

CHARLES KINGSLEY

TOWN
GEOLOGY

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Charles Kingsley

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PREFACE

This little book, including the greater part of this Preface, has shaped itself out of lectures given to the young men of the city of Chester. But it does not deal, in its present form, with the geology of the neighbourhood of Chester only. I have tried so to recast it, that any townsman, at least in the manufacturing districts of England and Scotland, may learn from it to judge, roughly perhaps, but on the whole accurately, of the rocks and soils of his own neighbourhood. He will find, it is true, in these pages, little or nothing about those "Old Red Sandstones," so interesting to a Scotchman; and he will have to bear in mind, if he belong to the coal districts of Scotland, that the "stones in the wall" there belong to much older rocks than those "New Red Sandstones" of which this book treats; and that the coal measures of Scotland, with the volcanic rocks which have disturbed them, are often very different in appearance to the English coal measures. But he will soon learn to distinguish the relative age of rocks by the fossils found in them, which he can now, happily, study in many local museums; and he may be certain, for the rest, that all rocks and soils whatsoever which he may meet have been laid down

by the agents, and according to the laws, which I have tried to set forth in this book; and these only require, for the learning of them, the exercise of his own observation and common sense. I have not tried to make this a handbook of geological facts. Such a guide (and none better) the young man will find in Sir Charles Lyell's "Student's Elements of Geology." I have tried rather to teach the method of geology, than its facts; to furnish the student with a key to all geology, rough indeed and rudimentary, but sure and sound enough, I trust, to help him to unlock most geological problems which he may meet, in any quarter of the globe. But young men must remember always, that neither this book, nor all the books in the world, will make them geologists. No amount of book learning will make a man a scientific man; nothing but patient observation, and quiet and fair thought over what he has observed. He must go out for himself, see for himself, compare and judge for himself, in the field, the quarry, the cutting. He must study rocks, ores, fossils, in the nearest museum; and thus store his head, not with words, but with facts. He must verify—as far as he can—what he reads in books, by his own observation; and be slow to believe anything, even on the highest scientific authority, till he has either seen it, or something like enough to it to make it seem to him probable, or at least possible. So, and so only, will he become a scientific man, and a good geologist; and acquire that habit of mind by which alone he can judge fairly and wisely of facts of any kind whatsoever.

I say—facts of any kind whatsoever. If any of my readers

should be inclined to say to themselves: Geology may be a very pleasant study, but I have no special fancy for it. I had rather learn something of botany, astronomy, chemistry, or what not—I shall answer: By all means. Learn any branch of Natural Science you will. It matters little to me which you learn, provided you learn one at least. But bear in mind, and settle it in your hearts, that you will learn no branch of science soundly, so as to master it, and be able to make use of it, unless you acquire that habit and method of mind which I am trying to teach you in this book. I have tried to teach it you by geology, because geology is, perhaps, the simplest and the easiest of all physical sciences. It appeals more than any to mere common sense. It requires fewer difficult experiments, and expensive apparatus. It requires less previous knowledge of other sciences, whether pure or mixed; at least in its rudimentary stages. It is more free from long and puzzling Greek and Latin words. It is specially, the poor man's science.

But if you do not like it, study something else. Only study that as you must study geology; proceeding from the known to the unknown by observation and experiment.

But here some of my readers may ask, as they have a perfect right to ask, why I wish young men to learn Natural Science at all? What good will the right understanding of geology, or of astronomy, or of chemistry, or of the plants or animals which they meet—what good, I say, will that do them?

In the first place, they need, I presume, occupation after their hours of work. If any of them answer: "We do not want

occupation, we want amusement. Work is very dull, and we want something which will excite our fancy, imagination, sense of humour. We want poetry, fiction, even a good laugh or a game of play"—I shall most fully agree with them. There is often no better medicine for a hard-worked body and mind than a good laugh; and the man who can play most heartily when he has a chance of playing is generally the man who can work most heartily when he must work. But there is certainly nothing in the study of physical science to interfere with genial hilarity; though, indeed, some solemn persons have been wont to reprove the members of the British Association, and specially that Red Lion Club, where all the philosophers are expected to lash their tails and roar, of being somewhat too fond of mere and sheer fun, after the abstruse papers of the day are read and discussed.

And as for harmless amusement, and still more for the free exercise of the fancy and the imagination, I know few studies to compare with Natural History; with the search for the most beautiful and curious productions of Nature amid her loveliest scenery, and in her freshest atmosphere. I have known again and again working men who in the midst of smoky cities have kept their bodies, their minds, and their hearts healthy and pure by going out into the country at odd hours, and making collections of fossils, plants, insects, birds, or some other objects of natural history; and I doubt not that such will be the case with some of my readers.

Another argument, and a very strong one, in favour of

studying some branch of Natural Science just now is this—that without it you can hardly keep pace with the thought of the world around you.

Over and above the solid gain of a scientific habit of mind, of which I shall speak presently, the gain of mere facts, the increased knowledge of this planet on which we live, is very valuable just now; valuable certainly to all who do not wish their children and their younger brothers to know more about the universe than they do.

Natural Science is now occupying a more and more important place in education. Oxford, Cambridge, the London University, the public schools, one after another, are taking up the subject in earnest; so are the middle-class schools; so I trust will all primary schools throughout the country; and I hope that my children, at least, if not I myself, will see the day, when ignorance of the primary laws and facts of science will be looked on as a defect, only second to ignorance of the primary laws of religion and morality.

I speak strongly, but deliberately. It does seem to me strange, to use the mildest word, that people whose destiny it is to live, even for a few short years, on this planet which we call the earth, and who do not at all intend to live on it as hermits, shutting themselves up in cells, and looking on death as an escape and a deliverance, but intend to live as comfortably and wholesomely as they can, they and their children after them—it seems strange, I say, that such people should in general be so careless about

the constitution of this same planet, and of the laws and facts on which depend, not merely their comfort and their wealth, but their health and their very lives, and the health and the lives of their children and descendants.

I know some will say, at least to themselves: “What need for us to study science? There are plenty to do that already; and we shall be sure sooner or later to profit by their discoveries; and meanwhile it is not science which is needed to make mankind thrive, but simple common sense.”

I should reply, that to expect to profit by other men’s discoveries when you do not pay for them—to let others labour in the hope of entering into their labours, is not a very noble or generous state of mind—comparable somewhat, I should say, to that of the fattening ox, who willingly allows the farmer to house him, till for him, feed him, provided only he himself may lounge in his stall, and eat, and *not* be thankful. There is one difference in the two cases, but only one—that while the farmer can repay himself by eating the ox, the scientific man cannot repay himself by eating you; and so never gets paid, in most cases, at all.

But as for mankind thriving by common sense: they have not thriven by common sense, because they have not used their common sense according to that regulated method which is called science. In no age, in no country, as yet, have the majority of mankind been guided, I will not say by the love of God, and by the fear of God, but even by sense and reason.

Not sense and reason, but nonsense and unreason, prejudice

and fancy, greed and haste, have led them to such results as were to be expected—to superstitions, persecutions, wars, famines, pestilence, hereditary diseases, poverty, waste—waste incalculable, and now too often irremediable—waste of life, of labour, of capital, of raw material, of soil, of manure, of every bounty which God has bestowed on man, till, as in the eastern Mediterranean, whole countries, some of the finest in the world, seem ruined for ever: and all because men will not learn nor obey those physical laws of the universe, which (whether we be conscious of them or not) are all around us, like walls of iron and of adamant—say rather, like some vast machine, ruthless though beneficent, among the wheels of which if we entangle ourselves in our rash ignorance, they will not stop to set us free, but crush us, as they have crushed whole nations and whole races ere now, to powder. Very terrible, though very calm, is outraged Nature.

Though the mills of God grind slowly,
Yet they grind exceeding small;
Though He sit, and wait with patience,
With exactness grinds He all.

It is, I believe, one of the most hopeful among the many hopeful signs of the times, that the civilised nations of Europe and America are awakening slowly but surely to this truth. The civilised world is learning, thank God, more and more of the importance of physical science; year by year, thank God, it is learning to live more and more according to those laws of

physical science, which are, as the great Lord Bacon said of old, none other than “Vox Dei in rebus revelata”—the Word of God revealed in facts; and it is gaining by so doing, year by year, more and more of health and wealth; of peaceful and comfortable, even of graceful and elevating, means of life for fresh millions.

If you want to know what the study of physical science has done for man, look, as a single instance, at the science of Sanatory Reform; the science which does not merely try to cure disease, and shut the stable-door after the horse is stolen, but tries to prevent disease; and, thank God! is succeeding beyond our highest expectations. Or look at the actual fresh amount of employment, of subsistence, which science has, during the last century, given to men; and judge for yourselves whether the study of it be not one worthy of those who wish to help themselves, and, in so doing, to help their fellow-men. Let me quote to you a passage from an essay urging the institution of schools of physical science for artisans, which says all I wish to say and more:

“The discoveries of Voltaic electricity, electromagnetism, and magnetic electricity, by Volta, Œrsted, and Faraday, led to the invention of electric telegraphy by Wheatstone and others, and to the great manufactures of telegraph cables and telegraph wire, and of the materials required for them. The value of the cargo of the Great Eastern alone in the recent Bombay telegraph expedition was calculated at three millions of pounds sterling.

It also led to the employment of thousands of operators to transmit the telegraphic messages, and to a great increase of our

commerce in nearly all its branches by the more rapid means of communication. The discovery of Voltaic electricity further led to the invention of electro-plating, and to the employment of a large number of persons in that business. The numerous experimental researches on specific heat, latent heat, the tension of vapours, the properties of water, the mechanical effect of heat, etc., resulted in the development of steam-engines, and railways, and the almost endless employments depending upon their construction and use. About a quarter of a million of persons are employed on railways alone in Great Britain. The various original investigations on the chemical effects of light led to the invention of photography, and have given employment to thousands of persons who practise that process, or manufacture and prepare the various material and articles required in it. The discovery of chlorine by Scheele led to the invention of the modern processes of bleaching, and to various improvements 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, has 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.”¹

“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

¹ See “Nature,” No. XXV. (Macmillan & Co.)

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 hedgerow plants, he would find that there is much more to be seen in those mere hedgerow 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 further still. Suppose that he extended his researches somewhat to those minuter vegetable forms, the mosses, fungi, lichens; suppose that he went a little further 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 learnt 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 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. 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?—someone 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 someone else chooses for you? Are you sure that you make up your own mind before you speak, or let someone 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.

Equality, too: whatever equality may or may not be just, or possible; this at least, is just, and I hope possible; that every man, every child, of every rank, should have an equal chance of education; an equal chance of developing all that is in him by nature; an equal chance of acquiring a fair knowledge of those facts of the universe which specially concern him; and of having his reason trained to judge of them. I say, whatever equal rights

men may or may not have, they have this right. Let every boy, every girl, have an equal and sound education. If I had my way, I would give the same education to the child of the collier and to the child of a peer. I would see that they were taught the same things, and by the same method. Let them all begin alike, say I. They will be handicapped heavily enough as they go on in life, without our handicapping them in their first race. Whatever stable they come out of, whatever promise they show, let them all train alike, and start fair, and let the best colt win.

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 helpful 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 instructions? 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 Nature for her own sake? And next—Is he a man who will not quarrel, or otherwise behave in an unbrotherly fashion to his fellow-students?—If you want a ground of brotherhood with men, not merely in these islands, but in America, on the Continent—in a word, all over the world—such as rank, wealth, fashion, or other artificial arrangements of the world cannot give

and cannot take away; if you want to feel yourself as good as any man in theory, because you are as good as any man in practice, except those who are better than you in the same line, which is open to any and every man; if you wish to have the inspiring and ennobling feeling of being a brother in a great freemasonry which owns no difference of rank, of creed, or of nationality—the only freemasonry, the only International League which is likely to make mankind (as we all hope they will be some day) one—then become men of science. Join the freemasonry in which Hugh Miller, the poor Cromarty stonemason, in which Michael Faraday, the poor bookbinder's boy, became the companions and friends of the 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 towards 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 honour”—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 organised 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 civilised 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 learnt 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 towards 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 towards 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 of 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 aeronaut 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, crystallisation, 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 heavenly bodies; and what he says of sun and stars is true likewise of the flowers around our feet, of which the greatest Christian poet of modern times has said—

To me the meanest 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 anyone undervalues the sciences which teach us concerning stones and plants and animals, or thinks that nothing can be learnt 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 instance, 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. viii. 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 for ever 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 for ever." 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 light 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 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 ²

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

² These Lectures were delivered to the members of the Natural Science Class at Chester in 1871.

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 anyone 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 know.

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 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 especially 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 honour 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 downwards 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 yourself, 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 superposition 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 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 æstuary, 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 æstuaries 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.

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