of the material which goes to build up the frame. Excessive expenditure for fuel entails diminished means for other purposes; wherefore there necessarily results a body small in size, or inferior in texture, or both.

Hence the great importance of clothing. As Liebig says: "Our clothing is, in reference 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 entirely confirmed by the experience of those who manage animals. Cold can be borne by animals only at an expense of fat, or muscle, or growth, as the case may be. "If fattening cattle are exposed to a low temperature, either their progress must be retarded or a great additional expenditure of food incurred."* Mr. Apperley insists strongly that to bring hunters into good condition 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 ethnology, and recognized by agriculturists and sportsmen, applies with double force to children. In proportion to their smallness 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 the office of the *maire* for registration. "M. Quetelet 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 maturity the undeveloped frame is comparatively unable to bear exposure: as witness the quickness with which young soldiers succumb in a trying campaign. The *rationale* is obvious. We have already adverted to the fact that, in consequence of the varying relation between surface and bulk, a child loses a relatively larger amount of heat than an adult; and here we must point out that the disadvantage under which the child thus labors is very great. Lehmann says: "If the carbonic acid excreted by children or young animals is calculated for an equal

* "Cyclopædia of Anatomy and Physiology."
† Morton's "Cyclopædia of Agriculture."

* "Morton's Cyclopædia of Agriculture."

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 heat produced. And thus we see that in children the system, even when not placed at a disadvantage, is called upon to provide nearly double the proportion of material for generating heat.

See, then, the extreme folly of clothing the young scantily. What father, full grown though he is, losing heat less rapidly as he does, and having no physiological necessity 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 neck? Yet this tax upon the system, from which he would shrink, he inflicts upon his little ones, who are so much less able to bear it! or, if he does not inflict it, sees it inflicted without protest. Let him remember that every ounce of nutriment needlessly expended for the maintenance of temperature is so much deducted from the nutriment going to build up the frame and maintain the energies, and that even when colds, congestions, or other consequent disorders are escaped, diminished growth or less perfect structure is inevitable.

The rule is, therefore, not to dress in an invariable way in all cases, but to put on clothing in kind and quantity *sufficient in the individual case to protect the body effectually from an abiding sensation of cold, however slight.*" This rule, the importance of which Dr. Combe indicates by the italics, is one in which men of science and practitioners agree. We have met with none competent to form a judgment on the matter who do not strongly condemn the exposure of children's limbs. If there is one point above others in which "pestilent custom" should be ignored it is this.

Lamentable, indeed, is it to see mothers seriously damaging the constitutions of their children out of compliance with an irrational fashion. It is bad enough that they should themselves conform to every folly which our Gallic neighbors please to initiate; but that they should clothe their children in any mountebank dress which *Le petit Courrier des Dames* indicates, regardless of its insufficiency and unfitness, is monstrous. Discomfort, more or less great, is inflicted; frequent disorders are entailed, growth is checked or stamina undermined, premature death not uncommonly caused, and all because it is thought needful to make frocks of a size and material dictated by French caprice. Not only is it that for the sake of conformity 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 forbids healthful 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 damage the unrestrained play is interdicted. "Get up this moment: you will soil your clean frock," is the mandate issued to some urchin creeping about on the floor. "Come back: you will dirty your stockings," calls out the governess to one of her charges, who has left the footpath to scramble up a bank. Thus is the evil doubled. That they may come up to their mamma's standard of prettiness, and be admired by her visitors, children must have habiliments deficient in quantity and unfit in texture; and that these easily-damaged habiliments may be kept clean and uninjured, the restless activity, so natural and needful for the young, is more or less restrained. The exercise which becomes doubly requisite when the clothing is insufficient is cut short lest it should deface the clothing. Would that the terrible cruelty of this system could be seen by those who maintain it. We do not hesitate to say that, through enfeebled health, defective energies, and consequent non-success in life, thousands are annually doomed to unhappiness by this unscrupulous regard for appearances, even when they are not, by early death, literally sacrificed to the Moloch of maternal vanity. We are reluctant to counsel strong measures, but really the evils are so great as to justify, or even to demand, a peremptory interference on the part of fathers.

Our conclusions are, then, that while the clothing of children should never be in such excess as to create oppressive warmth, it should always be sufficient to prevent any general feeling of cold;* that instead of the flimsy cotton, linen, or mixed fabrics commonly used, it should be made of some good non-conductor, such as coarse woollen cloth; that it should be so strong as to receive little 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 use and 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 usually a fair share of time for out-of-door 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 may advantageously be followed; and, indeed, in the modern practice of breaking the prolonged morning and afternoon's lessons by a few minutes' open-air recreation we see an increasing tendency to conform 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 fact is quite otherwise in the case of girls. It chances, somewhat strangely, that we have daily opportunity of drawing a comparison. We have both a boys' and a girls' school within view, and the contrast between them is remarkable. In the one case nearly the whole of a large garden is turned into an open gravelled space, affording ample scope for games, and supplied with poles and horizontal bars for gymnastic exercises. Every day before breakfast, again toward eleven o'clock, again at mid-day, again in the afternoon, and once more after school is over, the neighborhood is awakened by a chorus of shouts and laughter as the boys rush out to play; and for as long as they remain, both eyes and ears give proof that they are absorbed in that enjoyable activity which makes the pulse bound and insures the healthful activity of every organ. How unlike is the picture offered by the "Establishment for Young Ladies!" Until the fact was pointed out, we actually did not know that we had a girls' school as close to us as the school for boys. The garden, equally large with the other, affords no sign whatever of any provision for juvenile recreation, but is entirely laid out with prim grassplots, gravel-walks, shrubs, and flowers, after the usual suburban style. During five months we have not once had our attention drawn to the premises by a shout or a laugh. Occasionally girls may be observed sauntering along the paths with their lesson-books in their hands, or else walking arm-in-arm. Once, indeed, we saw one chase another round the garden; but, with this exception, nothing like vigorous exertion has been visible.

Why this astonishing difference? Is it that the constitution of a girl differs so entirely from that of a boy as not to need these active exercises? Is it that a girl has none of the promptings to vociferous play by which boys are impelled? Or is it that, while in boys these promptings are to be regarded as securing that bodily activity without which there cannot be adequate development, to their sisters nature has given them for no purpose whatever—unless it be for the vexation of schoolmistresses? Perhaps, however, we mistake the aim of those who train the gentler sex. We have a vague suspicion that to produce a robust *physique* is thought undesirable; that rude health and abundant vigor are considered somewhat plebeian; that a certain delicacy, a strength not competent to more than a mile or two's walk, an appetite fastidious and easily satisfied, joined with that timidity which commonly accompanies feebleness, are held more ladylike. 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 so, it must be admitted that 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. That men are not commonly drawn toward masculine women, is doubtless true. That such relative weakness as calls for the protection of superior strength is an element of attraction we quite admit. But the difference to which the feelings thus respond is the natural, pre-established difference, which will assert itself without artificial appliances. And when, by artificial appliances, the degree of this difference is increased, it becomes an element of repulsion rather than attraction.

"Then girls should be allowed to run wild—to become as rude as boys, and grow up into romps and hoydens!" exclaims some defender of the proprieties. This, we presume, is the ever-present dread of schoolmistresses. It appears, on inquiry, that at "Establishments for Young Ladies" noisy play like that daily indulged in by boys is a punishable offence; and it is to be inferred that this noisy play is forbidden, lest unladylike habits should be formed. The fear is quite groundless, however. For if the sportive activity allowed to boys does not prevent them from growing up into gentlemen, why should a like sportive activity allowed to girls prevent them from growing up into ladies? Rough as may have been their accustomed play-ground frolics, youths who have left school do not indulge in leap-frog in the street or marbles in the drawing-room. Abandoning their jackets, they abandon at the same time boyish games, and display an anxiety—often a ludicrous anxiety—to avoid whatever is not manly. If now, on arriving at the due age, this feeling of masculine dignity puts so efficient a restraint on the romping sports of boyhood, will not the feeling of feminine modesty, gradually strengthening as maturity is approached, put an efficient restraint on the like sports of girlhood? Have not women even a greater regard for appearances than men? and will there not consequently arise in them even a stronger check to whatever is rough or boisterous? How absurd is the supposition that the womanly instincts would not assert themselves but for the rigorous discipline of schoolmistresses!

In this, as in other cases, to remedy the evils of one artificiality another artificiality has been introduced. The natural spontaneous exercise having been forbidden, and the bad consequences of no exercise having become conspicuous, there has been adopted a system of factitious exercise—gymnastics. That this is better than nothing we admit; but that it is an adequate substitute for play

* It is needful to remark that children whose legs and arms have been from the beginning habitually without covering, cease to be conscious that the exposed surfaces are cold, just as by use we have all ceased to be conscious that our faces are cold, even when out of doors. But though in such children the sensations no longer protest, it does not follow that the system escapes injury; any more than it follows that the Fuegian is undamaged by exposure because he bears with indifference the melting of the falling snow on his naked body.

we deny. The defects are both positive and negative. In the first place, these formal, muscular motions, necessarily much less varied than those accompanying juvenile sports, do not secure so equable a distribution of action to all parts of the body, whence it results that the exertion falling on special parts produces fatigue sooner than it would else have done: add to which that, if constantly repeated, this exertion of special parts leads to a disproportionate development. Again, the quantity of exercise thus taken will be deficient, not only in consequence of uneven distribution, but it will be further deficient in consequence of lack of interest. Even when not made repulsive, as they sometimes are, by assuming the shape of appointed lessons, these monotonous movements are sure to become wearisome from the absence of amusement. Competition, it is true, serves as a stimulus; but it is not a lasting stimulus, like that enjoyment which accompanies varied play. Not only, however, are gymnastics inferior in respect of the *quantity* of muscular exertion which they secure; they are still more inferior in respect of the *quality*. This comparative want of enjoyment to which we have just referred as a cause of early desistance from artificial exercises is also a cause of inferiority in the effects they produce on the system. The common assumption that so long as the amount of bodily action is the same, it matters not whether it be pleasurable or otherwise, is a grave mistake. An agreeable 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. The truth is that happiness is the most powerful of tonics. By accelerating the circulation of the blood it facilitates the performance of every function, and so tends alike to increase health when it exists and to restore it 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 must be fundamentally defective.

Granting then, as we do, that formal exercises of the limbs are better than nothing; granting, further, that they may be used with advantage as supplementary aids, we yet contend that such formal exercises can never supply the place of the exercises prompted by nature. For girls as well as boys the sportive activities to which the instincts impel are essential to bodily welfare. Whoever forbids them forbids the divinely-appointed means to physical development.

A topic still remains—one perhaps more urgently demanding consideration than any of the foregoing. It is asserted by not a few, that among the educated classes the younger adults and those who are verging upon maturity are, on the average, neither so well grown nor so strong as their seniors. When first we heard this assertion we were inclined to disregard it as one of the many manifestations 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 men are proved to be larger than ancient men, and that the tables of mortality show no diminution, but rather an increase in the duration of life, we paid little attention to what seemed a groundless belief. Detailed 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 riotously as they did, could bear much more than men of the present generation, who live soberly, can bear. Though they drank hard, kept irregular hours, were regardless of fresh air, and thought little of cleanliness, our recent ancestors were capable of prolonged application without injury even to a ripe old age: witness the annals of the bench and the bar. Yet we who think much about our bodily welfare; who eat with moderation, and do not drink to excess; who attend to ventilation, and use frequent ablutions; who make annual excursions, and have the benefit of greater medical knowledge—we are continually breaking down under our work. Paying considerable attention to the laws of health, we seem to be weaker than our grandfathers, who in many respects defied the laws of health. And judging from the appearance and frequent ailments of the rising generation, they are likely to be even less robust than ourselves.

What is the meaning of this? Is it that past overfeeding, alike of adults and juveniles, was less injurious than the underfeeding to which we have adverted as now so general? Is it that the deficient clothing which this delusive hardening theory has encouraged is to blame? Is it that the greater or less discouragement of juvenile sports, in deference to a false refinement, is the cause? From our reasonings it may be inferred that each of these has probably had a share in producing the evil. But there has been yet another detrimental influence at work, perhaps more potent than any of the others: we mean excess of mental application.

On old and young the pressure of modern life puts a still-increasing strain. In all businesses and professions intenser competition taxes the energies and abilities of every adult; and, with the view of better fitting the young to hold their place under this intenser competition, they are subject to a more severe discipline than heretofore. The damage is thus doubled. Fathers, who find not only that they are run hard by their multiplying competitors, but that, while laboring under this disadvantage, they have to maintain a more expensive style of living, are all the year round obliged to work early and late, taking little exercise and getting but short holidays. The constitutions, shaken by this long-continued over-application, they bequeath to their children. And then these comparatively feeble children, predisposed as they are to break down even under an ordinary strain upon their energies, are required to go through a *curriculum* much more extended than that prescribed for the unenfeebled 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 before long there come under your notice cases of children or youths of either sex more or less injured by undue study. Here, to recover from a state of debility thus produced, a year's rustication has been found necessary. There you find a chronic congestion of the brain, that has already lasted many months, and threatens to last much longer. Now you hear of a fever that resulted from the over-excitement in some way brought on at school. And, again the instance is that of a youth who has already had once to desist from his studies, and who, since he has returned to them, is frequently taken out of his class in a fainting fit. We state facts—facts that have not been sought for, but have been thrust upon our observation during the last two years, and that too within a very limited range. Nor have we by any means exhausted the list. Quite recently we had the opportunity of marking how the evil becomes hereditary, the case being that of a lady of robust parentage whose system was so injured by the regime of a Scotch boarding-school, where she was underfed and overworked, that she invariably suffers from vertigo on rising in the morning, and whose children, inheriting this enfeebled brain, are several of them unable to bear even a moderate amount of study without headache or giddiness. At the present time we have daily under our eyes a young lady whose system has been damaged for life by the college course through which she has passed. Taxed as she was to such an extent that she had no energy left for exercise, she is, now that she has finished her education, a constant complainant. Appetite small and very capricious, mostly refusing meat; extremities perpetually cold, even when the weather is warm; a feebleness which forbids anything but the slowest walking, and that only for a short time; palpitation on going upstairs; greatly impaired vision—these, joined with checked growth and lax tissue, are among the results entailed. And to her case we may add that of her friend and fellow-student, who is similarly weak, who is liable to faint even under the excitement of a quiet party of friends, and who has at length been obliged by her medical attendant to desist from study entirely.

If injuries so conspicuous are thus frequent, how very general must be the smaller and inconspicuous injuries. To one case where positive illness is directly traceable to over-application, there are probably at least half a dozen cases where the evil is unobtrusive and slowly accumulating—cases where there is frequent derangement of the functions, attributed to this or that special cause, or to constitutional delicacy; cases where there is retardation and premature arrest of bodily growth; cases where a latent tendency to consumption is brought out and established; cases where a predisposition is given to that now common cerebral disorder brought on by the hard work of adult life. How commonly constitutions are thus undermined, will be clear to all who, after noting the frequent ailments of hard-worked professional and mercantile men, will reflect on the disastrous effects which undue application must produce upon the undeveloped systems of the young. The young are competent to bear neither as much hardship nor as much physical exertion, nor as much mental exertion, as the full grown. Judge, then, if the full grown so manifestly suffer from the excessive mental exertion required of them, how great must be the damage which a mental exertion, often equally excessive, inflicts upon the young!

Indeed, when we examine the merciless school-drill to which many children are subjected, the wonder is, not that it does great injury, but that it can be borne at all. Take the instance given by Sir John Forbes from personal knowledge; and which he asserts, after much inquiry, to be an average sample of the middle-class girls'-school system throughout England. Omitting the detailed divisions of time, we quote the summary of the twenty-four hours:

In bed	9 hours	(the younger 10)
In school, at their studies and tasks	9 "	
In school, or in the house, the other at optional studies or the work, younger at play	3½ "	(the younger 2½)
At meals	1½ "	
Exercise in the open air, in the shape of a formal walk, often with lesson-books in hand, and even this only when the weather is fine at the appointed time	1 "	
	24	

And what are the results of this "astounding regimen," as Sir John Forbes terms it? Of course feebleness, pallor, want of spirits, 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 disordered functions but by malformation. He says: "We lately visited, 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 been at the school two years (and the majority had been as long) that was not more or less *crooked!*" *

It may be that since 1833, when this was written, some improvement has taken place. We hope it has. But that the system is still common—nay, that it is in some cases carried even to a greater extreme than ever—we can personally testify. We recently went over a training college for young men—one of those instituted of late years for the purpose of supplying schools with well-disciplined teachers. Here, under official supervision, 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 12 studies.
" 12 to 1½ leisure, nominally devoted to walking or other exercise, but often spent in study.
" 1½ to 2 dinner, the meal commonly occupying twenty minutes.
" 2 to 5 studies.
" 5 to 6 tea and relaxation.
" 6 to 8½ studies.
" 8½ to 9½ 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; ten and a half are given to study; and one and a quarter to exercise, which is optional and often avoided. Not only, however, is it that the ten and a half hours of recognized study are frequently increased to eleven and a half by devoting to hooks the time set apart for exercise, but some of the students who are not quick in learning get up at four o'clock in the morning to prepare their lessons, 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 are so urgent, and the difficulty of satisfying the requirements is so great, that pupils are not uncommonly induced to spend twelve and thirteen hours a day in mental labor!

It needs no prophet to see that the bodily injury inflicted must be great. As we were told by one of the inmates, those who arrive with fresh complexions quickly become blanched. Illness is frequent; there are always some on the sick-list. Failure of appetite and indigestion are very common. Diarrhœa is a prevalent disorder, not uncommonly a third of the whole number of students suffering under it at the same time. Headache is generally complained of, and by some is borne almost daily for months; while a certain percentage break down entirely and go away.

That this should be the regimen of what is in some sort a model institution, established 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, should practically compel recourse to a system which inevitably undermines the health of all who pass through it, is proof, if not of cruelty, then of woful ignorance.

Doubtless the case is in a great 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 overtasked. Expressing as they do the ideas of the educated community, these training colleges, even in the absence of all other evidence, would conclusively imply a prevailing tendency to an unduly urgent system of culture.

It seems strange that there should be so little consciousness of the dangers of over-education during youth, when there is so general a consciousness of the dangers of over-education during childhood. Most parents are more or less aware of the evil consequences that follow infant precocity. In every society may be heard reprobation of those who too early stimulate the minds of their little ones. And the dread of this early stimulation is great in proportion as there is adequate knowledge of the effects; witness the implied opinion of one of our most distinguished professors of physiology, who told us that he did not intend his little boy 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 entails disastrous results—either physical feebleness, or ultimate stupidity, or early death—it appears not to be perceived that throughout youth the same truth holds. Yet it is certain that it must do so. There is 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 rate, well. If not—if the higher faculties are early taxed by presenting an order of knowledge more complex and abstract than can be readily assimilated; or if, by excess of culture, the intellect in general is developed to a degree beyond that which is natural to the age—the abnormal result so produced will inevitably be accompanied by some equivalent, or more than equivalent, evil.

For nature is a strict accountant; and if you demand of her in one direction more than she is prepared to lay out, she balances the account by making a deduction elsewhere. If you will let her follow her own course, taking care to supply, in right quantities and kinds, the raw materials of bodily and mental growth required at each age, she will eventually produce an individual more or less evenly developed. If, however, you insist on premature or undue growth of any one part, she will, with more or less protest, concede 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 the amount of vital energy which the body at any moment possesses is limited, and that, being limited, it is impossible to get from it more than a fixed quantity of results. In a child or youth the 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 certain additional growth of body has to be provided for, and also a certain additional growth of brain; add to which the amount of energy absorbed in the digestion of the large quantity of food required for meeting these many demands. Now, that to divert an excess of energy into any one of these channels is to abstract it from the others is not only manifest *à priori*, but may be shown *à 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 lassitude of mind and body, ending not unfrequently in sleep. Every one knows, too, that excess of bodily exercise diminishes the power of thought—that the temporary prostration following any sudden exertion, or the fatigue produced by a thirty miles' walk, is accompanied by a disinclination to mental effort; that after a month's pedestrian tour the mental inertia is such that some days are required to overcome it; and that in peasants who spend their lives in muscular labor the activity of mind is very small. Again, it is a truth familiar to all that during those fits of extreme rapid growth which sometimes occur in childhood, the great abstraction of energy is shown in the attendant prostration, bodily and mental. Once more, the facts that violent muscular exertion after eating will stop digestion, and that children who are early put to hard labor become stunted, similarly exhibit the antagonism—similarly imply that excess of activity in one direction involves deficiency of it in other directions. Now the law which is thus manifest in extreme cases holds in all cases. These injurious abstractions of energy as certainly take place when the undue demands are slight and constant as when they are great and sudden. Hence if in youth the expenditure in mental labor exceeds that which nature had provided for, the expenditure for other purposes falls below what it should have been, and evils of one kind or other are inevitably entailed. Let us briefly consider these evils.

Supposing the over-activity of brain not to be extreme, but to exceed the normal activity only in a moderate degree, there will be nothing more than some slight reaction on the development of the body: the stature falling a little below that which it would else have reached, or the bulk being less than it would have been, or the quality of tissue being not so good. One or more of these effects must necessarily occur. The extra quantity of blood supplied to the brain, not only during the period of mental exertion but during the subsequent period in which the waste of cerebral substance is being made good, is blood that would else have been circulating through the limbs and viscera; and the amount of growth or repair for which that blood would have supplied materials is lost. This physical reaction being certain, the question is, whether the gain resulting from the extra culture is equivalent to the loss? whether defect of bodily growth, or the want of that structural perfection which gives high vigor and endurance, is compensated for by the additional knowledge gained?

When the excess of mental exertion is greater, there follow results far more serious, telling not only against bodily perfection but against the perfection of the brain itself. It is a physiological law, first pointed out by M. Isidore St. Hilaire, and to which attention has been drawn by Mr. Lewes in his essay on "Dwarfs and Giants," that there is an antagonism between *growth* and *development*. By growth, as used in this antithetical sense, is to be understood *increase of size;* by development, *increase of structure*. And the law is, that great activity in either of these processes involves retardation or arrest of the other. A familiar illustration is furnished by the cases of the caterpillar and the chrysalis. In the caterpillar there is extremely rapid augmentation of bulk; but the structure is scarcely at all more complex when the caterpillar is full-grown than when it is small. In the chrysalis the bulk does not increase; on the contrary, weight is lost during this stage of the creature's life; but the elaboration of a more complex structure goes on with great activity. The antagonism, here so clear, is less traceable in higher creatures, because the two processes are carried on together. But we see it pretty well illustrated among ourselves by contrasting the sexes. A girl develops in body and mind rapidly, and ceases to grow comparatively early. A boy's bodily and mental development is slower, and his growth greater. At the age when the one is mature, finished, and having all faculties in full play, the other, whose vital energies have been more directed toward increase of size, is relatively incomplete in structure, and shows it in a comparative awkwardness, bodily and mental. Now this law is true not only of the organism as a whole, but of each separate part. The abnormally rapid advance of any part in respect of structure involves prema-

* "Cyclopædia of Practical Medicine," vol. i. pp. 697, 698.

ture arrest of its growth, and this happens with the organ of the mind as certainly as with any other organ. The brain, which during early years is relatively large in mass but imperfect in structure, will, if required to perform its functions with undue activity, undergo a structural advance greater than is 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 this is a part cause—probably the chief cause—why precocious children, and youths who up to a certain time were carrying all before them, so often stop short and disappoint the high hopes of their parents.

But these results of over-education, disastrous as they are, are perhaps less disastrous than the results produced upon the health—the undermined constitution, the enfeebled 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. Whoever has seen repeated, as we have, the experiment first performed by Weber, showing the consequence of irritating the *vagus* nerve which connects the brain with the viscera—whoever has seen the action of the heart suddenly arrested by the irritation of this nerve, slowly recommencing when the irritation is suspended, and again arrested the moment it is renewed—will have a vivid conception of the depressing influence which an overwrought brain exercises on the body. The effects thus physiologically explained are indeed exemplified in ordinary experience. There is no one but has felt the palpitation accompanying hope, fear, anger, joy—no one but has observed how labored becomes the action of the heart when these feelings are very violent. And though there are many who have never themselves suffered that extreme emotional excitement which is followed by arrest of the heart's action and fainting, yet every one knows them to be cause and effect. It is a familiar fact, too, that disturbance of the stomach is entailed by mental excitement exceeding a certain intensity. Loss of appetite is a common result alike of very pleasurable and very painful states of mind. When the event producing a pleasurable or painful state of mind occurs shortly after a meal, it not unfrequently happens either that the stomach rejects what has been eaten, or digests it with great difficulty and under prolonged protest. And as every one who taxes 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 visceral disturbances. This is not simply an inference—it is a truth to which every medical man can bear witness, and it is one to which a long and sad experience enables us to give personal testimony. Various degrees and forms of bodily derangement, often taking years of enforced idleness to set partially right, result from this prolonged over-exertion of mind. Sometimes the heart is chiefly affected—habitual palpitations, a pulse much enfeebled, and very generally a diminution in the number of beats from seventy-two to sixty, or even fewer. 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 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 constitutional disturbance will inevitably follow an exertion of brain beyond that which nature had provided for; and when not so excessive as to produce absolute illness, is sure to entail a slowly accumulating degeneracy of *physique*. With a small and fastidious appetite, an imperfect digestion, and an enfeebled circulation, how can the developing body flourish? The due performance of every vital process depends on the adequate supply of good blood. Without enough good blood, no gland can secrete properly, no viscus can fully discharge its office. Without enough good blood, no nerve, muscle, membrane, or other tissue can be efficiently repaired. Without enough good blood, growth will neither be sound nor sufficient. Judge, then, how bad must be the consequences when to a growing body the weakened stomach supplies blood that is deficient in quantity and poor in quality, while the debilitated heart propels this poor and scanty blood with unnatural slowness.

And if, as all who candidly investigate the matter must admit, physical degeneracy is a consequence of excessive study, how grave is the condemnation to be passed upon this cramming system above exemplified. It is a terrible mistake, from whatever point of view 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 assimilate beyond a certain rate; and if you ply it with facts faster than it can assimilate them, they are very soon rejected again: they do not become permanently built into the intellectual fabric, but fall out of recollection after the passing of the examination for which they were got up. It is a mistake, too, because it tends to make study distasteful. Either through the painful associations produced by ceaseless mental toil, or through the abnormal state of brain it leaves behind, it often generates an aversion to books; and instead of that subsequent self-culture induced by a rational education, there comes a continued retrogression. 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 requisite. Just as Humboldt remarks respecting the progress of intelligence in general, that "the interpretation of nature is obscured when the description languishes under too great an accumulation of insulated facts," so it may be remarked, respecting the progress of individual intelligence, 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 were the system good as a system of intellectual training, which it is not, it would still be bad, because, as we have shown, it is fatal to that vigor of *physique* which is needful to make intellectual training available in the struggle of life. Those who, in eagerness to cultivate their pupils' minds, are reckless of their bodies, do not remember that success in the world depends much more upon energy than upon information; and that a policy which in cramming with information undermines energy is self-defeating. The strong will and untiring activity which result from abundant animal vigor go far to compensate even for great defects of education; and when joined with that quite adequate education which may be obtained without sacrificing health they insure an easy victory over competitors enfeebled by excessive study, prodigies of learning though they may be. A comparatively small and ill-made engine, worked at high pressure, will do more than a larger and well-finished one worked at low pressure. What folly is it, then, while finishing the engine, so to damage the boiler that it will not generate steam! Once more, the system is a mistake, as involving a false estimate of welfare in life. Even supposing it were a means to worldly success, instead of a means to worldly failure, yet, in the entailed ill-health it would inflict a more than equivalent curse. What boots it to have attained wealth, if the wealth is accompanied by ceaseless ailments? Once more, the system is a mistake, as involving a false estimate of welfare in life. Even supposing it were a means to worldly success, instead of a means to worldly failure, yet, in the entailed ill-health it would inflict a more than equivalent curse. What boots it to have attained wealth, if the wealth is accompanied by ceaseless ailments? What is the worth of distinction, if it has brought hypochondria with it? Surely none needs telling that a good digestion, a bounding pulse, and high spirits are elements of happiness which no external advantages can outbalance. Chronic bodily disorder casts a gloom over the brightest prospects, while the vivacity of strong health gilds even misfortune. We contend, then, that this over-education is vicious in every way — vicious, as giving knowledge that will soon be forgotten; vicious, as producing a disgust for knowledge; vicious, as neglecting that organization of knowledge which is more important than its acquisition; vicious, as weakening or destroying that energy, without which a trained intellect is useless; vicious, as entailing that ill-health for which even success would not compensate, and which makes failure doubly bitter.

On women the effects of this forcing system are, if possible, even more injurious than on men. Being in great measure debarred from those vigorous and enjoyable exercises of body by which boys mitigate the evils of excessive study, girls feed these evils in their full intensity. Hence the much smaller proportion of them who grow up well made and healthy. In the pale, angular, flat-chested young ladies so abundant in London drawing-rooms we see the effect of merciless application unrelieved by youthful sports; and this physical degeneracy exhibited by them hinders their welfare far more than their many accomplishments aid it. Mammas anxious to make their daughters attractive could scarcely choose a course more fatal than this, which sacrifices the body to the mind. Either they disregard the tastes of the opposite sex, or else their conception of those tastes is erroneous. Men care comparatively little for erudition in women, but very much for physical beauty, and good nature, and sound sense. How many conquests does the blue-stocking make through her extensive knowledge of history? What man ever fell in love with a woman because she understood Italian? Where is the Edwin who was brought to Angelina's feet by her German? But rosy cheeks and laughing eyes are great attractions. A finely-rounded figure draws admiring glances. The liveliness and good-humor that overflowing health produces go a great way toward establishing attachments. Every one knows cases where bodily perfections, in the absence of all other recommendations, have incited a passion that carried all before it; but scarcely any one can point to a case where mere intellectual acquirements, apart from moral or physical attributes, have aroused such a feeling. The truth is that, out of the many elements uniting in various proportions to produce in a man's breast that complex emotion which we call love, the strongest are those produced by physical attractions; the next in order of strength are those produced by moral attractions; the weakest are those produced by intellectual attractions; and even these are dependent much less upon acquired knowledge than on natural faculty—quickness, wit, insight. If any think the assertion a derogatory one, and inveigh against the masculine character for being thus swayed, we reply that they little know what they say when they thus call in question the divine ordinations. Even were there no obvious meaning in the arrangement, we might be sure that some important end was subserved. But the meaning is quite obvious to those who examine. It needs but to remember that one of nature's ends, or rather her

provements 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 esparto grass to be bleached and formed into paper for the use 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 workmen and others 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, have led 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 numerous original experimental researches, many of which have resulted, in a greater or less degree, in increasing the employment for workmen and others."—*Nature*, No. 25.

"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, instead of stopping here to scramble over each other's backs for the scraps, like black beetles 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 a tenth 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, what not, enough to give employment and wealth to thousands and tens of thousands, wasting for want of being known and worked—then you would see what a man who emigrates may do, by a little sound knowledge of botany alone.

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 amuse him, then puzzle him, and at last (I hope) awe him, as he perceives that smallness of size interferes in no way with perfection of development, and that "nature," as has been well said, "is greatest in that which is least." And more. Suppose that he went farther still. Suppose that he extended his researches somewhat to those minuter vegetable forms, the mosses, fungi, lichens; suppose that he went a little farther still, and tried what the microscope would show him in any stagnant pool, whether fresh water or salt, of desmidiæ, diatoms, and all those wondrous atomies which seem as yet to defy our classification into plants or animals. Suppose he learned something of this, but 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 politics, in 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 had almost said on 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 that therefore they will 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 men, in studying science and acquiring 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 a breach of the peace. That last was my poor friend Mr. Buckle's definition of freedom of speech. That was the only limit to it which 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 one will 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 one else 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 reflects your own feelings, your own opinions? 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 remember always that a newspaper editor, however honest or able, is no more infallible 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 or four; and if you only see the 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 it all over, 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 tendency to become bigoted and 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 Huxley 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, of perceiving 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 virtues of a truly free spirit? Then, as I said just now, I know no study so able to give that free habit of mind as the study of natural science.

[redacted]

Well; but there is a branch of education in which, even now, the poor man can compete fairly against the rich; and that is natural science. In the first place, the rich, blind to their own interest, have neglected it hitherto in their schools; so that they have not the start of the poor man on that subject which they have on many. In the next place, natural science is a subject which a man cannot learn by paying for teachers. He must teach it himself, by patient observation, by patient common-sense. And if the poor man is not the rich man's equal in those qualities, it must be his own fault, not his purse's. Many shops have I seen about the world in which fools could buy articles more or less hopeful to them; but never saw I yet an observation-shop, nor a common-sense shop either. And if any man says, "We must buy books," I answer, a poor man now can obtain better scientific books than a duke or a prince could sixty years ago, simply because then the books did not exist. When I was a boy I would have given much, or rather my father would have given much, if I could have got hold

of such scientific books as are to be found now 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? Can you not form yourselves into 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, the comparing of your observations, general mutual help and mutual instruction? Such societies are becoming numerous now, and gladly should I see one in every town. For in science, as in most matters, "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 a' 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 from you anything you can teach them, asking no questions about you, save, first, Is he an honest student of [illegible] when the irritation is suspended, and a[illegible] arrested the moment it is renewed—will [illegible] a vivid conception of the depressing i[illegible] ence which an overwrought brain exer[illegible] on the body. The effects thus physio[illegible] cally explained are indeed exemplifie[illegible] ordinary experience. There is no one [illegible] has felt the palpitation accompanying h[illegible] fear, anger, joy—no one but has obse[illegible] how labored becomes the action of the h[illegible] when these feelings are very violent. [illegible] though there are many who have never t[illegible] selves suffered that extreme emotiona[illegible] citement which is followed by arrest o[illegible] heart's action and fainting, yet every [illegible] knows them to be cause and effect. I[illegible] familiar fact, too, that disturbance o[illegible] stomach is entailed by mental excitemen[illegible] ceeding a certain intensity. Loss of [illegible] tite is a common result alike of very [illegible] urable and very painful states of [illegible] When the event producing a pleasura[illegible] painful state of mind occurs shortly a[illegible] meal, it not unfrequently happens eithe[illegible] the stomach rejects what has been eat[illegible] digests it with great difficulty and unde[illegible] longed protest. And as every one who [illegible] his brain much can testify, even pure[illegible] came the companions and [illegible] noblest and most learned on earth, looked up to 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 wise? Then be wise with true wisdom; 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, again, knowing the facts of nature, and being able to use them.

I dare say some of my readers, especially the younger ones, will demur to that last speech of mine. Well, I hope they will not be angry with me for saying it. I, at least, shall certainly not be angry with 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 freedom, and social reform, and all that I 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 improved arrangements, something can be done by acts of Parliament, I hold still, as every rational man must hold.

But as I grew older I began to see that if things were to be got right, the freedom-mill would do very little toward 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 had put in at the other; and I began to see that the 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 there is to be learned in such a universe as this. Men who are accustomed 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 facts. In one word, 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 who 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 in the same scientific 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 you ought and must if you are Britons, think much of social and political questions—therefore, I say, I entreat you to cultivate the scientific spirit by which alone you can judge justly of those questions. I ask you to learn how to "conquer nature by obeying her," as the great Lord Bacon said two hundred and fifty years ago. For so only will you, in your theories and your movements, draw "bills which nature will honor"—to use Mr. Carlyle's famous parable—because they are according to her unchanging laws, and not have them returned on your hands, as too many theorists' are, with "no effects" written across their backs.

Take my advice for yourselves, dear readers, and for your children after you; for, believe me, I am showing you the way to true and useful, and, therefore, to just and deserved power. I am showing you 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 society and of history. Power will pass more and more, if all goes healthily and well, into the hands of scientific men; into the hands of those who have made due use of that great heirloom which the philosophers 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 die, and give place to aristocracies of mere wealth; and they again to "aristocracies of genius," which are really aristocracies of the noisiest, of mere scribblers and spouters, such as France is writhing under at this moment. And when these last have blown off their steam, with mighty roar, but without moving the engine a single yard, then they are but too likely to give place to the worst of all aristocracies, the aristocracy of mere "order," which means 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 day by day over the civilized world), on them will the future of that world mainly depend. They will rule, and they will act—cautiously, we may hope, and modestly and charitably, because in learning true knowledge they will have learned also their own ignorance, and the vastness, the complexity, the mystery of nature. But they will be able to rule, they will be able to act, because they have taken the trouble 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 of man 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 becoming (as many of them as 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 natural science? Am I not going out of my proper sphere to meddle with secular matters? Am I not, indeed, going into a sphere out of which I had better keep myself and all over whom I may have influence? 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 grudge that epithet of secular to any matter whatsoever. But I do more; I deny it to anything which God has made, even to the tiniest of insects, the most insignificant atom of dust. To those who believe in God, and try to see all things in God, the most minute natural phenomenon cannot be secular. It must be divine; I say, deliberately, divine; and I can use no less lofty word. The grain or dust is a thought of God; God's power made it; 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 causes and effects which reaches 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 atmosphere which the aëronaut has never visited, whither 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; and if it go down into 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 bowels of the earth? Is it not 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? Only look at all created things in this light—look at them as what 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 know of the works and of the will of God. At least you will be in harmony with the teaching of the Psalmist: "The heavens," says he, "declare 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 Psalmist concerning astronomy, the knowledge of the heaveuly 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 flower 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 Lycaonia that "God had not left himself without witness, in that he did good and sent men rain from heaven, and fruitful seasons, filling men's hearts with food and gladness." Rain and fruitful seasons witnessed to all men of a Father in heaven. 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 assertion, and how the ocean and the rain-cloud, like the sun and stars, declare the glory of God. And if any one undervalues the sciences which teach us concerning stones and plants and animals, or thinks that nothing can be learned from them 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 frankness, who it was who said, "Consider the lilies of the field, how they grow." "Consider the birds of the air, and how your Heavenly Father feedeth them."

Consider them. If he has bid you 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 itself is deeper, wider, more literally true, more wonderful, more tender, and, if I dare use such a word, more poetic, than the unscientific man can guess.

But let me ask you further, do you think that our Lord in that instane, and 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 subject of contemplation, in the laws and processes of the natural world, and their analogy with those of the spiritual world, the kingdom of God—a subject of contemplation, I say, which it was not safe to contemplate too much?

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 have 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 can be otherwise than 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 bear witness of aught save the mind and 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 that physical world which, like 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, "This would be all very true if there were 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 world, and that therefore physical facts could not be trusted, because they were disordered, 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 contrary to the doctrines 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. While the earth remaineth, 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. The Psalmist says, "They continue 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."

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 natural laws, and the trustworthiness of 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 called the Song of the Three Children, which is, as it were, the very flower and crown of the Old Testament—the summing up of all that is true and eternal in the old Jewish faith; as true for us as for them; as true millions of years hence as it is now—which cries to all heaven and earth, from the skies above our heads to the green herb beneath our feet, "O all ye works of the Lord, bless ye the Lord; praise him and magnify him forever." On that one hymn I take my stand. That is my charter as a student of natural science. As long as that is sung in an English church I have a right to investigate nature boldly without stint or stay, and to call on all who have the will to investigate her boldly likewise, and, with Socrates of old, to follow the Logos whithersoever it leads.

The Logos. I must pause on that word. It meant at first, no doubt, simply speech, argument, reason. In the mind of Socrates it had a deeper meaning, at which he only dimly guessed; which was seen more clearly by Philo and the Alexandrian Jews; which was revealed in all its fulness to the beloved Apostle St. John, till he gathered speech to tell men of a Logos, a Word, who was in the beginning with God, and was God; by whom all things were made, and without him was not anything made that was made; and how in him was life, and the life was the light of men; and that he was none other than Jesus Christ our Lord.

Yes, that is the truth. And to that truth no man can add, and from it no man can take away. And as long as we believe that—as long as we believe that in his light alone can we see light—as long as we believe that the life around us, whether physical or spiritual, is given by Him without whom nothing is made—so long we shall not fear to meet light, so long we shall not fear to investigate life; for we shall know, however strange or novel, beautiful or awful, the discoveries we may make may be, we are only following the Word whithersoever he may lead us; and that he can never lead us amiss.

I.

THE SOIL OF THE FIELD.

My dear readers, let me, before touching on the special subject of this paper, say a few words on that of the whole series.

It is geology—that is, the science which explains to us the *rind* of the earth; of what it is made; how it has been made. It tells us nothing of the mass of the earth. That is, properly speaking, an astronomical question. If I may be allowed to liken this earth to a fruit, then astronomy will tell us—when it knows—how the fruit grew, and what is inside the fruit. Geology can only tell us at most how its rind, its outer covering, grew, and of what it is composed—a very small part, doubtless, of all that is to be known about this planet.

But, as it happens, the mere rind of this earth-fruit, which has, countless ages since, dropped, as it were, from the bosom of God, the Eternal Fount of Life—the mere rind of this earth-fruit, I say, is so beautiful and so complex that it is well worth our awful and reverent study. It has been well said, indeed, that the history of it, which we call geology, would be a magnificent epic poem were there only any human interest in it; did it deal with creatures more like ourselves than stones, and bones, and the dead relics of plants

and beasts. Whether there be no human interest in geology, whether man did not exist on the earth during ages 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 the free use of the imagination, 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 yet it is not 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 because it is the science from which you will 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 copy the late illustrious 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. They may be expressed in the simplest English, because they are discovered by simple common-sense. And thus geology is (or ought to be), in popular parlance, the people's science—the science by studying which the man ignorant of Latin, Greek, mathematics, scientific chemistry, can yet become—as far as his brain enables him—a truly scientific man.

But how shall we learn science by mere common-sense ?

First. Always try to explain the unknown by the known. If you meet something which you have not seen before, then think of the thing most like it which you have seen before ; and try if that which you know explains the one will not explain the other also. Sometimes it will ; sometimes it will not. But if it will, no one has a right to ask you to try any other explanation.

Suppose, for instance, that you found a dead bird on the top of a cathedral tower, and were asked how you thought it had got there. You would say, " Of course, it died up here." But if a friend said, " Not so ; it dropped from a balloon or from the clouds," and told you the prettiest tale of how the bird came to so strange an end, you would answer, " No, no ; I must reason from what I know. I know that birds haunt the cathedral tower ; I know that birds die ; and therefore, let your story be as pretty as it may, my common-sense bids me take the simplest explanation and say, it died here." In saying that, you would be talking scientifically. You would have made a fair and sufficient induction (as it is called) from the facts about birds' habits and birds' deaths which you knew.

But suppose that when you took the bird up you found that it was neither a jackdaw, nor a sparrow, nor a swallow, as you expected, but a humming-bird. Then you would be adrift again. The fact of it being a humming-bird would be a new fact which you had not taken into account, and for which your old explanation was not sufficient ; and you would have to try a new induction—to use your common-sense afresh—saying, " I have not to explain merely how a dead bird got here, but how a dead humming-bird."

And now if your imaginative friend chimed in triumphantly with, " Do you not see that I was right after all ? Do you not see that it fell from the clouds—that it was swept away hither, all the way from South America, by some south-westerly storm, and, wearied out at last, dropped here to find rest, as in a sacred place ?" what would you answer ? " My friend, that is a beautiful imagination ; but I must treat it only as such, as long as I can explain the mystery more simply by facts which I do know. I do not know that humming-birds can be blown across the Atlantic alive. I do know that they are actually brought across the Atlantic dead—are stuck in ladies' hats. I know that ladies visit the cathedral ; and, odd as the accident is, I prefer to believe, till I get a better explanation, that the humming-bird has simply dropped out of a lady's hat." There, again, you would be speaking common-sense, and using, too, sound inductive method, trying to explain what you do not know from what you do know already.

Now, I 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 making of the world around them, its 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 no more rational, because no more founded on known facts, than that of the New Zealand Maories, who hold that some god, when fishing, fished up their islands out of the bottom of the ocean. But a sounder and wiser school of geologists now reigns, the father of whom, in England at least, is the venerable Sir Charles Lyell. He was almost the first of Englishmen who taught us to see—what common-sense tells us—that the laws which we see at work around us now have been most probably at work since the creation of the world ; and that whatever changes may seem to have taken place in past ages and in ancient rocks should be explained, if possible, by the changes which are taking place now in the most recent deposits—in the soil of the field.

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 more really astonishing and awful than 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 us, which we see most often—namely, the soil ; intending, if my readers do me the honor to read the papers which follow, to lead them downward, as it were, into the earth, deeper and deeper in each paper, to rocks and minerals which are probably less known to them than the soil in the fields. Thus you will find I shall lead you or try to lead you on, throughout the series, from the known to the unknown, and show you how to explain the latter by the former. Sir Charles Lyell has, I see, in the new edition of his " Student's Elements of Geology," begun his book with the uppermost, that is newest, strata or layers, and has gone regularly downward, in the course of the book, 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—namely, that the uppermost strata are really almost always the newest ; that when two or more layers, whether of rock or earth—or, indeed, two stones in the street, or two sheets on a bed, or two books on a table—any two or more 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 ? Do I seem almost impertinent in asking you to remember it ? So much 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 should 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 something else. You may say, " What ? When I want to hide a paper, say, under the sofa-cover, do I not thrust it under ?" No, you lift up the cover, and slip the paper in, and let the cover fall on it again. And so, even in that 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 to overcome friction. That is why you do it, though you are hardly aware of it ; simply because so you employ less force and take less trouble.

And so do clays and sands and stones. They are laid down on each other, 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 nature does try to thrust one 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 beneath from rocks which have been laid 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, or 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 on this matter. I have special reasons for it. Until I can get you to " let your thoughts play freely" round this question of the superpositiou of soils and rocks, there will be no use in my going on with these papers.

Suppose then (to 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 dead leaves. Would not 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 so on down to the bottom of the pond, where, lastly, I think common-sense would tell you that the bottom of the pond was there already before all the layers which were laid down on it. Is not that simple common-sense?

Then apply that reasoning to the soils and rocks in any spot on earth. If you made a deep boring, and found, as you would in many parts of this kingdom, that the boring, after passing through the soil of the field, entered clays or loose sands, you would say the clays were there before the soil. If it then went down into sandstone, you would say—would you not?—that sandstone must have been here before the clay; and however thick—even thousands of feet—it might be, that would make no difference to your judgment. If next the boring came into quite different rocks, into a different sort of sandstone and shales and among them beds of coal, would you not say, These coal-beds must have been here before the sandstones? And if you found in those coal-beds dead leaves and stems of plants, would you not say, Those plants must have been laid down here before the layers above them, just as the dead leaves in the pond were?

If you then came to a layer of limestone, would you not say the same? And if you found that limestone full of shells and corals, dead, but many of them quite perfect, some of the corals plainly in the very place in which they grew, would you not say, These creatures must have lived down here before the coal was laid on top of them? And if, lastly, below the limestone you came to a bottom rock quite different again, would you not say, The bottom rock must have been here before the rocks on the top of it?

And if that bottom rock rose up a few miles off, two thousand feet, or any other height, into hills, what would you say then? Would you say, "Oh, but the rock is not bottom rock; is not under the limestone here, but higher than it. So perhaps in this part it has made a shift, and the highlands are younger than the lowlands; for see, they rise so much higher"? Would not that be about as wise as to say that the bottom of the pond was not there before the pond mud, because the banks round the pond rose higher than the mud?

Now for the soil of the field.

If we can understand a little about it, what it is made of, and how it got there, we shall perhaps be on the right road toward understanding what all England—and, indeed, the crust of this whole planet—is made of, and how its rocks and soils got there.

But we shall best understand how the soil in the field was made by reasoning, as I have said, from the known to the unknown. What do I mean? This. On the uplands are fields in which the soil is already made. You do not know how? Then look for a field in which the soil is still being made. There are plenty in every lowland. Learn how it is being 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 seeing soil made. Thousands of square feet of fresh-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 field, 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 of the field may have been made in the very same way in which the soil of the field is made. If so, it is well worth our while to examine it.

You all know from whence the soil comes which has filled up, in the course of ages, the great estuaries below London, Stirling, Chester, or Cambridge.

It is river mud and sand. The river, helped by tributary brooks right and left, has brought down from the inland that enormous mass. You know that. You know that every flood and freshet brings a fresh load, either of fine mud or of fine sand, or possibly some of it peaty matter out of distant hills. Here is one indisputable fact from which to start. Let us look for another.

How does the mud get into the river? The rain carries it thither.

If you wish to learn the first elements of geology by direct experiment, do this. The next rainy day—the harder it rains the better—instead of sitting at home over the fire, and reading a book about geology, put on a mackintosh and thick boots, and get away, I care not whither, provided you can find there running water. If you have not time to get away to a hilly country, then go to the nearest bit of turnpike road, or the nearest sloping field, and see in little how whole continents are made, and unmade again. Watch the rain raking and sifting with its million delicate fingers, separating the finer particles from the coarser, dropping the latter as soon as it can, and carrying the former downward with it toward the sea. Follow the nearest roadside drain where it runs into a pond, and see how it drops the pebbles the moment it enters the pond, and then the sand in a fan-shaped heap at the nearest end; but carries the fine mud on, and holds it suspended, to be gradually deposited at the bottom in the still water: and say to yourself, Perhaps the sands which cover so many inland tracts were dropped by water, very near the shore of a lake or sea, and by rapid currents. Perhaps, again, the brick clays, which are often mingled with these sands, were dropped, like the mud in the pond, in deeper water farther from the shore, and certainly in still water. But more. Suppose once more, then, that, looking and watching a pond being cleared out, under the lowest layer of mud, you found—as you would find in any of those magnificent reservoirs so common in the Lancashire hills—a layer of vegetable soil, with grass and brushwood rooted in it. What would you say but, The pond has not been always full. It has at some time or other been dry enough to let a whole copse grow up inside it?

And if you found—as you will actually find along some English shores—under the sand hills, perhaps a bed of earth with shells and bones; under that a bed of peat; under that one of blue silt; under that a buried forest, with the trees upright and rooted; under that another layer of blue silt full of roots and vegetable fibre; perhaps under that again another old land surface with trees again growing in it; and under all the main bottom clay of the district—what would common-sense tell you? I leave you to discover for yourselves. It certainly would not tell you that those trees were thrust in there by a violent convulsion, or that all those layers were deposited there in a few days, or even a few years, and you might safely indulge in speculations about the antiquity of the estuary, and the changes which it has undergone, with which I will not frighten you at present.

It will be fair reasoning to argue thus. You may not be always right in your conclusion, but still you will be trying fairly to explain the unknown by the known.

But have rain and rivers alone made the soil?

How very much they have done toward making it you will be able to judge for yourselves, if you will read the sixth chapter of Sir Charles Lyell's new "Elements of Geology," or the first hundred pages of that admirable book, De la Bêche's "Geological Observer;" and last, but not least, a very clever little book called "Rain and Rivers," by Colonel George Greenwood.

But though rain, like rivers, is a carrier of soil, it is more. It is a maker of soil likewise; and by it mainly the soil of an upland field is made, whether it be carried down to the sea or not.

If you will look into any quarry you will see that, however compact the rock may be a few feet below the surface, it becomes, in almost every case, rotten and broken up as it nears the upper soil, till you often cannot tell where the rock ends and the soil begins.

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, freezes there, expands in freezing, and splits and peels the stone with a force which is slowly 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. What has broken them up but frost? Look again, as stronger proof, at the talus of broken stones—screes, as they call them in Scotland; rattles, as we call them in Devon—which lie along the base of many mountain cliffs. What has brought them down but frost? 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 for yourselves, by the fresh frost crop 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 at you by the frost giants up above. 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, then you will be ready to believe the geologist who tells you that frost, and

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, where the snow Alps now stand, there shall be rolling uplands of rich cultivable 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 (in the case of limestone) the insoluble carbonate 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 brook. You can calculate it, if you like, by 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 be astonished to find it one not of 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, it is still less pure. It carries with 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 chemical action, especially if the cement be lime or iron. You may see this for yourselves, again and again. You may see how the root of a tree, penetrating the earth, discolors 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 vegetables.

But there is another force 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, the waves of the sea.

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 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 clampings during the gale of three winters since. Look steadily 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 wave-power as that have had beating and breaking for thousands of years along the western coasts of England, Scotland, Ireland? It must have eaten up thousands of acres—whole shires, maybe, ere now. Its teeth are strong enough, and 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 counteracting force, of which I shall speak hereafter.

As you go on 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. Now you will not wonder how old harbors 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 pile it up in shifting sand-banks 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 down by the sea, and mixed with the mud of the tide-flats, and so is formed a mingled soil, partly of clayey mud, partly of sand—such a soil as stretches over the greater part of all our lowlands.

Now, why should not that soil, whether in England or in Scotland, have been made by the same means as that of every estuary?

You find over great tracts of East Scotland, Lancashire, Norfolk, etc., pure loose sand just beneath the surface, which looks as if it were blown sand from a beach. Is it not reasonable to suppose that it is? You find rising out of many lowlands crags which look exactly like old sea-cliffs eaten by the waves, from the base of which the waters have gone back. Why should not those crags be old sea-cliffs? Why should we not, following our rule of explaining the unknown by the known, assume that such they are 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 soil of any tide-flat is being made now?

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 meanwhile, to satisfy you that I wish to 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 were once beneath the sea, then will 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, when I speak 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 see is made by the destruction of older soils, whether 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 doing so as 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 and unmade, we may stumble on some hints as to how the first primeval continents rose out of the bosom of the sea.

And thus I end this paper. I trust it has not been intolerably dull. But I wanted, at starting, 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 common-sense, which will be of infinite use to both you and me in my future papers.

I hope, meanwhile, that you will agree with me 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 sea or a tidal estuary, there is geology enough to be learned to explain the greater part of the making of all the continents on the globe.

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—to the discomfort of your feet—whole streets, or set up as bourne-stones at corners, or laid in heaps to be broken up for road-metal, certain round pebbles, usually dark brown or speckled gray, and exceedingly tough and hard. Some of them will be very large—boulders of several feet in diameter. If you move from town to town, from the north of Scotland as far down as Essex on the east, or as far down as Shrewsbury and Wolverhampton (at least) on the west, you will still find these pebbles, but fewer and smaller as you go south. It matters not what the rocks and soils of the country round may be. However much they may differ, these pebbles will be, on the whole, the same everywhere.

But if your town be south of the valley of the Thames, you will find, as far as I am aware, no such pebbles there. The gravels round you will be made up entirely of rolled chalk flints, and bits of beds immediately above or below the chalk. The blocks of "Sarsden" sandstone—those of which Stonehenge is built—and the "plum-pudding stones" which are sometimes found with them, have no kindred with the northern pebbles. They belong to beds above the chalk.

Now if, seeing such pebbles about your town, you inquire, like a sensible person who wishes to understand something of the spot on which he lives, whence they come, you will be shown either a gravel-pit or a clay-pit. In the gravel the pebbles and boulders lie mixed with sand, as they do in the railway cutting just south of Shrewsbury, or in huge mounds of fine sweet earth, as they do in the gorge of the Tay about Dunkeld, and all the way up Strathmore, where they form long grassy mounds—*tomauns* as they call them in some parts of Scotland—*askers* as they call them in Ireland. These mounds, with their sweet fresh turf rising out of heather and bog, were tenanted—so Scottish children used to believe—by fairies. He that was lucky might hear inside them fairy

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 years, which would seem to him but 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.

Or, 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 pudding. This clay goes usually by the name of boulder-clay. You would see such near any town 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 of that town, you will see, 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 rock down to great angular 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, some 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 act of mere common-sense to say, 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, These pebbles were once angular, and 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 an example a sample of these boulder-clay pebbles from the neighborhood of Liverpool and Birkenhead, made by Mr. De Rance, the government geological surveyor:

Granite, greenstone, felspar porphyry, felstone, quartz rock (all igneous rocks—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), 43 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 seventy miles north of Liverpool? I think your common-sense will 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 mineralogy would prove that. But even if you are no mineralogist, common-sense will tell you that if they were all concreted out of the same clay, it is most likely that they would be all of the same kind, and not of a dozen or more different kinds. Common-sense will tell you, also, that if they were all concreted out of the same clay, it is a most extraordinary coincidence—indeed one too strange to be believed, if any less strange explanation can be found—that they should have taken the composition of 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 come from a granite mountain; if this be grit, from a gritstone mountain; 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?

Next—and this is 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 often, too, in more than one direction, two 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 quarrymen's tools, but 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, These scratches have been made by the sharp points of other stones which have rubbed against the pebbles somewhere and somewhen with great force?

So far so good. The next question is, How did these stones 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, will explain all the facts of the case, and not only a few of them.

What, then, brought the stones?

We cannot, I think, answer tha 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 of any such violent currents; and we have no right to put 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 their existence.

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 fine clayey mud onward in solution, and 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 farther still; and we should find the boulders, not in 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 that theory also we 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 lie about in your mud as they 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 are to suppose, which I don't think you will 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 you—but known but too well to 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 therefore a very 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 imbedded in 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 we see them in the brick-pits—would not 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, lie far enough north or south 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 outward, by its own weight, along the valleys, as glaciers.

We find underneath the glaciers first 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 pass, under the enormous weight of the superincumbent 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 supérieures*—long lines of stones and dirt which have fallen from neighboring cliffs, and are now travelling downward with the glaciers.

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 glaciers know, in a turbid torrent.

Their fate, again, is what was to be expected if the glacier ends, as it commonly does in 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 into water eight hundred feet deep. At last, when it gets out of its depth, the buoyancy of the water breaks it off in icebergs, which float away, at the mercy of tides and currents, often grounding again in shallower water, and ploughing the sea-bottom as they drag along it. These bergs carry stones and dirt, often in large quantities; so that, whenever a berg melts or capsizes, it strews its burden confusedly about the sea floor.'

Meanwhile the fine mud which is flowing out from under the ice goes out to sea likewise, coloring the water far out, and then subsiding, as a soft tenacious ooze, in which the stones brought out by the ice are imbedded. And this ooze—so those who have examined it assert—cannot be distinguished from the brick-clay or fossiliferous boulder-clay so common in the North. A very illustrious Scandinavian explorer, visiting Edinburgh, declared, as soon as he saw the sections of boulder-clay exhibited near that city, that this was the very substance which he saw forming in the Spitzbergen ice-fiords.*

I have put these facts as simply and baldly as I can, in order that the reader may look steadily at them, without having his attention drawn off or his fancy excited by their real poetry and grandeur. Indeed, it would have been an impertinence to have done otherwise; for I have never seen a live glacier, by land or sea, though I have seen many a dead one. And the public has had the opportunity, lately, of reading so many delightful books about "peaks, passes, and glaciers," that I am bound to suppose that many of my readers know as much or more about them than I do.

But let us go a step farther; and, bearing in our minds what live glaciers are like, let us imagine what a dead glacier would be like—a glacier, that is, which had melted and left nothing but its skeleton of stones and dirt.

We should find the faces of the rock scored and polished, generally in lines pointing down the valleys, or at least outward from the centre of the highlands, and polished and scored most in their upland or weather sides. We should find blocks of rock left behind, and perched about on other rocks of a different kind. We should find in the valleys the old moraines left as vast deposits of boulder and shingle, which would be in time sawn through and sorted over by the rivers. And if the sea-bottom outside were upheaved and became dry land, we should find on it the remains of the mud from under the glacier, stuck full of stones and boulders, iceberg-dropped. This mud would be often very irregularly bedded; for it would have been disturbed by the ploughing of the icebergs, and mixed here and there with dirt which had fallen from them. Moreover, as the sea became shallower and the mud-beds got awash one after the other, they would be torn about, resifted, and reshaped by currents and by tides, and mixed with shore-sand ground out of shingle-beach, thus making 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 beaches, some in deeper water in the ancient ooze, 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 a dreary and lifeless waste of sands, gravels, loose boulders, and boulder-bearing clays; and wherever a boss of bare rock still stood up it would be found ground down, and probably polished and scored by the ponderous icebergs 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 I believe thus only, can we explain the facts connected with these boulder-pebbles. 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 accumulated the vast beds of boulders which lie along the course of certain northern rivers—notably along the Dee about Aboyne—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 scored and fluted *rochers moutonnés*—"sheep-backed rocks"—so common in the Lake district; so common, too, in Snowdon, especially between the two lakes of Llanberis; 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 unweathered surface of rock, in the direction in which a glacier would have pressed against it had one been there. Where these polishings and scorings are found in narrow glens, it is, no doubt, an open question whether some of them may not be the work of water. But nothing but the action of ice can have produced what I have see in land-locked and quiet fiords in Kerry—ice-flutings in polished rocks below high-water mark, so large that I could lie down in one of them. Nothing but the action of ice 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 brows and summits of mountains, often ending 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 fulfilling the rule laid down (I think by Professor Geikie 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 picturesqueness which it must have lost when it lay, like Greenland, under the indiscriminating grinding of a heavy sheet of ice.

Lastly, no known agent save ice will explain those perched 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 and dry on mountain ridges and promontories, upon rocks of a totally different kind. Some of my readers surely recollect Wordsworth's noble lines about these mysterious wanderers, of which he had seen many a one about his native hills:

"As a huge stone is sometimes seen to lie
Couched on the bald top of an eminence,
Wonder to all who do the same espy
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 shelf
Of rock or sand reposeth, there to sun 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 to be. It is not a sea-beast which has crawled forth, but an ice-beast which has been left behind, lifted up thither by the ice, as surely as the famous Pierre-à-bot, forty feet in diameter, and hundreds of boulders more, almost as large as cottages, have been carried by ice from the distant Alps right across the lake of Neufchâtel, and stranded on the slopes of the Jura, nine hundred feet above the lake.*

Thus, I think, we have accounted for facts enough to make it probable that Britain was once covered partly by an ice-sheet, as Greenland is now, and partly, perhaps, by an icy sea. But, to make assurance more sure, let us look for new facts, and try whether our ice-dream will account for them also. Let us investigate our case 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 probable. He ought also to have symptom *e*, 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 icy 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 icebergs 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 conchology—of a northern type; of shells 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 a most charming paper on "The Physics of Arctic Ice," by Dr. Robert Brown, of Campster, published in the *Quarterly Journal of the Geological Society*, June, 1870. This article is so remarkable, not only for its sound scientific matter, but for the vividness 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.

* See Lyell, "Antiquity of Man," p. 294, *et seqq.*

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 be worth 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 at last of an Arctic climate; which last have since retreated either toward their native north, or into cold water at great depths. From Essex across to Wales, from Wales to the estuary of the Clyde, this fact has been verified again and again. And in the search for these shells, a fresh fact, and a most startling one, was discovered. They are to be found not only in the clay of the lowlands, but at considerable heights up the hills, showing that, at some time or other, these hills have been submerged beneath the sea.

Let me give one example, which any tourist into Wales may see for himself. Moel Tryfaen is a mountain over Carnarvon. Now, perched on the side of that mountain, fourteen hundred feet above the present sea-level, is an ancient sea-beach, five-and-thirty feet thick, lying on great ice-scratched boulders, which again lie on the mountain slates. It was discovered by the late Mr. Trimmer, now, alas! lost to geology. Out of that beach fifty-seven different species of shells have been taken; eleven of them are now exclusively Arctic, and not found in our seas; four of them are still common to the Arctic seas and to our own; and almost all the rest are northern shells.

Fourteen hundred feet above the present sea: and that, it must be understood, is not the greatest height at which such shells may be found hereafter. For, according to Professor Ramsay, drift of the same kind as that on Moel Tryfaen is found at a height of two thousand three hundred feet.

Now I ask my readers to use their common-sense over this astounding fact—which, after all, is only one among hundreds; to let (as Mr. Matthew Arnold would well say) their "thought play freely" about it; and consider for themselves what those shells must mean. I say not may, but must, unless we are to believe in a "Deus quidam deceptor," in a God who puts shells upon mountain-sides only to befool honest human beings, and gives men intellects which are worthless for even the simplest work. Those shells must mean that that mountain, and therefore the mountains round it, must have been once fourteen hundred feet at least lower than they are now. That the sea in which they were sunk was far colder than now. That icebergs brought and dropped boulders round their flanks. That upon those boulders a sea-beach formed, and that dead shells were beaten into it from a sea-bottom close by. That, and no less, Moel Tryfaen must mean.

But it must mean, also, a length of time which has been well called "appalling." A length of time sufficient to let the mountain sink into the sea. Then length of time enough to enable those Arctic shells to crawl down from the northward, settle, and propagate themselves generation after generation; then length of time enough to uplift their dead remains, and the beach, and the boulders, and all Snowdonia, fourteen hundred feet into the air. And if any one should object that the last upheaval may have been effected suddenly by a few tremendous earthquakes, we must answer, We have no proof of it. Earthquakes upheave lands now only by slight and intermittent upward pulses; nay, some lands we know to rise without any earthquake pulses, but by simple, slow, upward swelling of a few feet in a century; and we have no reason, and therefore no right, to suppose that Snowdonia was upheaved by any means or at any rate which we do not witness now; and 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, will be ready to cry, Stop. It may be our own weakness; but you are really going on 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 as 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 say—what I am sure every scientific man will say, So much the better. That is the sort of audience which we want, if we are teaching natural science. We do not want haste, enthusiasm, *gobe-moucherie*, as the French call it, which is agape to snap up any new and vast fancy, just 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 stop and think. I don't like the look of 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 see whether it is the right road; 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, but once 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 corrections, 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 may say that I have been looking 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 home by rail 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 height of the land above the sea. Well, 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 northern hemisphere has changed enormously more than once. There can be no doubt that the distribution of land and water, the shape and size of its continents and seas, have changed again and again. There can be no doubt that, for instance, long before the age of ice, the whole North of Europe was much warmer than it is now.

Take Greenland, for instance. Disco Island lies in Baffin's Bay, off the west coast of Greenland, in latitude 70°, far within the Arctic circle. Now there certain strata of rock, older than the ice, have not been destroyed by the grinding of the ice-cap; and they are full of fossil plants. But of what kind of plants? Of the same families as now grow in the warmer parts of the United States. Even a tulip-tree has been found among them. Now how is this to be explained?

Either we must say that the climate of Greenland was then so much warmer than now, that it had summers probably as hot as those of New York; or we must say that these leaves and stems were floated thither from the United States. But if we say the latter, we must allow a change in the shape of the land which is enormous. For nothing now can float northward from the United States into Baffin's Bay. The polar current sets *out* of Baffin's Bay southward, bringing icebergs down, not leaves up, through Davis's Straits. And in any case we must allow that the hills of Disco Island were then the bottom of a sea; or how would the leaves have been deposited in them at all?

So much for the change of climate and land which can be proved to have gone on in Greenland. It has become colder. Why should it not some day become warmer again?

Now for England. It can be proved, as far as common-sense can prove anything, that England was, before the age of ice, much warmer than it is now, and grew gradually cooler and cooler, just as, while the age of ice was dying out, it grew warmer again.

Now what proof is there of that?

This. Underneath London—as, I dare say, many of you know—there lies four or five hundred feet of clay. But not ice-clay. Anything but that, as you will see. It belongs to a formation late (geologically speaking), but somewhat older than those Disco Island beds.

And what sort of fossils do we find in it?

In the first place, the shells, which are abundant, are tropical—Nautili, Cones, and such like. And more, fruits and seeds are found in it, especially at the Isle of Sheppey. And what are they? Fruits of Nipa palms, a form only found now at river-mouths in Eastern India and the Indian islands; Anona-seeds; gourd-seeds; Acacia fruits—all tropical again; and Proteaceous plants too—of an Australian type. Surely your common-sense would hint to you, that this London clay must be mud laid down off the mouth of a tropical river. But your common-sense would be all but certain of that, when you found, as you would find, the teeth and bones of crocodiles and turtles, who come to land, remember, to lay their eggs; the bones, too, of large mammals allied to the tapir of India and South America, and the water-hog of the Cape. If all this does not mean that there was once a tropic climate and a tropic river running into some sea or other where London now stands, I must give up common-sense and reason as deceitful and useless faculties; and believe nothing, not even the evidence of my own senses.

And now, 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 commonsense, that the lowlands of Britain were underneath the sea in the days in which these pebbles and boulders were laid down over your plains? Nay, have we not proved more? Have we not found that that old sea was an icy sea? Have we not wandered on, step by step, into a whole true fairy-land of wonders? to a time when all England, Scotland, and Ireland were as Greenland is 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?" when Snowdon was sunk for at least fourteen hundred 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 not what we shall discover. But this, at least, 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 his father's asses, and found them—and a kingdom besides.

I should have liked to have told you more about this bygone age of ice. I should have liked to say something to you on the curious question—which is still an open one—whether there were not two ages of ice; whether the climate here did not, after perhaps thousands of years of Arctic cold, soften somewhat for a while—a few thousand years, perhaps—and then harden again into a second age of ice, somewhat less severe, probably, than the first. I 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, finally, the age of ice was caused by an actual 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 speak. 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-animals—how the ice-age helps to explain, and 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 tell the botanist somewhat 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 summits of Snowdon, and 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 bear, the reindeer, the musk oxen, 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 them—the mammoth and rhinoceros, the bison, the lion, and many another mighty beast—reoccupied our lowlands, at a time when the hippopotamus, at least in summer, ranged freely from Africa and Spain across what was then dry land between France and England, and fed by the side of animals which have long since retreated to Norway and to Canada. I should have liked to tell the archæologist of the human beings—probably from their weapons and their habits—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 turn driven northward 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 grand and strange pages in the book of nature, and taught you, I hope, a key by which to decipher their hieroglyphics. 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 problem to solve in the nearest wall, on moving from one town to another twenty miles off. All 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 vast tract—and that a rich and busy one—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 northwestward 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 Frith, stretches the New Red sandstone plain, from under which everywhere the coal-bearing rocks rise as from a sea. It contains, in many places, excellent quarries of building stone; 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 and temples of ancient Chester, and from which the stone for the restoration of Chester Cathedral is being taken at this day. In some quarters, especially in the northwest of England, its soil is poor, because it is masked by that very boulder-clay of which I spoke 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, wheat, roots, 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 solid 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 living for—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 England, especially about the manufacturing 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 laid down 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 the top of it, in the same sea.

A fair and reasonable guess, which 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, and probably the whole continent of 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, or 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 these changes have taken place, is my main thesis. 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 now 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, only giving proof where proof is specially needed.

Now you must understand that in England there are two great divisions of these New Red sandstones, "Trias," as geologists call them. An upper, called in Germany Keuper, which consists, atop, of the rich red marl, below them, of sandstones, and of those vast deposits of rock-salt, which have been long worked, and worked to such good purpose, that a vast subsidence 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 whence the salt has been quarried. Underneath 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 "Bunter," from its mottled and spotted appearance. What lies under 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. Where is the third?

Not here, but in Germany. There, between the Keuper above and the Bunter below, lies a great series of limestone beds, which, from the abundance of fossils which they contain, go by the name of 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. The Keuper lies, certainly, immediately on the Bunter, but not always "conformably" on it. That is, the beds are not exactly parallel. The Bunter had been slightly tilted and slightly waterworn before the Keuper was laid on it.

It is reasonable, therefore, to suppose that the Bunter in England was dry land, and therefore safe from fresh deposit, through ages during which it was deep enough beneath the sea in Germany, to have the Muschelkalk laid down on it. Here again, then, as everywhere, we have evidence of time—time, not only beyond all counting, but beyond all imagining.

And now, perhaps, the reader will ask, If I am to believe that all new land is 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 Snowdon, between Port Madoc and Barmouth, 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—"denudation" as it is called—in the district round Malvern, is, I am told, provably enormous. Indeed, it is so over all Wales, North England, and West and North Scotland. So there is enough of rubbish to be accounted for to make our New Red sands. The round pebbles in it being, I believe, pieces of Old Red sandstone, may have come from the great Old Red sandstone region of South-East Wales and Herefordshire. Some of the rubbish, too, may have come from what is now the Isle of Anglesey.

For you find in the beds, from the top to the bottom (at least in Cheshire), particles of mica. Now this mica could not have been formed in the sand. It is a definite crystalline mineral, whose composition is well known. It is only found in rocks which have been subjected to immense pressure, and probably to heat. The granites and mica-slates of Anglesey are full of it; and from Anglesey—as likely as from anywhere else—these thin scales of mica came. And that is about all that I can say on the matter. But it is certain that most of these sands were deposited in a very shallow water, and very near to land. Sand and pebbles, as I said in my first paper, could not be carried far out to sea; and some of the beds of the Bunter are full of rounded pebbles. Nay, it is certain that their surface was often out of water. Of that you may see very pretty proofs. You find these sands riple-marked, as you do shore-sands now. You find cracks where the marl mud has dried in the sun; and, more, you find the little pits made by rain. Of that I have no doubt. I have seen specimens, in which you could not only see at a glance that the marks had been made by the large drops of a shower, but see also from what direction the shower had come. These delicate markings must have been covered up immediately with a fresh layer of mud or sand. How long since? How long since that flag had seen the light of the sun, when it saw it once again, restored to the upper air by the pick of the quarryman? Who can answer that? Not I.

Fossils are very rare in these sands; it is not easy to say why. It may be that the red oxide of iron in them has destroyed them. Few or none are ever found in beds in which it abounds. It is curious, too, that the Keuper, which is all but barren of fossils in England, is full of them in Würtemberg, reptiles, fish, and remains of plants being common. But what will interest the reader are the footprints of a strange beast, found alike in England and in Germany—the Cheirotherium, as it was first named, from its hand-like feet; the Labyrinthodon, as it is now named, from the extraordinary structure of its teeth. There is little doubt now, among anatomists, that the bones and teeth of the so-called Labyrinthodon belong to the animal which made the footprints. If so, the creature must have been a right loathly monster. Some think him to have been akin to lizards; but the usual opinion is that he was a cousin of frogs and toads. Looking at his hands and other remains, one pictures him to one's self as a short, squat brute, as big as a fat hog, with a head very much the shape of a baboon, very large hands behind and small ones in front, waddling about on the tide-flats of a sandy sea, and dragging after him, seemingly, a short tail which has left its mark on the sand. What his color was, whether he was smooth or warty, what he ate, and in general how he got his living, we know not. But there must have been something there for him to eat; and I dare say that he was about as happy and about as intellectual as a toad is now. Remember always that there is nothing alive now exactly like him, or, indeed, like any animal found in these sandstones. The whole animal world of this planet has changed entirely more than once since the Labyrinthodon waddled over the Cheshire flats. A lizard, for instance, which has been found in the Keuper, had a skull like a bird's, and no teeth—a type which is now quite extinct. But there is a more remarkable animal of which I must say a few words, and one which to scientific men is most interesting and significant.

Both near Warwick, and near Elgin in Scotland, in Central India, and in South Africa, fossil remains are found of a family of lizards utterly unlike anything now living save one, and that one is crawling about, plentifully I believe—of all places in the world—in New Zealand. How it got there; how so strange a type of creature should have died out over the rest of the world, and yet have lasted on in that remote island for long ages, ever since the days of the New Red sandstone, is one of those questions—quite awful questions I consider them—with which I will not puzzle my readers. I only mention it to show them what serious questions the scientific man has to face, and to answer, if he can. Only the next time they go to the Zoological Gardens in London, let them go to the reptile house, and ask the very clever and courteous attendant to show them the Sphenodons, or Hatterias, as he will probably call them—and then look, I hope with kindly interest, at the oldest Conservatives they ever saw, or are like to see; gentlemen of most ancient pedigree, who have remained all but unchanged, while the whole surface of the globe has changed around them more than once or twice.

And now, of course, my readers will expect to hear something of the deposits of rock-salt for which Cheshire and its red rocks are famous. I have never seen them, and can only say that the salt does not, it is said by geologists, lie in the sandstone, but at the bottom of the red marl which caps the sandstone. It was formed most probably by the gradual drying up of lagoons, such as are depositing salt, it is said now, both in the Gulf of Tadjara, on the Abyssinian frontier opposite Aden, and in the Runn of Cutch, near the Delta of the Indus. If this be so, then these New Red sandstones may be the remains of a whole Sahara—a sheet of sandy and all but lifeless deserts, reaching from the west of England into Germany, and rising slowly out of the sea; to sink, as we shall find, beneath the sea again.

And now, as to the vast period of time—the four or five worlds, as I called it—which elapsed between the laying down of the New Red sandstones and the laying down of the boulder-clays.

I think this fact—for fact it is—may be better proved by taking readers an imaginary railway journey to London from any spot in the manufacturing districts of central England—begging them, meanwhile, to keep their eyes open on the way.

And here I must say that I wish folks in general would keep their eyes a little more open when they travel by rail. When I see young people rolling along in a luxurious carriage, their eyes and their brains absorbed probably in a trashy shilling novel, and never lifted up to look out of the window, unconscious of all that they are passing—of the reverend antiquities, the admirable agriculture, the rich and peaceful scenery, the like of which no country upon earth can show; unconscious, too, of how much they might learn of botany and zoology, by simply watching the flowers along the railway banks and the sections in the cuttings: then it grieves me to see what little use people make of the eyes and of the understanding which God has given them. They complain of a dull journey: but it is not the journey which is dull; it is they who are dull. Eyes have they, and see not; ears have they, and hear not; mere dolls in smart clothes, too many of them, like the idols of the heathen.

But my readers, I trust, are of a better

mind. So the next time they find themselves running up southward 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 the following pages.

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 Permian, from the ancient kingdom of Permia, in Russia, where they cover a vast area. With them I will not confuse the reader just now, but will only ask him to keep his eye on the rolling plain of New Red sands and marls past, say, Birmingham and Warwick. After those places, these sands and marls dip to the south-east, and other rocks and soils appear above them, one after another, dipping likewise toward the south-east—that is, toward London.

First appear thin layers of a very hard blue limestone, full of shells, and parted by layers of blue mud. 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 extinct monsters — icthyosaurs and plesiosaurs, such as the unlearned 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 shires" 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 freestones, furnish the famous Bath stone, the Oxford stone, and 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 freestones 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 therefore nearer. There, too, are 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 a bat; but with one exception. In the 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 "little" finger alone is lengthened, 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 of natural philosophy—say, 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 the New Red sandstone, 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 limestone signifies a long period of time, during which that sea was pure enough to allow reefs of coral to grow and shells to propagate at the bottom. Each great band of clay signifies a long period, during which fine mud was brought down from some wasting land in the neighborhood. 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 them, of fragments of wood, impressions of plants, and even wing-shells of beetles; and lastly, if further proof was needed, by the fact that in the "dirt-bed" of the Isle of Portland and the neighboring shores, stumps of trees allied to the modern sago-palms are found as they grew in the soil, which, with them, has been covered up in layers of freshwater shale and limestone. A tropic forest has plainly sunk beneath a lagoon; and that lagoon, again, beneath the sea.

And how long did this period of slow sinking go on? Who can tell? The thickness of the lias and oolites together cannot be less than a thousand feet. Considering, then, the length of time required to lay down a thousand feet of strata, and considering the vast difference between the animals found in them, and the few found in the New Red sandstone, we have a right to all them another world, and that one which must have lasted for ages.

After we pass Oxford, or the Vale of Aylesbury, we enter yet another world. We come to a bed of sand, under which the freestones and their adjoining clays dip to the south-east. This is called commonly the lower Greensand, though it is not green, but rich iron-red. Then succeeds a band of stiff blue clay, called the gault, and then another bed of sand, 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 lower Greensand also are worth our attention; 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 Tunbridge—lay upon them: but that the fertile band was very narrow; that, as in the Surrey moors, vast sheets of the lower Greensand were not worth cultivation. What caused the striking difference?

My beloved friend and teacher, the late Dr. Henslow, when Professor of Botany at Cambridge, had brought to him by a 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—bone-earth. He said at once, as by an inspiration, "You have found a treasure—not a gold-mine, indeed, but a food-mine. This is bone-earth, which we are at our wits' end to get for our grain and pulse; which we are importing, as expensive bones, all the way from Buenos Ayres. Only find enough of them, and you will increase immensely the food supply of England, and perhaps make her independent of foreign phosphates in case of war."

His advice was acted on; for the British 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, underlying the chalk. It may be traced 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, from Hythe to Farnham—where it is 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 perpetually now for manure, being ground up, and then treated with sulphuric acid, till they become a "soluble superphosphate of lime."

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. That the fossils have been rolled on a sea-beach is plain to those who look at them. But what caused so vast a destruction of animal life along that beach, must remain one of the buried secrets of the past.

And now we are fast nearing another world, which is far younger than that coprolite bed, and has been formed under circumstances the most opposite to it. We are nearing, by whatever rail we approach London, the escarpment of the chalk downs.

All readers, surely, know the white chalk, the special feature and the special pride of the South of England. All know its softly-rounded downs, its vast beech woods, its short and sweet turf, its snowy cliffs, which have given—so some say—to the whole island the name of Albion—the white land. But all do not, perhaps, know that till we get to the chalk no single plant or animal has been found which is exactly like any plant or animal now known to be living. The plants and animals grow, on the whole, more and more like our living forms as we rise in the series of beds. But only above the chalk (as far as we yet know) do we begin to find species identical with those living now.

This in itself would prove a vast lapse of time. We shall have a further proof of that vast lapse when we examine the chalk itself. It is composed—of this there is now no doubt—almost entirely of the shells of minute animalcules; and animalcules (I use an unscientific word for the sake of unscientific readers) like these, and in some cases identical with them, are now forming a similar deposit of mud, at vast depths, over the greater part of the Atlantic sea-floor. This fact has been put out of doubt by recent deep-sea dredgings. A whole literature has been written on it of late. Any reader who wishes to know it, need only ask the first geologist he meets; and if he has the wholesome instinct of wonder in him, fill his imagination with true wonders, more grand and strange than he is like to find in any fairy-tale. All I have to do with the matter here is, to say that, arguing from the known to the unknown, from the Atlantic deep-sea ooze which we do know about, to the chalk which we do not know about, the whole of the chalk must have been laid down at the bottom of a deep and still ocean, far out of the reach of winds, tides, and even currents, as a great part of the Atlantic sea-floor is at this day.

Prodigious! says the reader. And so it is. Prodigious to think that that shallow Greensand shore, strewed with dead animals, should sink to the bottom of an ocean, perhaps a mile, perhaps some four miles deep. Prodigious the time during which it must have lain as a still ocean-floor. For so minute are the living atomies which form the ooze, that an inch,

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 course, but one as likely to be 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 late discoveries of Dr. Carpenter and Dr. Wyville Thompson have surely placed it beyond doubt.

Thus, surely, if we call the oolitic beds one new world above the New Red sandstone, we must call the chalk a second new world in like wise.

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 slowly and stately, as befits a 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 lie—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 a 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 flints out of chalk which has been destroyed, beds of shore-shingle, beds of oysters lying as they grew, fresh or brackish water-shells standing as they lived, bits 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 Reading beds) dip under that vast bed 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.

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 have been to Ascot races, or 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) a home and a work-field. Those sands 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 colder and colder still; till at last set in that age of ice, which spread the boulder pebbles over all rocks and soils indiscriminately, from the Lake mountains to within a few miles of London.

For everywhere about 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 ancient, the best geologists 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. But this 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 than like America or the South Sea Islands. And this we can tell besides: that that period was long enough for the Swiss Alps to be lifted up at least ten thousand feet of their present height And that was a work which—though God could, if He willed it, have done it in a single day—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 commonly said to be composed of vegetable matter, of the leaves and stems of ancient plants and trees—a startling statement, and one which I do not wish you to take entirely on trust. I shall therefore spend a few pages in showing 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 in look 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 are plenty in nature quite as great, and 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 whatsoever that the bread has 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 baker may have found it profitable to adulterate 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 see, in the case of bread, the processes of the transformation going on; but in the case of coal we do not see the wood and leaves being actually transformed into coal, or anything like it."

Now suppose we laid out the wheat on a table in a regular series, such as you may see in many exhibitions of manufactures; beginning with the wheat plant at one end, and ending with the loaf at the other; and called in to look at them a savage who knew nothing of agriculture and nothing of cookery—called in, as an extreme case, the man in the moon, who certainly can know nothing of either; for as there is neither air nor water round the moon, there can be nothing to grow there, and therefore nothing to cook—and suppose we asked him to study the series from end to end. Do you not think that the man in the moon, if he were half as shrewd as Crofton Croker makes him in his conversation with Daniel O'Rourke, would answer after due meditation, "How the wheat plant got changed into the loaf I cannot see from my experience in the moon; but that it has been changed, and that the two are the same thing I do see, for I see all the different stages of the change." And so I think you may say of the wood and the coal.

The man in the moon would be quite reasonable in his conclusion; for it is a law, a rule, and one which you will have to apply again and again in the study of natural objects, that however different two objects may look in some respects, yet if you can find a regular series of gradations between them, with all shades of likeness, first to one of them and then to the other, then you have a fair right to suppose them to be only varieties of the same species, the same kind of thing, and that, therefore, they have a common origin.

That sounds rather magniloquent. Let me give you a simple example.

Suppose you had come into Britain with Brute, the grandson of Æneas, at that remote epoch when (as all archæologists know who have duly read Geoffrey of Monmouth and the Arthurie legends) Britain was inhabited only by a few giants. Now if you had met giants with one head, and also giants with seven heads, and no others, you would have had a right to say, "There are two breeds of giants here, one-headed and seven-headed." But if you had found, as Jack the Giant Killer (who belongs to the same old cycle of myths) appears to have found, two-headed giants also, and three-headed, and giants, indeed, with any reasonable number of heads, would you not have been justified in saying, "They are all of the same breed, after all; only some are more capitate, or heady, than others?"

I hope that you agree to that reasoning; for by it I think we arrive most surely at a belief in the unity of the human race, and that the Negro is actually a man and a brother.

If the only two types of men in the world were an extreme white type, like the Norwegians, and an extreme black type, like the Negroes, then there would be fair ground for saying, "These two types have been always distinct; they are different races, who have no common origin." But if you found, as you will find many types of man showing endless gradations between the white man and the Negro, and not only that, but endless gradations between them both and a third type, whose extreme perhaps is the Chinese—endless gradations,

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 each other, 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. However distinct they are now, they were probably like each other at first, and therefore all probably had a common origin." That seems to me sound reasoning, and advanced natural science is corroborating it more and more daily.

Now apply the same reasoning to coal. You may find about the world—you may see even in England alone—every gradation between coal and growing forest. You may see the forest growing in its bed of vegetable mould; you may see the forest dead and converted into peat, with stems and roots in it; that, again, into sunken forests, like those to be seen below high-water mark on many coasts of this island. You find gradations between them and beds of lignite, or wood 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. Have you not a right to say, "These are all but 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 a 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 else is likely to be true too.

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 the coal, are so full of plant-remains, that three hundred species were known to Adolphe Brongniart as early as 1849, and that number has largely increased since.

Now one point is specially noticeable about these plants of the coal; namely, that they may 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 carbonic acid which is their special food, and 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 lastræa thelypteris, which of old filled 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 Devon, and Cornwall, and 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 parasol of delicate lace, as men might have long ages since have seen it, through the plume fronds of the ferns now buried in the coal, had there only been a man then created to enjoy its beauty.

Next we find plants called by geologists calamites. There is no doubt now that they are of the same family as our equiseta, 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 paltry little weeds. The tallest equisetum in England—the beautiful E. telmateia—is seldom five feet high. But they, too, are mostly mud and swamp plants; and so may the calamites have been

The lepidodendrons, again, are 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 surely not only of the vast amount of the vegetation in the coal-making 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 the sigillariæ we cannot 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 dadoxylon, of which the pith goes by the name of sternbergia, and the uncertain tree which furnishes in some coal-measures bushels of a seed connected with 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 in 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 explain the coal—like other phenomena 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, the atmosphere was intensely moist and 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 most of it now; and, really, there is no need to remember; for it is all, I verily 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 unscientific. 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 if they get the chance; that coal is 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 tertiary—that is, later than the chalk. Coal is 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 fens and embanking the rivers.

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 we see in ancient rocks is to take for granted, as long as we can do so fairly, that things were going on then very much as they are going on now.

When it was first seen that coal had been once vegetable, the question arose, How did all these huge masses of 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 the North Wales and the Scotch fields are I cannot say. But doubtless a great deal more coal than can 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 later 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 rise, owing to a peculiar disturbance of the strata, to within 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 is but a remnant of what 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 answer. It was a rational one. It proceeded 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.

It was natural, then, 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—the Mississippi, for instance—vast rafts of dead floating trees accumulated; and that the bottoms of the rivers were often full of snags, etc.; trees which had grounded, and stuck in the mud; and why should not 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 which, 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 such good work in Canada—showed that every bed of coal had a bed of clay under it, and that that clay always contained fossils called stigmaria. Then it came out that the stigmaria in the under clay had long filaments attached to them, while, when found in the sandstones or shales, they had lost their filaments, and seemed more or less rolled—in fact, that the natural place of the stigmaria was in the under clay. Then Mr. Binney discovered a tree—a sigillaria, standing upright in the coal-measures, with its roots attached. Those roots penetrated into the under clay of the coal; and those roots were stigmarias. 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 it bottomed by clay, which clay is pierced 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 seemed complete, that the coal had been formed out of vegetation growing where it was buried. If any further proof for that theory was needed, it would be found in this fact, most ingeniously suggested by Mr. Boyd Dawkins. The resinous spores or seeds of the lepidodendra make up—as said above—a great part of the bituminous coal. Now those spores are so light, that if the coal had been laid down by water, they would have floated on it, and have been carried away; 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 perfect purity of the coal? I think 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 themselves entirely before they reach the areas in which vegetable matter may accumulate for centuries, forming coal if the climate be favorable; and that in the cypress-swamps of that region no sediment mingles with the vegetable matter accumulated from the decay of trees and semi-aquatic plants; so that when, in a very dry season, the swamp is set on fire, pits are burnt into the ground many feet deep, or as far as the fire can go down without reaching water, and scarcely any earthy residuum is left; just as when the soil of the English fens catches fire, red-hot holes 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. What can be more transparent than many a pool surrounded by quaking bogs, fringed, as they are, in Ireland, with a ring of white water-lilies, which 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 West Indian swamps. Though it is of the color of coffee, or rather of dark beer, and so impregnated with gases that it produces fever or cholera when drunk, yet it is—at least when it does not mingle with the salt water—so clear, that one might see every marking on a boa-constrictor or alligator if he glided 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?

By gradual sinking 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 sank below the water-line; the trees were 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 trees? Do we not all 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 a mere cavern with touchwood at the bottom; into which caverns one used to peep with some caution. For though one might have found inside only a pair of toucans, or parrots, or a whole party of jolly little monkeys, one was quite as likely to find a poisonous snake four or five feet long, whose bite 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? Thus a core or pillar of hard sandstone would be formed, which might do to the collier of the future what they are too apt to do now in the Newcastle and Bristol collieries. For there, when the coal is worked out below, the sandstone stems —"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 again, if we find—as we very 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 broken off and lying in every direction, 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 violent convulsion; by a storm, or by a sudden inrush 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 on it.

In one of the Rocky Mountain coal-fields there are more than thirty seams of coal, each with its under-clay below it. What can that mean but thirty or more subsidences of the land, and the peat of thirty or more forests or peat-mosses, one above the other? And now if any reader shall say, Subsidence? 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 know of subsidence? You offered to explain the thing which had gone on once by that which is going on now. Where is subsidence going on now upon the surface of our planet? And where, too, upheaval, such as would bring us these buried forests up again from under the sea-level, and make them, like our British coal-field, dry land once 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 lately as 1819 a single earthquake shock in Cutch, at the mouth of the Indus, sunk a tract of land larger than the Lake of Geneva in some places to a depth of eighteen feet, and converted it into an inland sea. The same shock raised, a few miles 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 named by the country people the "Ullah Bund," or bank of God, to distinguish it from the artificial banks in the neighborhood.

Again: in the valley of the Mississippi —a tract which is now, it would seem, in much the same state as central England was while our coal-fields were being laid down—the earthquakes of 1811–12 caused large lakes to appear suddenly in many parts of the district, amid the dense forests of cypress. One of these, the "Sunk Country," near New Madrid, is between seventy and eighty miles in length, and thirty miles in breadth, and throughout it, as late as 1846, "dead trees were conspicuous, some erect in the water, others fallen, and strewed in dense masses over the bottom, in the shallows, and near the shore." I quote these words from Sir Charles Lyell's "Principles of Geology" (11th edit.), vol. i. p. 453. And I cannot 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 upraised again, alternating with beds of clay and sand, vegetable soil, recent sea-shells, and what not, forming, to a depth of several hundred feet, just such a mass of beds as 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 our coal was being laid down, he has only, 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 wooded marshes, at the mouth of 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

to explain how coal-measures were formed. I myself saw once a scene of that kind, which I should be sorry to forget; for 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 high-water mark, and killed by the waves; while inland huge trees stood dying, 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 and boa-constrictors, parrots and white herons, amid an inextricable confusion of vegetable mud, roots of the alder-like mangroves, and tangled creepers hanging from tree to tree; and overhead huge fan-palms, delighting in the moisture, mingled with still huger 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 boughs, 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 wood and leaf would be sunk 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, then lignite, and last, it may be, coal, with the stems of killed trees standing up out of it into the new mud and sand-beds above it, just as the sigillariæ and other stems stand up in the coal-beds both of Britain and of Nova Scotia; while over it a fresh 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 fens of Norfolk and Cambridgeshire, before the rivers were embanked, the water pumped off, the forests felled, and the reed-beds ploughed 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 they grew, and often mixed with beds of 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 over 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—they may find yet, if, which God forbid, England should become barbarous and the trees be thrown out of cultivation—instead of fossil lepidodendra and sigillariæ, calamites and ferns, fossil ashes and oaks, alders and poplars, bulrushes and reeds. Almost the only fossil fern would have been that tall and beautiful Lastræa thelypteris, once so abundant, now all but destroyed by drainage and the plough.

We need not, therefore, fancy any extraordinary state of things on this planet while 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 abundance of ferns, and especially of tree-ferns; but not so warm, 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; a few reptiles, too, and land-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 our English fens? The only explanation which I can offer is this—that the club-mosses, tree-ferns, pines, and other low-ranked vegetation of the coal afforded little or no food for animals, as the same families of plants do to this day; and if creatures can get nothing to eat, they certainly cannot 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 arrangements of sea and land must have been utterly 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, Belgium, Holland, and Germany were then under the sea; that Denmark and Norway were joined to Scotland by a continent, a tongue of which ran across the centre of England, and into Ireland, dividing the 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 and North America with Scotland 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 as 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 probable, they will 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 transformation takes place? Is it possible, according to known natural laws?"

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 gas, 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 about as much as the unscientific reader need know. But it is a fresh corroboration 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 carbonic acid, *i.e.* choke-damp, alone is given off. For in the wood-coal a great deal 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 carburetted hydrogen and olefiant gases. Now the occurrence of that fire-damp in 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 Pennsylvanian coal-fields some of the coal has actually done this, under the disturbing force of earthquakes; for the coal, which is bituminous, like our common coal, to the westward where the strata are horizontal, becomes gradually anthracite as it is tossed and torn by the earthquake faults of the Alleghany and Appalachian mountains.

And is a further transformation possible? Yes; and more than one. If we conceive the anthracite cleared of all but its last atoms 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, graphite—what we miscall blacklead. And, after that, it might go through one transformation more, and that the most startling of all. It would need only perfect purification and crystallization to become—a diamond; nothing less. We may consider 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, formed part of a growing plant.

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

The coal on the fire; the table at which I write—what are they made of? Gas and 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 growing plant—and what that life is who can tell?—laid hold of the gases in the air and in the soil; of the carbonic acid, the atmospheric air, the water, for that too is gas. It drank them in through its rootlets: it breathed them in through its leaf-pores, that it might distil them into sap, and bud, and leaf, and wood. But it had to take in another element, without which the distillation and the shaping could never have taken place. It had to drink in the sunbeams—that mysterious and complex force which is forever pouring from the sun, and making itself partly palpable to our senses as heat and light. So the life of the plant seized the sunbeams, and absorbed them, buried them in itself—no longer as light and heat, but as invisible chemical force, locked up for ages in that woody fibre.

So it 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 loved 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 fire, is buried, and turned to coal: but the plant cannot altogether undo its own work. Even in death and decay it cannot set free 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; transmuting them, or making them capable of being transmuted by man, into the manifold products of coal—coke, petroleum, mineral pitch, gases, coal-tar, benzole, delicate aniline dyes, and what not, till its day of deliverance comes.

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.

And then, like a dormant live 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 since 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-force bursts its prison-cells, and blazes into the free atmosphere, as 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—that truth is stranger than fiction.

V.

THE LIME IN THE MORTAR.

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

In 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 it could muster, each of course 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 which told the whole tale. For the 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 from flour. 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. But it is formed, as you all 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 gases.

In that state it will make, if it is crystalline 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 altered and hardened by volcanic heat. 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 deserves to rank as one of 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 the East, spreading westward gradually. The earlier Greek buildings are cyclopean, that is, of stone fitted together without mortar. The earlier Egyptian buildings, though the stones are exquisitely squared and polished, are 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 Nismes, in the South of France, has, if I recollect right, no mortar whatever in it. The stones of its noble double tier of circular arches have been dropped into their places upon the wooden centres, and stand unmoved 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, surpass them in the art even now; and in some of their old castles the mortar is actually to this day harder and tougher than the stones which it holds togther. And they had plenty of lime at hand if they had chosen to make mortar The Pont du Gard crosses a limestone ravine, and is itself built of limestone, But I presume the cunning Romans would not trust mortar made from that coarse Nummulite limestone, filled with gritty sand, and preferred, with their usual carefulness, no mortar at all to bad.

But I must return, and tell my readers, in a few words, the chemical history of mortar. If limestone be burnt, or rather roasted, in a kiln, the carbonic acid is given off—as you may discover by your own nose; as many a poor tramp has discovered too late, when, on a cold winter night, he has laid down by the side of the burning kiln to keep himself warm, and woke in the other world, stifled to death by the poisonous fumes.

The lime then gives off its carbonic acid, and also its water of crystallization, that is, water which it holds (as do many rocks) locked up in it unseen, and only to be discovered by chemical analysis. It is then anhydrous—that is, waterless—oxide of lime, what we call quick-lime; that which figured in the comi-tragedy of "Flour-bag Creek;" and then, as you may find if you get it under your nails or into your eyes, will burn and blister like an acid.

This has to be turned again into a hard and tough artificial limestone—in plain words, into mortar; and the first step is to slack it—that is, to give it back the water which it has lost, and for which it is as it were thirsting. So it is slacked with water, which it drinks in, heating itself and the water till it steams and swells in bulk, because it takes the substance of the water into its own substance. Slacked lime, as we all know, is not visibly wetter than quick-lime; it crumbles to a dry white powder in spite of all the water which it contains.

Then it must be made to set—that is, to return to limestone, to carbonate of lime—by drinking in the carbonic acid from water and air, which some sorts of lime will do instantly, setting at once, and being therefore used as cements. But the lime usually employed must be mixed with more or less sand to make it set hard: a mysterious process, of which it will be enough to tell the reader that the sand and lime are said to unite gradually, not only mechanically—that is, by sticking together; but also in part chemically—that is, by forming out of themselves a new substance, which is called silicate of lime.

Be that as it may, the mortar paste has now to do two things: first to dry, and next to take up carbonic acid from the air and water, enough to harden it again into limestone; and that it will take some time in doing. A thick wall, I am informed, requires several years before it is set throughout, and has acquired its full hardness, or rather toughness; and good mortar, as is well known, will acquire extreme hardness with age, probably from the very same cause that it did when it was 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 have 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., hardened 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? Let me tell you, or rather, help me to tell yourselves, by leading you, as before, from the known to the unknown. Let me lead you to places unknown indeed to most; but there may be sailors or soldiers among my readers 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 furred 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 a block of stone, or a few bushes, swarming with innumerable sea-fowl and their eggs? Let it be which you will: both are strange enough; both beautiful; 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, raging in before the warm trade-wind. And this, you will be told, 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 search for an opening in the reef, through 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 shallow; the blue white, from the gleam of 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 starred with innumerable live flowers, blue, crimson, gray, every conceivable hue; and that these are the coral polypes, 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 correct description, what a coral

polype is: all who have been to the sea-side know, or at least have heard of, sea-anemones. Now coral polypes are sea-anemones, which make each a shell of lime, growing with its growth. 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 Liverpool Museums, and judge for yourselves. Only remember that you must re-clothe each of those exquisite forms with a coating of live jelly of some delicate hue, and put back into every one of the thousand cells its living flower; and into the beds, or rather banks, of the salt-water flower garden, the gaudiest of shell-less sea-anemones, such as we have on our coasts, rooted in the cracks, and live shells and sea-slugs, as gaudy as they, crawling about, with fifty other forms of fantastic and exuberant life. You must not overlook, too, the fish, especially the parrot-fish, some of them of the gaudiest colors, who spend their lives in browsing on the live coral, with strong clipping and grinding teeth, just as a cow browses the grass, keeping the animal matter, and throwing away the lime in the form of an impalpable white mud, which fills up the interstices in the coral beds.

The bottom, just outside the reef, is covered with that mud, mixed with more lime-mud, which the surge wears off the reef; and if you have, as you should 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. One, I hope, would be some sort of terebratula, 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 brachiopod; a family with which the ancient seas once swarmed, but which is rare now, all over the world, having been supplanted and driven out of the seas by newer and stronger forms of shelled animals. The nearest spot at which you are likely to dredge a live brachiopod will be in the deep water of Loch Fyne, in Argyleshire, where two species still linger, fastened, strangely enough, to the smooth pebbles of a submerged glacier, formed in the open air during the age of ice, but sunk 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 feelings 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 remnants of a primeval world.

The other might be (but I cannot promise 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 exquisite 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 stone. You may see in museums specimens of this family, now so rare, all but extinct. And yet fifty or a hundred different forms of the same type swarmed in the ancient seas: whole masses of limestone are made up of little else but the fragments of such animals.

But we have not landed yet on the dry part of the reef. Let us make for it, taking care meanwhile that we do not get our feet cut by the coral, or stung as by nettles by the coral insects. We shall see that the dry land is made up entirely of coral, 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 rain, which filters through it, charged with lime from the rotting coral, the whole is setting, as cement sets, into rock. And what is this? A long bank of stone standing up as a low cliff, ten or twelve feet above high-water mark. It is full of fragments of shell, of fragments of coral, of all sorts 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? It must have been formed at the sea-level, some of it, indeed, under the sea; for here are great masses of madrepore and limestone corals imbedded just as they grew. What lifted it up? 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 on shore to the main island which rises 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 sea. I have seen such many a time.

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 coral rock. Did you never see that last? No? Yes, you have a hundred times. You have but to look at the marbles commonly used about these islands, with angular fragments imbedded in the mass, and here and there a shell, the whole cemented together by water holding in solution carbonate of lime, and there see the very same phenomenon perpetuated to this day.

Thus, 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 leading you away as far as you fancied by 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 which is not soft animal matter, 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 destruction; you will see whole layers made up of innumerable fragments of crinoids—no wonder they are innumerable, for, it has been calculated, there are in a single animal of some of the species 140,000 joints—140,000 bits of lime to fall apart when its soft parts decay. But is it not all there? 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 the upheaving force of earthquakes? 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 New York, 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 end by a dozen 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 earthquakes as that famous one at St. Thomas's, in 1866, became common and periodic, upheaving the land (they needs upheave it a very little, only two hundred and fifty feet), till St. Thomas's, and all the Virgin Isles, and the mighty mountain of Porto Rico, which looms up dim and purple to the west, were all joined into dry land once more, and the lonely coral-shoal of Anegada were raised, as it would be raised then, into a limestone table-land, like that of Central Ireland, of Galway, or of County Clare.

But you must clearly understand, that however much these coralline limestones have been upheaved since they 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 observations which he made in the world-famous Voyage of the Beagle; and the observations of subsequent great naturalists have all gone to corroborate his theory.

It was supposed at first, you must understand, that when a coral island rose steeply to the surface of the sea out of blue water, 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 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 of the strongest and largest species work best at the very surface, and in the cut of the fiercest surf. And so arose a puzzle as to how coral rock is often found of vast thickness, which Mr. Darwin explained. His theory was, and there is no doubt now that it is correct, that in these cases the sea-bottom is sinking; that as it sinks, carrying the coral beds down with it, the coral dies, and a fresh live crop of polypes builds on the top of the houses of their dead ancestors; so that, as the depression goes on, generation after generation builds upward, the living on the dead, keeping the upper surface of the reef at the same level, while its base is sinking downward into the abyss.

By applying this theory to the coral reef of the Pacific Ocean, the following interesting 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)—that is a pretty sure sign that that shore, or mountain, 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 mountain-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 geography of the South-Sea Islands by the light of this theory of Mr. Darwin's, the following extraordinary fact has been discovered :

That over a great part of the Pacific Ocean sinking is going on, and 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 for thousands of miles between Australia and South America.

Now, applying the same theory to limestone beds, which are, as you know, only fossil coral reefs, we have a right to say, when we see in England, Scotland, Ireland, limestones several thousand 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 thickness—to several thousand feet—before that later sinking which enabled several hunred feet of millstone grit to be laid down on the top of the limestone.

This millstone grit is a new and a very remarkable element in our strange story. From Derby to Northumberland it forms vast and lofty moors, capping, as at Whernside and Penygent, the highest limestone hills with its hard, rough, barren, and unfossiliferous strata. Wherever it is found, it lies on the top of the "mountain," or carboniferous limestone. Almost everywhere, where coal is found in England, it lies on the millstone grit. I speak roughly, for fear of confusing my readers with details. The three deposits pass more or less, 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 joined to them, which spread from Derby 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 reefs of coral sheets of sand, which killed 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. He will find layers in those beds, of several feet in thickness, as hard as flint, but as porous as sponge. On examining their cavities he will find them to be simply hollow casts of innumerable joints of crinoids, so exquisitely preserved, even to 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? They have been killed 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 lime of which the joints were made, and left their perfect casts behind.

So much for the millstone grits. How long the deposition of sand went on, how long after it that second deposition of sands took place, which goes by the name of the "gannister," or lower coal measures, we cannot tell. But it is clear at least that parts of that ancient sea were filling up and becoming dry land. For coal, or fossilized vegetable matter, becomes more and more common as we ascend in the series of beds ; till at last in the upper coal measures the enormous wealth of vegetation which grew, much of it, where it is now found, prove the existence of some such sheets of fertile and forest-clad lowland as I described in my last paper.

Thousands of feet of 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 violent 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, cliff-bred from 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 rock, the cats into lions, and the sparrows 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, Westmoreland, 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 regularity and smoothness of its surface, but still more for its color. Whether merely warm gray, as when dry, or bright purple, as when wet, the color of the English slate well justifies 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 beautiful is the hue of slate, when, shining wet 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 native mountains. Then, indeed, it reminds the voyager 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 tropic sun.

Beautiful, I say, is the slate, and curious likewise, nay, venerable ; a most ancient and elaborate work of God, which has lasted long enough, and endured enough likewise, to bring out in it whatsoever latent capabilities of strength and usefulness might lie hid in it ; which has literally been—as far as such words can apply to a thing inanimate—

> "Heated hot with burning fears,
> And bathed in baths of hissing tears,
> And battered by the strokes of doom
> To shape and use."

And yet it was at first naught but an ugly lump of soft and shapeless ooze.

Therefore, the slates to me are as a parable, on which I will not enlarge, but will leave each reader to interpret it for himself. 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 probable by the simple fact that it can be turned into mud again. If you grind up slate, and then analyze it, you will find its mineral constituents to be exactly those of a fine, rich, and tenacious clay. The slate districts (at least in Snowdon) 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 clay above may be clearly seen. Wherever 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 change take place?

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 and strange transformations. For these slates are found in the oldest beds of rocks, save 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 elaborate, is the slate. The best slates 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 thickness of some eighty thousand feet, in Labrador, Canada, and the Adirondack mountains of New York ; but their representatives in Europe are, 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 inconceivable antiquity, that they have been upheaved and shifted long before the Cambrian rocks were laid down "unconformably" on their worn and broken edges.

Above the "Cambrian" slates—whether the lower and older ones of Penrhyn and Llanberris, 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 and newer slate-bearing beds of inferior quality, and belonging to a yet newer world, the "Silurian." To them belong the Llandeilo flags and slates of Wales, and the Skiddaw slates of Cumberland, amid beds abounding in extinct fossil forms. 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 pressure, and chemical action, during long ages ; or whether, in these lower beds, we are actually reaching that "Primordial Zone" conceived of by M. Barrande, namely, rocks which existed before living things had begun to people this planet, is a question not yet answered. I believe the former theory to be the true one.

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 eozoon, in the Laurentian limestones, which seems to have grown layer after layer, and to have formed reefs of limestone as do the living coral-building polypes. We know no more as yet. But all that we do know points downward, downward still, warning us that we must dig deeper than we have dug as yet, before we reach the graves of the first living things.

Let this suffice at present for the Cambrian and Laurentian rocks.

The Silurian rocks, lower and upper, 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 in the Fans of Breeon and Carmarthenshire attain a thickness of ten thousand feet, must be passed through in an upward direction before we reach the bottom of that carboniferous limestone of which I spoke in my last paper. We thus find, on the Cambrian rocks, forty-five thousand feet at least of newer rocks, in several cases lying unconformably on each other, showing thereby that the lower beds had been upheaved, and their edges worn off on a sea-shore, ere the upper were laid down on them ; and throughout this vast thickness of rocks, the remains of hundreds of forms of animals, corals, shells, fish, older forms dying out in the newer rocks, and new ones 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 on earth. Whole families, indeed, disappear entirely, like 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 the Indian seas, a well-known animal, of which specimens may be sometimes seen alive in English aquaria. So perished, in the lapse of those same ages, the armor-plated or "ganoid" fish which Hugh Miller made so justly famous—and which made him so justly famous in return—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 lepidostei, or "bony pikes," of North America ; the polypteri of the Nile and Senegal ; the lepidosirens of the African lakes and Western rivers ; the ceratodus or barramundi of Queensland (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 in isolated stations through long ages, comparatively unchanged while all the world is changed around them, and their own kindred buried like the fossil ceratodus of the trias, beneath thousands of feet of ancient rock, among creatures the likes whereof are not to be found now on earth. And these are but two examples out of hundreds of the vast changes which have taken place in the animal life of the globe, 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 how were they 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 Geological Survey, which may be ordered at any good stationer's, price two shillings, and study it with me. He will see down the right-hand margin interpretations of the different colors which mark the different beds, beginning with the youngest (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 the surface of these volcanic beds. 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 broad patch of red, where the back of a 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 similar 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 volcanic ash. If he look below the little 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, lodes 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 wholesome fear of his own weakness and 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 confusion—for it is a true confusion—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 sees marked as felspathic traps, quartz porphyries, greenstones, and so forth, got intermingled with beds which he is told to believe are volcanic ashes, and those again with fossil-bearing Siluriau beds and Cambrian slates, which he is told to believe were deposited 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 1830, off the Azores in 1811, and in our day in 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 an enormous jet of high-pressure steam and 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 fancy sketch, as far as I am concerned. I have steamed into craters sawn through by 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 veins of hardened lava, which had burrowed 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-mitrailleuse hurls to 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 more than four miles into the air ; the jet from the Souffrière 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 the bottom of the ocean, several inches thick, eighty miles at least long, 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, or volcanic 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 subterranean steam would blast a bore. The dust and stones 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 flow out over the ashes and 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 more ash was blasted out, making 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 on layers of sediment deposited, with live 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 live and thrive in the ash-mud itself, 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 breaks out again—what would happen?

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 finds it in a more horizontal direction. 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 consider 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 overlying each other, which have come from 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 most 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 this:

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 some hundred feet out of the sea; that—as has happened to Sabrina Island—the cone is sunk again by earthquakes, and gnawn down at the same time by the sea-waves, till nothing is left but a shoal 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 say whether they are of volcanic or of marine 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 two or three times during 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 in order to end at the end. 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 anything of 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 fancy that in any known part of these islands 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 people hearing that certain mountains are volcanic, conclude—and very naturally and harmlessly—that the circular lakes about their tops are true craters. I have been told, for instance, that that wonderful little blue Glas Llyn, under the highest cliff of Snowdon, is the old 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 not one either. The fact is, 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.

For, as an eruption ceases, the melted 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 hill, as 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 overlying rocks. But where are these vents? Buried deep under successive eruptions, shifted probably from their places by successive upheavings and dislocations; and if we wanted to find them we should have to quarry the mountain range all over, a mile deep, before we hit upon here and there a tap-root of ancient lava, connecting the upper and the nether worlds. There are such tap-roots, probably, under each of our British mountain ranges. But Snowdon, certainly, does not owe its shape 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 stand the wear and tear of sea-wave, ice, 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 earthquakes, 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 craters they are not.

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.

Look at any 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 folded by being squeezed laterally. At least, that is the simplest explanation, as may be proved by experiment. Take a number of pieces of cloth, or any such stuff; lay them on each other, and then squeeze them together at each 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, as you squeeze on, these folds will tend to snap at the points of greatest tension or stretching, which will be of course at the anticlinal 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.

But again, 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 rise; and as they rose leave open 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 permanently apart, you would make them into a fair likeness of an average mountain-range—a mess—if I may make use of a 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 it. And the simplest general cause which I can give for it is this: That things expand as they are heated and contract as they are cooled.

Now I am not learned enough—and were I, I have not time—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. Elie 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 now.

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

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

That, therefore, in contracting, wrinkles (for the loftiest mountain chains are nothing 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 tends (as in the case of volcanoes) toward a particular spot, that spot must expand, and swell up, bulging the rocks 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 crumpled, and crushed, and shifted against each other still more, as those of our mountains have been.

But here may arise, in some of my readers' minds, a reasonable question, If these upheaved beds 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 answer.

They know, 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 by the fossils, usually shells, peculiar to them: so that if we find the same fashion of shells, and still more the same species of shells, in two beds in different quarters of the world, then we have a right to say, These beds were laid down at least about the same time. That is a general rule among all geologists, and not to be gainsaid.

Now I think I may say, that, granting that we can recognize a bed by its fossils, there are few or no beds which are found in one place upheaved, broken, and altered by heat, which are not found in some other place still horizontal, unbroken, unaltered, and more or less as they were at first.

From the most recent beds, from the upheaved coral rocks of the West Indies, and the upheaved and faulted boulder-clay and chalk of the Isle of Moen in Denmark—downward through all the strata, down to that very ancient one in which the best slates are found, this rule, I believe, stands true.

It stands true, certainly, of the ancient Silurian rocks of Wales, Cumberland, Ireland, and Scotland.

For, throughout great tracts of Russia, and in parts of Norway and Sweden, Sir Roderick Murchison discovered our own Silurian beds, recognizable from their peculiar fossils. But in what state? Not contracted, upheaved, and hardened, to slates and grits, as they are in Wales and elsewhere: but horizontal, unbroken, and still soft, because undisturbed by volcanic rocks and earthquakes. At the bottom of them all, near Petersburg, Sir Roderick found a shale of dried mud (to quote his own words), "so soft and incoherent, that it is even used by sculptors for modelling, although it underlies the great mass of fossil-bearing Silurian rocks, and is, therefore, of the same age as the lower crystalline hard slates of North Wales. So entirely have most of these oldest rocks in Russia been exempted from the influence of change, throughout those enormous periods which have passed away since their accumulation."

Among the many discoveries which science owes to that illustrious veteran, I know none more valuable for its bearing on the whole question of the making of the earth-crust, than this one magnificent fact.

But what a contrast between these Scandinavian and Russian rocks and those of Britain! Never exceeding, in Scandinavia, a thousand feet in thickness, and lying usually horizontal, as they were first laid down, they are swelled in Britain to a thickness of thirty thousand feet, by intruded lavas and ashes; snapt, turned, set on end at every conceivable angle; shifted against each other to such an extent, that, to give a single instance, in the Vale of Gwynnant, under Snowdon, an immense wedge of porphyry has been thrust up, in what is now the bottom of the valley, between rocks far newer than it, on one side to a height of eight hundred, on the other to a height of eighteen hundred feet—half the present height of Snowdon. Nay, the very slate beds of Snowdonia have not forced their way up from under the mountain without long and fearful struggles. They are set in places upright on end, then horizontal again, then sunk in an opposite direction, then curled like sea-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 newer beds, the rest of which has long vanished; and in their rise they have hurled 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-porphyry, which rises from under them to the north-west, crossing the end of the lower lake of Llanberris; and indeed the shifts and convulsions which 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 Professor Ramsay's "Geological Survey of North Wales." But any one who will study that section, and use (as with the map) a little imagination and common-sense, will see that between the heat of that porphyry, which must have been poured out as a fluid mass as hot, probably, as melted iron, and the pressure of it below, and of the Silurian beds above, the Cambrian mud-strata of Llanberris 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 over them—like the cats.

Look at any piece of slate. All know that slate splits or cleaves freely, in one direction only, into flat layers. Now any one would suppose at first sight, and fairly enough, that the flat surface—the "plane 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 is one of the little horizontal 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 slate. The plane of bedding in slate has nothing to do with the plane of cleavage. Or, more plainly the mud of which the slate is made may have been deposited at the sea-bottom at any angle to the plane of cleavage. We may sometimes see the lines of the true bedding—the lines which were actually horizontal when the mud was laid down—in bits of slate, and find them sometimes perpendicular to, sometimes inclined to, and sometimes again coinciding with the plane of cleavage, which they have evidently acquired long after.

Nay, more. These parallel planes of cleavage, at each of which the slate splits freely, will 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 particles of the now solid rock have actually moved on themselves. And this is proved by a very curious fact—which the reader, if he geologizes about slate quarries much, may see with his own eyes. The fossils in the slate are often distorted into quaint shapes, pulled out long if they lie along the plane of cleavage, or squeezed together, or doubled down on both sides, if they lie across the plane. So that some force has been at work which could actually change the shape 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 read what Sir Henry de la Bêche has said on it in his admirable "Geological Observer," pp. 706–725. He will find there, too, some remarks on that equally mysterious phenomena 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 produces single crystals; and similar, too, 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. Robert Hunt—are of opinion 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 mere mechanical pressure of enormous weights 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 enormously, all which could not have 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 had most time to endure the changes, whether mechanical or chemical, which have made the earth's surface what we see it now.

Another startling fact the section 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 these elder rocks, upon the lie of the 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, as it is a mountain which every one in 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 high into the air, dominating all the country round, at least upon three sides, and was told that its summit consisted of beds much newer, not much older, than the slate-beds fifteen hundred feet down on its north-western 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. Snowdon 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; and Snowdon is a mere insignificant 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 angles, in which they crop out, and vanish 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 restoring 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 Ffestiniog, where the Cambrian rocks rise again to the surface, the south side of the trough must have sloped upward to 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 fact is certain, that off the surface of Wales, south of Ffestiniog, 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 Mowddy, which is now not two thousand feet high, was once—either under the sea or above it—nearer ten thousand feet.

If I am asked whither is all that enormous mass of rock—millions of tons—gone? 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 them to have come from is from North 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 Chester walls was probably once blasted 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 not it have come from the same quarter? Why should it not be simply the remains of the Snowdon slate? 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 black slates of Ilfracombe, wherever they are 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 slate.

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 which would fully explain the fact, though it may be explicable 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 Lower Cambrian slates would be laid 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 older rock, when redeposited by water, 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, such as is seen over the west and south of Cheshire and Staffordshire and far away into Nottinghamshire. The red marl must almost certainly have been black slate somewhere, somewhen. Why should it not have been such in Snowdon? And why should not the slates in the roof be the remnants 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. I do so, well knowing how imperfect they are—though not, I believe, inaccurate. 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 townsman, 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 or an excursion train. 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 given: 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 begin to fancy, as too many do already, that the world is composed mainly of bricks and deal, and governed by acts of parliament. If I shall have awakened any townsmen here and there to think seriously of the complexity, the antiquity, the grandeur, the true poetry, of the commonest objects around them, even the stones beneath their feet; if I shall 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, the great book which is free to all alike, to peasant as to peer, to men of business as to men of science, even that great book of nature, which is, as Lord Bacon said of old, the Word of God revealed in facts—then I shall have a fresh reason for loving that science of geology, which has been my favorite study since I was a boy.

VII.

ON CORAL AND CORAL REEFS.

The marine productions which are commonly known by the names of "corals" and "corallines" were thought by the ancients to be sea-weeds, which had the singular property of becoming hard and solid when they were fished up from their native depths and came into contact with the air.

"Sic et curalium, quo primum contigit auras
Tempore durescit: mollis fuit herba sub undis,"

says Ovid (Metam. xv.); and it was not until the seventeenth century that Bocconc was emboldened, by personal experience of the facts, to declare that the holders of this belief were no better than "idiots," who had been misled by the softness of the outer coat of the living red coral to imagine that it was soft all through.

Messer Boccone's strong epithet is probably undeserved, as the notion he controverts, in all likelihood, arose merely from the misinterpretation of the strictly true statement which any coral fisherman would make to a curious inquirer; namely, that the outside coat of the red coral is quite soft when it is taken out of the sea. At any rate, he did good service by eliminating this much error from the current notions about coral. But the belief that corals are plants remained, not only in the popular, but in the scientific mind; and it received what appeared to be a striking confirmation from the researches of Marsigli in 1706. For this naturalist, having the opportunity of observing freshly-taken red coral, saw that its branches were beset with what looked like delicate and beautiful flowers, each having eight petals. It was true that these "flowers" could protrude and retract themselves, but their motions were hardly more extensive, or more varied, than those of the leaves of the sensitive plant; and therefore they could not be held to militate against the conclusion so strongly suggested by their form and their grouping upon the branches of a tree-like structure.

Twenty years later, a pupil of Marsigli, the young Marseilles physician, Peyssonel, conceived the desire to study these singular sea-plants, and was sent by the French Government on a mission to the Mediterranean for that purpose. The pupil undertook the investigation full of confidence in the ideas of his master, but being able to see and think for himself, he soon discovered that those ideas by no means altogether corresponded with reality. In an essay entitled "Traité du Corail," which was communicated to the French Academy of Science, but which has never been published, Peyssonel writes:

"Je fis fleurir le corail dans des vases pleins d'eau de mer, et j'observai que ce que nous croyons être la fleur de cette prétendue plante n'était au vrai, qu'un insecte semblable à une petite ortie ou poulpe. J'avais le plaisir de voir remuer les pattes, ou pieds, de cette ortie, et ayant mis le vase plein d'eau où le corail était à une douce chaleur auprès du feu, tous les petites insectes s'épanouirent. . . . L'ortie sortie étend les pieds, et forme ce que M. de Marsigli et moi avions pris pour les pétales de la fleur. Le calice de cette prétendue fleur est le corps même de l'animal avancé et sortie hors de la cellule."*

The comparison 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 French appellation for our "sea-anemone," a creature with which everybody, since the great aquarium mania, must have become familiar, even to the limits of boredom. In 1710 the great naturalist Réaumur had written a memoir for the express purpose of demonstrating that these "orties" are animals; and with this important paper Peyssonel must necessarily have been familiar. Therefore, when he declared the "flowers" of the red coral to be little "orties," it was the same thing 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. Lacaze Duthiers in his valuable "Histoire Naturelle du Corail" (1866).

this was an extremely startling announcement. It was hard to imagine the existence of such a thing as an association of animals into a structure with stem and 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 Réaumur could not bring himself to accept the notion, and France 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 unmannerly fellows as Peyssonel from blurting out unedifying truths, they suppressed him; and, as aforesaid, his great work remained in manuscript, and may at this day be consulted by the curious in that state, in the "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 upon the 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 resented the treatment he met with. 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 upon the fresh-water *pydra*. Bernard de Jussieu and Guettard followed them up by like inquiries upon the marine sea-anemones and corallines; Réaumur, convinced against his will of the entire justice of Peyssonel's views, adopted them, and made him a half-and-half apology in the preface to the next published volume of the "Mémoires pour servir à l'Histoire des Insectes;" and, from this time forth, Peyssonel's doctrine that corals are the work of animal organisms has been part of the body of established scientific truth.

Peyssonel, in the extract from his memoir already cited, compares the flower-like animal of the coral to a "poulpe," which is the French form of the name "polypus,"—"the many-footed,"—which the ancient naturalists gave to the soft-bodied cuttle-fishes, which, like the coral animal, have eight arms, or tentacles, disposed around a central mouth. Réaumur, admitting the analogy indicated by Peyssonel, gave the name of *polypes*, not only to the sea-anemone, the coral animal, and the fresh-water *hydra*, but to what are now known as the *polyzoa*, and he termed the skeleton which they fabricate a "*polypier*" or "polypidom."

The progress of discovery, since Réaumur'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 open at its inner end, 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 one polype may, by repeated incomplete divisions, give rise to a sort of sheet, or turf, formed by innumerable connected, and yet independent, descendants. Or, what is still more common, a polype may throw out buds, which are converted into 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 together by a fleshy substance, traversed 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, somewhat in the same fashion as our own bones 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 commoner white corals each polype has a complete 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 once separated and held 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 of which has but a very insignificant 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 possess the more ordinary methods of 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 which has no sort of resemblance to 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 multitudes of little hair-like filaments, called cilia, with which its body is covered. These cilia all lash the water in one direction, and so 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 polype form and growing up to the size of 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 easily flow at the speed of two or even more 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 hundreds, 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 coral which may be formed by the assemblages 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 form huge half globes, like the brainstone corals, or may reach the magnitude of stout shrubs, or even small trees. There is reason to believe that such masses as these take a long time to form, and hence that the age 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 parts of the world, comprised within a distance 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 form very strong and large skeletons, 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, heaped 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."

Such 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 continuously, for more than 1100 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 such reefs; and they abound no less in the West Indies, along the coast of Florida, and even as far north as the Bahama Islands. But it is a very remarkable circumstance that, within the area of what we may call the "coral zone," there are no 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-

rupted, 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 polypes which fabricate them require for their vigorous growth a temperature which must not fall below 68° 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. But even within the coral 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 regions which surround the South Pole 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 polypes 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.

Such is 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. The reefs, in fact, are of three different 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 land; and when this land 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, space of sea, which is called 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, irregularly oval, or circular, breakwater, inclosing 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 to 200 or 300 fathoms. The depth 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 volcanic craters, except that their sides would be steeper than those of an ordinary volcano. In the case of the encircling reefs, the cone, with the inclosed island, would look like Vesuvius with Monte 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, girded by a vast parapet, within which would lie a shallow moat. And the dry bed of the Pacific might afford grounds for an inhabitant of the moon to speculate upon the extraordinary subterranean activity to which these vast and numerous "craters" bore witness!

When the structure of a fringing reef is 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 there lie, here and there, growing corals, 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 of which the reef is built up. Close to 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, which contains a great deal of lime—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-polypes make their appearance, and, in different forms, coat the steep seaward face 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 ordinary shelving sea-bottom. And the 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 animal flowers of the coral, while its surface 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 coral, add a very important contribution of finely-triturated calcareous matter; and the corals and mud becoming incorporated together, gradually harden and give rise to a sort of limestone rock, which may vary a good deal in texture. Sometimes 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 interstices of the nascent rock, thus gluing and cementing the 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, where the coral sand is washed 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; and even sometimes incloses the eggs of turtles in a state of petrifaction. The active and vigorous growth of the reef goes on only at the seaward margins, where the polypes are exposed to the wash of the surf, and are thereby provided with an abundant supply of air and of food. The interior portion of the reef may be regarded as almost wholly an accumulation of dead skeletons. Where a river comes down from the land there is a break in the reef, for the reasons which have been already mentioned.

The origin and mode of formation of a fringing reef, such as that just described, are plain enough. The embryos of the coral polypes have 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 itself up upon the dead skeletons of its 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 100 or 150 feet high on its seaward face 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 in the encircling reefs and in the atolls is essentially the same as in the fringing reef. But, in addition to the differences of depth inside and out, they present some other peculiarities. These reefs, and especially the atolls, are usually interrupted at one 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 from the south-east, 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 polypes. For, as we have seen, these polypes cannot live at a greater depth than about twenty-five fathoms; and actual observation has shown that while, down to this depth, the sounding-lead will bring up branches of live coral from the outer wall of such a reef, at a greater depth it fetches to the surface 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 summit, with coral polypes busily engaged 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 bed 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 presented by many high mountains on land. 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 summits would be gay 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 or of an encircling reef, are so great, in 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. There is no reason to doubt, however, that 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 surface of the sea?

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 what is there in physical geography to 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 submarine 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?

These and other puzzling 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, and every difficulty was shown to be 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 relatively to that of the land is falling, the only reefs which can be formed are fringing reefs. While if, on the contrary, the level of the sea is rising relatively to that of the land, at a rate not faster than that 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. Then the reef cannot extend 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 gradual accumulation, at the foot 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 limits 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 were slowly and gradually lowered, it is clear that the parts of its 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 neither to an encircling reef nor to an 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 most, a foot or two, in a hundred 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 the coral polypes is possible, it would be able to grow upward as fast as the sea rose. But the growth would take place almost exclusively around the circumference of the reef, this being the only region in which the coral polypes would find the conditions favorable for their existence. The bottom of the lagoon would be raised, in the main, only by the coral *débris* and coral mud, formed in the manner already described; consequently, the margins of the reef would rise faster than 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 occupy a 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 island surrounded by an encircling 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 over those areas which are now covered by atolls and encircling reefs; or, the land 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 over all 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 has been suggested, for example, that the accumulation of ice about 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-cellars; 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 reasoning must be admitted to be sound in 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 and subtractions might be either intensified or nullified, by contemporaneous 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, has taken place since 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 atolls, 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, and all full of marine remains, occur in 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 underwent a slow and gradual depression to a 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 was entirely 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. If his view be correct, it is clear 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 has long been either stationary, or 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 on coral reefs, there is a map 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 upheaving volcanic agencies had lifted up the edges of these great areas, while their centres had undergone a corresponding depression. An atoll area may, in short, 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, and 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-girdled 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 cassowaries 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 peopled by immigrants from the already existing marine Australian fauna.

Inasmuch as the growth of the reef depends upon that of successive generations of coral polypes, and as each generation takes a certain time to grow to its full size, and can only separate its calcareous skeleton from the water in 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 madrepore 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 madrepore ; and, as they are also porous, to not over three eighths of an inch of solid limestone. But a coral plantation 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 sixth 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 relics may contribute one fourth as much as corals. 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." *

Halve, 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 carboniferous and Devonian strata. Then as regards the latter group of rocks in America, the high authority already quoted tells us :

"The Upper Helderberg period is eminently the coral-reef period of the palæozoic ages. Many of the rocks abound in coral, and are as truly coral reefs as 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 trituration 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 but few distinct fossils, although formed in water that abounded in life. At the fall of the Ohio, near Louisville, there is a magnificent display of the old reef. Hemispherical *Favosites*, five or six feet in diameter, lie there nearly as perfect as when they were covered by their flower-like polypes ; and besides these, there are various branching corals, and a profusion of *Cyathophyllia*, 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 own skeletons. Grain by grain, and particle by particle, they have built up vast masses of rock, the thickness of which is measured by hundreds of feet, and their area by thousands of square miles. The slow oscillations of 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 variation and 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 there were no other evidence, suffice to prove the general constancy of the operations of Nature in this world, through periods of almost inconceivable duration.

THE END.

* Dana, "Manual of Geology," p. 591.

* Dana, "Manual of Geology," p. 272.

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hem to celibacy.

Our general conclusion is, then, that he ordinary treatment of children is, in various ways, seriously prejudicial. It errs in deficient feeding, in deficient clothing, in deficient exercise (among girls at least), and in excessive mental application. Considering the regime as a whole, its tendency is too exacting: it asks too much and gives too little. In the extent to which it taxes the vital energies it makes the juvenile life much more like the adult life than it should be. It overlooks the truth that as in the fœtus the entire vitality is expended in the direction of growth—as in the infant the expenditure of vitality in growth is so great as to leave extremely little for either physical or mental action—so throughout childhood and youth growth is the dominant requirement to which all others must be subordinated: a requirement which dictates the giving of much and the taking away of little—a requirement which, therefore, restricts the exertion of body and mind to a degree proportionate to the rapidity of growth—a requirement which permits the mental and physical activities to increase only as fast as the rate of growth diminishes.

Regarded from another point of view, this high-pressure education manifestly results from our passing phase of civilization. In primitive times, when aggression and defence were the leading social activities, bodily vigor with its accompanying courage were the desiderata; and then education was almost wholly physical: mental cultivation was little cared for, and indeed, as in our own feudal ages, was often treated with contempt. But now that our state is relatively peaceful—now that muscular power is of use for little else than manual labor, while social success of nearly every kind depends very much on mental power, our education has become almost exclusively mental. Instead of respecting the body and ignoring the mind, we now respect the mind and ignore the body. Both these attitudes are wrong. We do not yet sufficiently realize the truth that as in this life of ours the physical underlies the mental, the mental must not be developed at the expense of the physical. The ancient and modern conceptions must be combined.

Perhaps nothing will so much hasten the time when body and mind will both be adequately cared for as a diffusion of the belief that the preservation of health is a *duty*. Few seem conscious that there is such a thing as physical morality. Men's habitual words and acts imply the idea that they are at liberty to treat their bodies as they please. Disorders entailed by disobedience to nature's dictates they regard simply as grievances, not as the effects of a conduct more or less flagitious. Though the evil consequences inflicted on their dependants and on future generations are often as great as those caused by crime, yet they do not think themselves in any degree criminal. It is true that, in the case of drunkenness, the viciousness of a purely bodily transgression is recognized, but none appear to infer that, if this bodily transgression is vicious, so too is every bodily transgression. The fact is, that all breaches of the laws of health are *physical sins*. When this is generally seen, then, and perhaps not till then, will the physical training of the young receive all the attention it deserves.

THE END.

CONTENTS.

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