

of the common order of nature, as those which have effected the changes of the inorganic world.

Few will venture to affirm that the reasoning which applies to crocodiles loses its force among other animals, or among plants. If one series of species has come into existence by the operation of natural causes, it seems folly to deny that all may have arisen in the same way.

A small beginning has led us to a great ending. If I were to put the bit of chalk with which we started into the hot but obscure flame of burning hydrogen, it would presently shine like the sun. It seems to me that this physical metamorphosis is no false image of what has been the result of our subjecting it to a jet of fervent, though nowise brilliant, thought to-night. It has become luminous, and its clear rays, penetrating the abyss of the remote past, have brought within our ken some stages of the evolution of the earth. And in the shifting "without haste, but without rest" of the land and sea, as in the endless variation of the forms assumed by living beings, we have observed nothing but the natural product of the forces originally possessed by the substance of the universe.

## THE PRINCIPAL SUBJECTS OF EDUCATION

I KNOW quite well that launching myself into this discussion is a very dangerous operation; that it is a very large subject, and one which is difficult to deal with, however much I may trespass upon your patience in the time allotted to me. But the discussion is so fundamental, it is so completely impossible to make up one's mind on these matters until one has settled the question, that I will even venture to make the experiment. A great lawyer-statesman and philosopher of a former age — I mean Francis Bacon — said that truth came out of error much more rapidly than it came out of confusion. There is a wonderful truth in that saying. Next to being right in this world, the best of all things is to be clearly and definitely wrong, because you will come out somewhere. If you go buzzing about between right and wrong, vibrating and fluctuating, you come out nowhere; but if you are absolutely and thoroughly and persistently wrong, you must, some of these days, have the extreme good fortune of knocking your head against a fact, and that sets you all straight again. So I will not trouble myself as to whether I may be right or wrong in what I am about to say, but at any rate I hope to be clear and definite; and then you will be able to judge for yourselves whether, in following out the train of thought I have to introduce, you knock your heads against facts or not.



I take it that the whole object of education is, in the first place, to train the faculties of the young in such a manner as to give their possessors the best chance of being happy and useful in their generation; and, in the second place, to furnish them with the most important portions of that immense capitalised experience of the human race which we call knowledge of various kinds. I am using the term knowledge in its widest possible sense; and the question is, what subjects to select by training and discipline, in which the object I have just defined may be best attained.

I must call your attention further to this fact, that all the subjects of our thoughts — all feelings and propositions (leaving aside our sensations as the mere materials and occasions of thinking and feeling), all our mental furniture — may be classified under one of two heads — as either within the province of the intellect, something that can be put into propositions and affirmed or denied; or as within the province of feeling, or that which, before the name was defiled, was called the æsthetic side of our nature, and which can neither be proved nor disproved, but only felt and known.

According to the classification which I have put before you, then, the subjects of all knowledge are divisible into the two groups, matters of science and matters of art; for all things with which the reasoning faculty alone is occupied, come under the province of science; and in the broadest sense, and not in the narrow and technical sense in which we are now accustomed to use the word art, all things feelable, all things which stir our emotions, come under the term of art, in the sense of the subject-matter of the æsthetic faculty. So that we are shut up to this — that the business of education is, in the first place, to provide the young with the

means and the habit of observation; and, secondly, to supply the subject-matter of knowledge either in the shape of science or of art, or of both combined.

Now, it is a very remarkable fact — but it is true of most things in this world — that there is hardly anything one-sided, or of one nature; and it is not immediately obvious what of the things that interest us may be regarded as pure science, and what may be regarded as pure art. It may be that there are some peculiarly constituted persons who, before they have advanced far into the depths of geometry, find artistic beauty about it; but, taking the generality of mankind, I think it may be said that, when they begin to learn mathematics, their whole souls are absorbed in tracing the connection between the premisses and the conclusion, and that to them geometry is pure science. So I think it may be said that mechanics and osteology are pure science. On the other hand, melody in music is pure art. You cannot reason about it; there is no proposition involved in it. So, again, in the pictorial art, an arabesque, or a “harmony in grey,” touches none but the æsthetic faculty. But a great mathematician, and even many persons who are not great mathematicians, will tell you that they derive immense pleasure from geometrical reasonings. Everybody knows mathematicians speak of solutions and problems as “elegant,” and they tell you that a certain mass of mystic symbols is “beautiful, quite lovely.” Well, you do not see it. They do see it, because the intellectual process, the process of comprehending the reasons symbolised by these figures and these signs, confers upon them a sort of pleasure, such as an artist has in visual symmetry. Take a science of which I may speak with more confidence, and which is the most attractive of those I am



concerned with. It is what we call morphology, which consists in tracing out the unity in variety of the infinitely diversified structures of animals and plants. I cannot give you any example of a thorough æsthetic pleasure more intensely real than a pleasure of this kind — the pleasure which arises in one's mind when a whole mass of different structures run into one harmony as the expression of a central law. That is where the province of art overlays and embraces the province of intellect. And, if I may venture to express an opinion on such a subject, the great majority of forms of art are not in the sense what I just now defined them to be — pure art; but they derive much of their quality from simultaneous and even unconscious excitement of the intellect.

When I was a boy, I was very fond of music, and I am so now; and it so happened that I had the opportunity of hearing much good music. Among other things, I had abundant opportunities of hearing that great old master, Sebastian Bach. I remember perfectly well — though I knew nothing about music then, and, I may add, know nothing whatever about it now — the intense satisfaction and delight which I had in listening, by the hour together, to Bach's fugues. It is a pleasure which remains with me, I am glad to think; but, of late years, I have tried to find out the why and wherefore, and it has often occurred to me that the pleasure derived from musical compositions of this kind is essentially of the same nature as that which is derived from pursuits which are commonly regarded as purely intellectual. I mean, that the source of pleasure is exactly the same as in most of my problems in morphology — that you have the theme in one of the old master's works followed out in all its endless variations,

always appearing and always reminding you of unity in variety. So in painting; what is called "truth to nature" is the intellectual element coming in, and truth to nature depends entirely upon the intellectual culture of the person to whom art is addressed. If you are in Australia, you may get credit for being a good artist — I mean among the natives — if you can draw a kangaroo after a fashion. But, among men of higher civilisation, the intellectual knowledge we possess brings its criticism into our appreciation of works of art, and we are obliged to satisfy it, as well as the mere sense of beauty in colour and in outline. And so, the higher the culture and information of those whom art addresses, the more exact and precise must be what we call its "truth to nature."

If we turn to literature, the same thing is true, and you find works of literature which may be said to be pure art. A little song of Shakespeare or of Goethe is pure art; it is exquisitely beautiful, although its intellectual content may be nothing. A series of pictures is made to pass before your mind by the meaning of words, and the effect is a melody of ideas. Nevertheless, the great mass of the literature we esteem is valued, not merely because of having artistic form, but because of its intellectual content; and the value is the higher the more precise, distinct, and true is that intellectual content. And, if you will let me for a moment speak of the very highest forms of literature, do we not regard them as highest simply because the more we know the truer they seem, and the more competent we are to appreciate beauty the more beautiful they are? No man ever understands Shakespeare until he is old, though the youngest may admire him, the reason being that he satisfies the artistic instinct of the youngest and har-



monises with the ripest and richest experience of the oldest.

I have said this much to draw your attention to what, in my mind, lies at the root of all this matter, and at the understanding of one another by the men of science on the one hand, and the men of literature, and history, and art, on the other. It is not a question whether one order of study or another should predominate. It is a question of what topics of education you shall select which will combine all the needful elements in such due proportion as to give the greatest amount of food, support, and encouragement to those faculties which enable us to appreciate truth, and to profit by those sources of innocent happiness which are open to us, and, at the same time, to avoid that which is bad, and coarse, and ugly, and keep clear of the multitude of pitfalls and dangers which beset those who break through the natural or moral laws.

I address myself, in this spirit, to the consideration of the question of the value of purely literary education. Is it good and sufficient, or is it insufficient and bad? Well, here I venture to say that there are literary educations and literary educations. If I am to understand by that term the education that was current in the great majority of middle-class schools, and upper schools too, in this country when I was a boy, and which consisted absolutely and almost entirely in keeping boys for eight or ten years at learning the rules of Latin and Greek grammar, construing certain Latin and Greek authors, and possibly making verses which, had they been English verses, would have been condemned as abominable doggerel, — if that is what you mean by liberal education, then I say it is scandalously insufficient and almost worthless. My reason for saying so

is not from the point of view of science at all, but from the point of view of literature. I say the thing professes to be literary education that is not a literary education at all. It was not literature at all that was taught, but science in a very bad form. It is quite obvious that grammar is science and not literature. The analysis of a text by the help of the rules of grammar is just as much a scientific operation as the analysis of a chemical compound by the help of the rules of chemical analysis. There is nothing that appeals to the æsthetic faculty in that operation; and I ask multitudes of men of my own age, who went through this process, whether they ever had a conception of art or literature until they obtained it for themselves after leaving school? Then you may say, "If that is so, if the education was scientific, why cannot you be satisfied with it?" I say, because although it is a scientific training, it is of the most inadequate and inappropriate kind. If there is any good at all in scientific education it is that men should be trained, as I said before, to know things for themselves at first hand, and that they should understand every step of the reason of that which they do.

I desire to speak with the utmost respect of that science — philology — of which grammar is a part and parcel; yet everybody knows that grammar, as it is usually learned at school, affords no scientific training. It is taught just as you would teach the rules of chess or draughts. On the other hand, if I am to understand by a literary education the study of the literatures of either ancient or modern nations — but especially those of antiquity, and especially that of ancient Greece; if this literature is studied, not merely from the point of view of philological science, and its practical application to the interpretation of texts, but as an exempli-



fication of and commentary upon the principles of art; if you look upon the literature of a people as a chapter in the development of the human mind, if you work out this in a broad spirit, and with such collateral references to morals and politics, and physical geography, and the like as are needful to make you comprehend what the meaning of ancient literature and civilisation is, — then, assuredly, it affords a splendid and noble education. But I still think it is susceptible of improvement, and that no man will ever comprehend the real secret of the difference between the ancient world and our present time, unless he has learned to see the difference which the late development of physical science has made between the thought of this day and the thought of that, and he will never see that difference, unless he has some practical insight into some branches of physical science; and you must remember that a literary education such as that which I have just referred to, is out of the reach of those whose school life is cut short at sixteen or seventeen.

But, you will say, all this is fault-finding; let us hear what you have in the way of positive suggestion. Then I am bound to tell you that, if I could make a clean sweep of everything — I am very glad I cannot because I might, and probably should, make mistakes, — but if I could make a clean sweep of everything and start afresh, I should, in the first place, secure that training of the young in reading and writing, and in the habit of attention and observation, both to that which is told them, and that which they see, which everybody agrees to. But in addition to that, I should make it absolutely necessary for everybody, for a longer or shorter period, to learn to draw. Now, you may say, there are some people who cannot draw, however much they may be

taught. I deny that *in toto*, because I never yet met with anybody who could not learn to write. Writing is a form of drawing; therefore if you give the same attention and trouble to drawing as you do to writing, depend upon it, there is nobody who cannot be made to draw, more or less well. Do not misapprehend me. I do not say for one moment you would make an artistic draughtsman. Artists are not made; they grow. You may improve the natural faculty in that direction, but you cannot make it; but you can teach simple drawing, and you will find it an implement of learning of extreme value. I do not think its value can be exaggerated, because it gives you the means of training the young in attention and accuracy, which are the two things in which all mankind are more deficient than in any other mental quality whatever. The whole of my life has been spent in trying to give my proper attention to things and to be accurate, and I have not succeeded as well as I could wish; and other people, I am afraid, are not much more fortunate. You cannot begin this habit too early, and I consider there is nothing of so great a value as the habit of drawing, to secure those two desirable ends.

Then we come to the subject-matter, whether scientific or æsthetic, of education, and I should naturally have no question at all about teaching the elements of physical science of the kind I have sketched, in a practical manner; but among scientific topics, using the word scientific in the broadest sense, I would also include the elements of the theory of morals and of that of political and social life, which, strangely enough, it never seems to occur to anybody to teach a child. I would have the history of our own country, and of all the influences which have been brought to bear upon it,



with incidental geography, not as a mere chronicle of reigns and battles, but as a chapter in the development of the race, and the history of civilisation.

Then with respect to æsthetic knowledge and discipline, we have happily in the English language one of the most magnificent storehouses of artistic beauty and of models of literary excellence which exists in the world at the present time. I have said before, and I repeat it here, that if a man cannot get literary culture of the highest kind out of his Bible, and Chaucer, and Shakespeare, and Milton, and Hobbes, and Bishop Berkeley, to mention only a few of our illustrious writers — I say, if he cannot get it out of those writers he cannot get it out of anything; and I would assuredly devote a very large portion of the time of every English child to the careful study of the models of English writing of such varied and wonderful kind as we possess, and, what is still more important and still more neglected, the habit of using that language with precision, with force, and with art. I fancy we are almost the only nation in the world who seem to think that composition comes by nature. The French attend to their own language, the Germans study theirs; but Englishmen do not seem to think it is worth their while. Nor would I fail to include, in the course of study I am sketching, translations of all the best works of antiquity, or of the modern world. It is a very desirable thing to read Homer in Greek; but if you don't happen to know Greek, the next best thing we can do is to read as good a translation of it as we have recently been furnished with in prose. You won't get all you would get from the original, but you may get a great deal; and to refuse to know this great deal because you cannot get all, seems to be as sensible as for a hungry man to refuse bread

because he cannot get partridge. Finally, I would add instruction in either music or painting, or, if the child should be so unhappy, as sometimes happens, as to have no faculty for either of those, and no possibility of doing anything in any artistic sense with them, then I would see what could be done with literature alone; but I would provide, in the fullest sense, for the development of the æsthetic side of the mind. In my judgment, those are all the essentials of education for an English child. With that outfit, such as it might be made in the time given to education which is within the reach of nine-tenths of the population — with that outfit, an Englishman, within the limits of English life, is fitted to go anywhere, to occupy the highest positions, to fill the highest offices of the State, and to become distinguished in practical pursuits, in science, or in art. For, if he have the opportunity to learn all those things, and have his mind disciplined in the various directions the teaching of those topics would have necessitated, then, assuredly, he will be able to pick up, on his road through life, all the rest of the intellectual baggage he wants.

If the educational time at our disposition were sufficient, there are one or two things I would add to those I have just now called the essentials; and perhaps you will be surprised to hear, though I hope you will not, that I should add, not more science, but one, or, if possible, two languages. The knowledge of some other language than one's own is, in fact, of singular intellectual value. Many of the faults and mistakes of the ancient philosophers are traceable to the fact that they knew no language but their own, and were often led into confusing the symbol with the thought which it embodied. I think it is Locke who says that one-half



of the mistakes of philosophers have arisen from questions about words; and one of the safest ways of delivering yourself from the bondage of words is, to know how ideas look in words to which you are not accustomed. That is one reason for the study of language; another reason is, that it opens new fields in art and in science. Another is the practical value of such knowledge; and yet another is this, that if your languages are properly chosen, from the time of learning the additional languages you will know your own language better than ever you did. So, I say, if the time given to education permits, add Latin and German. Latin, because it is the key to nearly one-half of English and to all the Romance languages; and German, because it is the key to almost all the remainder of English, and helps you to understand a race from whom most of us have sprung, and who have a character and a literature of a fateful force in the history of the world, such as probably has been allotted to those of no other people, except the Jews, the Greeks, and ourselves. Beyond these, the essential and the eminently desirable elements of all education, let each man take up his special line — the historian devote himself to his history, the man of science to his science, the man of letters to his culture of that kind, and the artist to his special pursuit.

Bacon has prefaced some of his works with no more than this: *Franciscus Bacon sic cogitavit*; let "sic cogitavi" be the epilogue to what I have ventured to address to you to-night.

## THE METHOD OF SCIENTIFIC INVESTIGATION

THE method of scientific investigation is nothing but the expression of the necessary mode of working of the human mind. It is simply the mode at which all phenomena are reasoned about, rendered precise and exact. There is no more difference, but there is just the same kind of difference, between the mental operations of a man of science and those of an ordinary person, as there is between the operations and methods of a baker or of a butcher weighing out his goods in common scales, and the operations of a chemist in performing a difficult and complex analysis by means of his balance and finely graduated weights. It is not that the action of the scales in the one case, and the balance in the other, differ in the principles of their construction or manner of working; but the beam of one is set on an infinitely finer axis than the other, and of course turns by the addition of a much smaller weight.

You will understand this better, perhaps, if I give you some familiar example. You have all heard it repeated, I dare say, that men of science work by means of induction and deduction, and that by the help of these operations, they, in a sort of sense, wring from Nature certain other things, which are called natural laws, and causes, and that out of these, by some cunning skill of their own, they build up hypotheses and theories. And it is imagined by many, that the operations of the common mind can be by no means compared with these processes, and that they have to be acquired by a



sort of special apprenticeship to the craft. To hear all these large words, you would think that the mind of a man of science must be constituted differently from that of his fellow men; but if you will not be frightened by terms, you will discover that you are quite wrong, and that all these terrible apparatus are being used by yourselves every day and every hour of your lives.

There is a well-known incident in one of Molière's plays, where the author makes the hero express unbounded delight on being told that he had been talking prose during the whole of his life. In the same way, I trust, that you will take comfort, and be delighted with yourselves, on the discovery that you have been acting on the principles of inductive and deductive philosophy during the same period. Probably there is not one here who has not in the course of the day had occasion to set in motion a complex train of reasoning, of the very same kind, though differing of course in degree, as that which a scientific man goes through in tracing the causes of natural phenomena.

A very trivial circumstance will serve to exemplify this. Suppose you go into a fruiterer's shop, wanting an apple, — you take up one, and, on biting it, you find it is sour; you look at it, and see that it is hard and green. You take up another one, and that too is hard, green, and sour. The shopman offers you a third; but, before biting it, you examine it, and find that it is hard and green, and you immediately say that you will not have it, as it must be sour, like those that you have already tried.

Nothing can be more simple than that, you think; but if you will take the trouble to analyse and trace out into its logical elements what has been done by the mind, you will be greatly surprised. In the first place

you have performed the operation of induction. You found that, in two experiences, hardness and greenness in apples went together with sourness. It was so in the first case, and it was confirmed by the second. True, it is a very small basis, but still it is enough to make an induction from; you generalise the facts, and you expect to find sourness in apples where you get hardness and greenness. You found upon that a general law that all hard and green apples are sour; and that, so far as it goes, is a perfect induction. Well, having got your natural law in this way, when you are offered another apple which you find is hard and green, you say, "All hard and green apples are sour; this apple is hard and green, therefore this apple is sour." That train of reasoning is what logicians call a syllogism, and has all its various parts and terms, — its major premiss, its minor premiss and its conclusion. And, by the help of further reasoning, which, if drawn out, would have to be exhibited in two or three other syllogisms, you arrive at your final determination, "I will not have that apple." So that, you see, you have, in the first place, established a law by induction, and upon that you have founded a deduction, and reasoned out the special particular case. Well now, suppose, having got your conclusion of the law, that at some time afterwards, you are discussing the qualities of apples with a friend: you will say to him, "It is a very curious thing, — but I find that all hard and green apples are sour!" Your friend says to you, "But how do you know that?" You at once reply, "Oh, because I have tried them over and over again, and have always found them to be so." Well, if we were talking science instead of common sense, we should call that an experimental verification. And, if still opposed, you go further, and say,



"I have heard from the people in Somersetshire and Devonshire, where a large number of apples are grown, that they have observed the same thing. It is also found to be the case in Normandy, and in North America. In short, I find it to be the universal experience of mankind wherever attention has been directed to the subject." Whereupon, your friend, unless he is a very unreasonable man, agrees with you, and is convinced that you are quite right in the conclusion you have drawn. He believes, although perhaps he does not know he believes it, that the more extensive verifications are, — that the more frequently experiments have been made, and results of the same kind arrived at, — that the more varied the conditions under which the same results are attained, the more certain is the ultimate conclusion, and he disputes the question no further. He sees that the experiment has been tried under all sorts of conditions, as to time, place, and people, with the same result; and he says with you, therefore, that the law you have laid down must be a good one, and he must believe it.

In science we do the same thing; — the philosopher exercises precisely the same faculties, though in a much more delicate manner. In scientific inquiry it becomes a matter of duty to expose a supposed law to every possible kind of verification, and to take care, moreover, that this is done intentionally, and not left to a mere accident, as in the case of the apples. And in science, as in common life, our confidence in a law is in exact proportion to the absence of variation in the result of our experimental verifications. For instance, if you let go your grasp of an article you may have in your hand, it will immediately fall to the ground. That is a very common verification of one of the best established laws

of nature — that of gravitation. The method by which men of science establish the existence of that law is exactly the same as that by which we have established the trivial proposition about the sourness of hard and green apples. But we believe it in such an extensive, thorough, and unhesitating manner because the universal experience of mankind verifies it, and we can verify it ourselves at any time; and that is the strongest possible foundation on which any natural law can rest.

So much, then, by way of proof that the method of establishing laws in science is exactly the same as that pursued in common life. Let us now turn to another matter (though really it is but another phase of the same question), and that is, the method by which, from the relations of certain phenomena, we prove that some stand in the position of causes towards the others.

I want to put the case clearly before you, and I will therefore show you what I mean by another familiar example. I will suppose that one of you, on coming down in the morning to the parlor of your house, finds that a tea-pot and some spoons which had been left in the room on the previous evening are gone, — the window is open, and you observe the mark of a dirty hand on the window-frame, and perhaps, in addition to that, you notice the impress of a hob-nailed shoe on the gravel outside. All these phenomena have struck your attention instantly, and before two seconds have passed you say, "Oh, somebody has broken open the window, entered the room, and run off with the spoons and the tea-pot!" That speech is out of your mouth in a moment. And you will probably add, "I know there has; I am quite sure of it!" You mean to say exactly what you know; but in reality you are giving expression to what is, in all essential particulars, an hypothesis. You



do not *know* it at all; it is nothing but an hypothesis rapidly framed in your own mind. And it is an hypothesis founded on a long train of inductions and deductions.

What are those inductions and deductions, and how have you got at this hypothesis? You have observed in the first place, that the window is open; but by a train of reasoning involving many inductions and deductions, you have probably arrived long before at the general law — and a very good one it is — that windows do not open of themselves; and you therefore conclude that something has opened the window. A second general law that you have arrived at in the same way is, that tea-pots and spoons do not go out of a window spontaneously, and you are satisfied that, as they are not now where you left them, they have been removed. In the third place, you look at the marks on the window-sill, and the shoe-marks outside, and you say that in all previous experience the former kind of mark has never been produced by anything else but the hand of a human being; and the same experience shows that no other animal but man at present wears shoes with hob-nails in them such as would produce the marks in the gravel. I do not know, even if we could discover any of those “missing links” that are talked about, that they would help us to any other conclusion! At any rate the law which states our present experience is strong enough for my present purpose. You next reach the conclusion that, as these kind of marks have not been left by any other animal than man, or are liable to be formed in any other way than a man’s hand and shoe, the marks in question have been formed by a man in that way. You have, further, a general law, founded on observation and experience, and that, too,

is, I am sorry to say, a very universal and unimpeachable one, — that some men are thieves; and you assume at once from all these premisses — and that is what constitutes your hypothesis — that the man who made the marks outside and on the window-sill, opened the window, got into the room, and stole your tea-pot and spoons. You have now arrived at a *vera causa*; — you have assumed a cause which, it is plain, is competent to produce all the phenomena you have observed. You can explain all these phenomena only by the hypothesis of a thief. But that is a hypothetical conclusion, of the justice of which you have no absolute proof at all; it is only rendered highly probable by a series of inductive and deductive reasonings.

I suppose your first action, assuming that you are a man of ordinary common sense, and that you have established this hypothesis to your own satisfaction, will very likely be to go off for the police, and set them on the track of the burglar, with the view to the recovery of your property. But just as you are starting with this object, some person comes in, and on learning what you are about, says, “My good friend, you are going on a great deal too fast. How do you know that the man who really made the marks took the spoons? It might have been a monkey that took them, and the man may have merely looked in afterwards.” You would probably reply, “Well, that is all very well, but you see it is contrary to all experience of the way tea-pots and spoons are abstracted; so that, at any rate, your hypothesis is less probable than mine.” While you are talking the thing over in this way, another friend arrives, one of the good kind of people that I was talking of a little while ago. And he might say, “Oh, my dear sir, you are certainly going on a great deal too fast. You



are most presumptuous. You admit that all these occurrences took place when you were fast asleep, at a time when you could not possibly have known anything about what was taking place. How do you know that the laws of Nature are not suspended during the night? It may be that there has been some kind of supernatural interference in this case." In point of fact, he declares that your hypothesis is one of which you cannot at all demonstrate the truth, and that you are by no means sure that the laws of Nature are the same when you are asleep as when you are awake.

Well, now, you cannot at the moment answer that kind of reasoning. You feel that your worthy friend has you somewhat at a disadvantage. You will feel perfectly convinced in your own mind, however, that you are quite right, and you say to him, "My good friend, I can only be guided by the natural probabilities of the case, and if you will be kind enough to stand aside and permit me to pass, I will go and fetch the police." Well, we will suppose that your journey is successful, and that by good luck you meet with a policeman; that eventually the burglar is found with your property on his person, and the marks correspond to his hand and to his boots. Probably any jury would consider those facts a very good experimental verification of your hypothesis, touching the cause of the abnormal phenomena observed in your parlor, and would act accordingly.

Now, in this supposititious case, I have taken phenomena of a very common kind, in order that you might see what are the different steps in an ordinary process of reasoning, if you will only take the trouble to analyse it carefully. All the operations I have described, you will see, are involved in the mind of any man of

sense in leading him to a conclusion as to the course he should take in order to make good a robbery and punish the offender. I say that you are led, in that case, to your conclusion by exactly the same train of reasoning as that which a man of science pursues when he is endeavouring to discover the origin and laws of the most occult phenomena. The process is, and always must be, the same; and precisely the same mode of reasoning was employed by Newton and Laplace in their endeavours to discover and define the causes of the movements of the heavenly bodies, as you, with your own common sense, would employ to detect a burglar. The only difference is, that the nature of the inquiry being more abstruse, every step has to be most carefully watched, so that there may not be a single crack or flaw in your hypothesis. A flaw or crack in many of the hypotheses of daily life may be of little or no moment as affecting the general correctness of the conclusions at which we may arrive; but, in a scientific inquiry, a fallacy, great or small, is always of importance, and is sure to be in the long run constantly productive of mischievous if not fatal results.

Do not allow yourselves to be misled by the common notion that an hypothesis is untrustworthy simply because it is an hypothesis. It is often urged, in respect to some scientific conclusion, that, after all, it is only an hypothesis. But what more have we to guide us in nine-tenths of the most important affairs of daily life than hypotheses, and often very ill-based ones? So that in science, where the evidence of an hypothesis is subjected to the most rigid examination, we may rightly pursue the same course. You may have hypotheses, and hypotheses. A man may say, if he likes, that the moon is made of green cheese: that is an hypothesis.



But another man, who has devoted a great deal of time and attention to the subject, and availed himself of the most powerful telescopes and the results of the observations of others, declares that in his opinion it is probably composed of materials very similar to those of which our own earth is made up: and that is also only an hypothesis. But I need not tell you that there is an enormous difference in the value of the two hypotheses. That one which is based on sound scientific knowledge is sure to have a corresponding value; and that which is a mere hasty random guess is likely to have but little value. Every great step in our progress in discovering causes has been made in exactly the same way as that which I have detailed to you. A person observing the occurrence of certain facts and phenomena asks, naturally enough, what process, what kind of operation known to occur in Nature applied to the particular case, will unravel and explain the mystery? Hence you have the scientific hypothesis; and its value will be proportionate to the care and completeness with which its basis had been tested and verified. It is in these matters as in the commonest affairs of practical life: the guess of the fool will be folly, while the guess of the wise man will contain wisdom. In all cases, you see that the value of the result depends on the patience and faithfulness with which the investigator applies to his hypothesis every possible kind of verification.

## ON THE PHYSICAL BASIS OF LIFE

IN order to make the title of this discourse generally intelligible, I have translated the term "Protoplasm," which is the scientific name of the substance of which I am about to speak, by the words "the physical basis of life." I suppose that, to many, the idea that there is such a thing as a physical basis, or matter, of life may be novel — so widely spread is the conception of life as a something which works through matter, but is independent of it; and even those who are aware that matter and life are inseparably connected, may not be prepared for the conclusion plainly suggested by the phrase, "*the* physical basis or matter of life," that there is some one kind of matter which is common to all living beings, and that their endless diversities are bound together by a physical, as well as an ideal, unity. In fact, when first apprehended, such a doctrine as this appears almost shocking to common sense.

What, truly, can seem to be more obviously different from one another, in faculty, in form, and in substance, than the various kinds of living beings? What community of faculty can there be between the bright-coloured lichen, which so nearly resembles a mere mineral incrustation of the bare rock on which it grows, and the painter, to whom it is instinct with beauty, or the botanist, whom it feeds with knowledge?

Again, think of the microscopic fungus — a mere infinitesimal ovoid particle, which finds space and duration enough to multiply into countless millions in the