

be only  $\frac{1}{\sqrt{3}}$ , or 0.5774 times the maximum value of the currents in I, I<sub>2</sub>, III, III<sub>2</sub>, V, V<sub>2</sub>. Hence the number of convolutions in each of the coils II, II<sub>2</sub>, IV, IV<sub>2</sub>, VI, VI<sub>2</sub> should be  $\frac{2}{3}$  of the number in each of the coils I, I<sub>2</sub>, III, III<sub>2</sub>, V, V<sub>2</sub>, and the cross-section of the wire in each of the first six coils only  $\frac{2}{3}$  of that in the last six, both of which ratios are symbolically indicated in Fig. 31.

By still further following out the same general idea, an alternate current motor with twenty-four, or more, coils on it can be developed, requiring only three main wires to supply the current. And thus, thanks to the labours of Tesla, Bradley, Haselwander, Wenström, and last, but by no means least, to the striking ingenuity of Dolivo Doblowsky, a practical alternate current motor can now be constructed, which will produce as steady a driving force as the best modern direct current motor.

W. E. A.

(To be continued.)

### THE IMPLICATIONS OF SCIENCE.<sup>1</sup>

#### I.

WHEN I was honoured by an invitation to lecture here this evening, I felt much troubled as to the subject which I might most fitly select as my theme. During the forty years I have been a member of the Royal Institution, I have had the privilege of listening to lectures on many very different branches of science, and I know that all branches of science have few or many followers amongst the audience I am now addressing.

It has struck me, however, that for this single lecture it might be well not to confine myself to any subordinate department of scientific inquiry, but rather to invite your attention to certain questions which deeply concern them all. Thus, it has seemed to me, I might hope to interest a greater number of hearers than it would be possible for me otherwise to do.

I felt the more encouraged to take this course when I recalled to mind on how many previous occasions I had myself listened to discourses of a similar breadth of scope, given in this theatre by very distinguished men of science.

Foremost among them I may mention Prof. Huxley, who has here, as elsewhere, called attention to questions which underlie all physical science. I may also refer to that brilliant mathematician, Prof. Clifford, the sad and sudden ending of whose brief career we have good reason to deplore.

It would be easy to mention the names of other scientific celebrities who have here discoursed on matters beyond the scope of any one branch of science. These two, however, will, I think, suffice.

But before proceeding further I would feign say a few words as to the title of my lecture, so as at once to prevent any misunderstanding as to the object I have in view.

By "*the implications of science*," I mean nothing to which any section of my hearers can object, whatever their notions about "creed" or "conduct" may be. I desire carefully to eliminate all questions of either religion or morals, and I shall confine myself purely and simply to the consideration of certain propositions which appear to me to be latent within, and give force to, what we regard as well-ascertained scientific truths. They are propositions which must, I believe, be assented to by every consistent follower of science, who is convinced that science has brought to our knowledge *some* truths on which we can, with entire confidence, rely.

My appeal, then, is to the pure intellect of my hearers,

<sup>1</sup> Friday Evening Discourse delivered at the Royal Institution by Dr. St. George Mivart, on June 5, 1891.

and to nothing else. And indeed I desire to take this opportunity plainly to declare, before this distinguished audience, that not only here and now, but everywhere and always, I unhesitatingly affirm that no system can, or should, stand, which is unable to justify itself to reason. I possess no faculty myself, nor do I believe that any human faculty exists, superior to the intellect, or which has any claim to limit or dominate the intellect's activity. Feelings and sentiments have their undoubted charm and due place in human life, but that place is a subordinate one, and should be under the control of right reason.

But it is by no means only or mainly against those who would undervalue *reason* in the interest of *sentiment*, that I have this evening to protest. My object is to uphold what I believe to be the just claims of our rational nature against all who, from whatever side, or in the name of whatsoever authority, would impugn its sovereign claims upon our reverence, or unduly restrict the area of its sway.

As I have already intimated, I propose to fulfil this task by calling attention to some half-dozen far-reaching truths implicitly contained in scientific doctrines universally admitted, so that those doctrines cannot logically be maintained, if such implied truths are *really* and *seriously* doubted, and still less if they are *really* disbelieved and denied. These truths, then, are what I mean by "*the implications of science*." But what *is* science?

The word "science" is now very commonly taken as being synonymous with "*physical science*." There is much to be said against giving the word so narrow a meaning; nevertheless that meaning will sufficiently serve my purpose this evening. "Science," then, thus understood, is merely ordinary knowledge pursued with extreme care—most careful observation, measuring, weighing, &c.—together with most careful reasoning as to the results of observations and experiments, and also painstaking verification of any anticipations which may have been hazarded. In this way our thoughts are made to conform as accurately as may be with what we regard as the realities they represent.

The value and the progress of science are unquestioned. Many foolish discussions are carried on in the world about us; but certainly no one disputes or doubts the value of science or the fact of its progress. The value of carefully ascertained scientific truths will not at any rate be disputed in *this* theatre, which has witnessed the triumphs of the immortal Faraday, and which may justly claim to be a very temple of science. And certainly I have no disposition to undervalue it, who have loved it from my earliest years, and devoted such small powers as I possess to its service. I am profoundly convinced that, since I can recollect, biological science has made great progress, and I see grounds for absolute certainty now about many propositions in zoology which were doubtful or undreamed of when I was a lad.

We all, then, agree that science does advance. Nevertheless, it is obvious that such advance would be impossible if we could not, by observations, experiments, and inferences, become so certain with respect to *some* facts as to be able to make them the starting-points for fresh observations and inferences as to other facts. Thus, with respect to the world we live in, most educated men are now certain as to its daily and annual revolutions, as also that its crust is largely composed of sedimentary rocks, containing remains or indications of animals and plants more or less different from those which now live. No one can reasonably deny that we may rely with absolute confidence and entire certainty upon a variety of such assertions.

But our scientific certainties have been acquired more or less laboriously, and a questioning attitude of mind is emphatically the scientific attitude. We ought never to

rest satisfied about any scientific inquiry the truth of which has not been demonstrated, unless we find that it is one which we have no possible power to answer. It would obviously be idle to occupy ourselves about the shape or number of the mountains on that side of the moon which is constantly turned away from us.

Yet, although doubt and inquiry are necessary in science, nevertheless doubt has its legitimate limits. Blind disbelief is scientifically fatal, as well as blind belief. We all know how apt men are, when seeking to avoid one extreme, to fall into the opposite one, and it is possible to get into an unhealthy condition of mind so as to be unable to give a vigorous assent to anything. It is necessary distinctly to recognize there is such a thing as *legitimate* certainty, not to perceive the force of which is *illegitimate* doubt. Such doubt would necessarily discredit all physical science.

*Universal* doubt, for example, is an absurdity. It is scepticism run mad.

If anyone affirms that "*nothing is certain*," he obviously contradicts himself, since he thereby affirms the certainty of uncertainty. He says *that*, which, if true, absolutely contradicts what he has declared to be true.

But a man who affirms what the system he professes to adopt forbids him to affirm, and who declares that he believes what he also declares to be unbelievable, should hardly complain if he is called "foolish." No system can be true, and no reasoning can be valid, which inevitably ends in absurdity. *Such* scepticism, then, cannot be the mark of an exceptionally intellectual mind, but of an exceptionally foolish one, and every position which *necessarily* leads to scepticism of this sort must be an untenable position.

A very little reflection suffices to show how self-refuting such modes of thought are.

Thus, if a man were to say, "*I cannot know anything because I cannot be sure that my faculties are not always fallacious*," or "*I cannot be sure of anything because, for all I know, I may be the plaything of a demon who amuses himself by constantly deceiving me*"—in both these cases he contradicts himself, because he obviously grounds his assertion upon his perception of the truth that "*we cannot arrive at conclusions which are certain by means of premisses which are uncertain or false*."

But if he knows *that* truth, he must know that his faculties are not always fallacious, and that his demon cannot deceive him in everything.

My object in making these remarks is to enable us to get clear of mere idle, irrational doubts which have no place in science and can have none, so that we may recognize the fact that we all of us have certainty as to *some* facts according to our degrees of knowledge. Obviously we can only judge of truth by our mental faculties, and if a man denies their validity we must pass him by, contenting ourselves with calling his attention to the fact that he refutes himself. If a man professes to doubt his faculties, or to doubt whether language can be trusted to convey thought, then plainly we cannot profitably argue with him. But if, on account of his absurdity, we cannot refute him, it is no less plain that he cannot defend his scepticism. Were he to attempt to do so, then he would show, by that very attempt, that he really had confidence in reason and in language, however he might verbally deny it.

Confident, then, that there are some scientific statements on which we may rely with *certainty*, let us consider a few truths implicitly contained in them.

In the first place, science makes use not only of observations and experiments, but also of reasoning as to the results of such experiments. It needs that we should draw valid inferences; but this implies that we may, and *must*, place confidence in the principle of deduction—in that perception of the mind which we express by the word "*therefore*." When we use that word, we mean to

express by it that there is a truth, the certainty of which is shown through the help of different facts or principles which themselves are known to be true.

It is sometimes objected to deductive reasoning—to the syllogism—that it really teaches us nothing new, all that is contained in the conclusion being contained already in the premisses. But this objection is due to a want of perception of the great difference which exists between *implicit* and *explicit* knowledge. Let us suppose a person to be looking at some very flexible and soft kind of fish. He may, perhaps, say to himself, "This creature can have no spinal column!" Then it may strike him that naturalists have classed fishes, together with other animals, in a great group, one character of which is the possession of a spinal column, and so he may *explicitly* recognize a truth implied in what he knew before. So great, indeed, is the difference between explicit and implicit knowledge, that the latter may not really deserve to be called "*real knowledge*" at all. No one will affirm that a student who has merely learned the axioms and definitions of Euclid has attained such a *real knowledge* of all the geometrical truths the work contains that he will fully understand all its propositions and theorems without having to study them. Yet all the propositions, &c., of Euclid are *implicitly* contained in the definitions and axioms. Nevertheless, the student will have to go through many processes of inference by which these implicit truths may be explicitly recognized by him, before he can be said to have any *real knowledge* of them.

The VALIDITY OF INFERENCE is, then, one of the truths implied by physical science, and we shall presently see the intellectual penalty which must be paid for any *real* doubt about it.

In the second place, physical science is emphatically experimental science. But every experiment, carefully performed, implies a most important latent truth. For when an experiment has shown us that anything is certain—as, for example, that a newt's leg may grow again, after amputation, because one actually *has* grown again; we shall find that such certainty implies a prior truth. It implies the truth that if the newt has come to have four legs once more, it cannot at the very same time have only three legs. This may seem too trivial a remark to some of my hearers, but there is nothing like a *concrete* example for making an *abstract* truth plain. Anything we are certain about, because it has been proved to us by experiment, is certain only if we know, and because we know, that a thing which has been actually proved cannot at the same time remain unproven. If we reflect again on this proposition, we shall see that it depends on a still more fundamental truth which our reason recognizes—the truth, namely, that "nothing can at the same time both be and not be"—the truth known as "THE LAW OF CONTRADICTION"; and this I bring forward as a second truth implied by physical science.

If we reflect upon this law, we shall see that our intellect recognizes it as an absolute and necessary truth which carries with it its own evidence. It is but the summing up in one general expression, of all the concrete separate cases—such as that of the newt's legs, of the fact that if a man possesses two eyes he cannot at the same time have only one, and so on.

But an objection has been made as follows: "It is very true that I cannot imagine having 'two eyes' and only 'one eye' at the same time, and so I must practically acquiesce in the statement, but I am only compelled to do so by the impotence of my imagination." Thus, instead of the "law of contradiction," Mr. Herbert Spencer has put forward as an ultimate truth—"his universal postulate"—the assertion that "*we must accept as true propositions we cannot help thinking, because we cannot imagine the contrary*." But if any of my hearers will reflect over what his mind tells him when it pronounces

that he cannot at the same time have both two eyes and only one eye, he will, I think, see that his perception is (as *mine* is) a perception of real incompatibility, and consequent positive impossibility. He will not find his mind a mere blank, passively unable to imagine something. He will find that his mind actively asserts its power to judge of the matter as well as what its judgment is, and that the truth is one which positively applies to *things*, and not merely to his own imaginings.

Moreover, this objection ignores the difference between intellect and imagination. Yet there are very many things we can conceive of but cannot imagine, as, for example, our "act of sight" or "our own annihilation."

But it appears to me evident that Mr. Herbert Spencer's "universal postulate" can never be itself an ultimate truth, but must depend upon the law of contradiction. For, supposing we had tried to imagine a thing and *failed*, how could we from that ever be sure we might not at the same time have actually tried and *succeeded*, if we could not rely upon the law of contradiction?

The consequences resulting from any real doubt as to this law we will see later on.

In the pursuit of science, observation is anterior to experiment; but in every observation in which we place confidence, and still more in every experiment, a third fundamental truth is necessarily implied: this implied truth is THE VALIDITY OF OUR FACULTY OF MEMORY.

It is plain that it would be impossible for us to be certain about any careful observation or any experiment, if we could not feel confidence in our memory being able to vouch for the fact that we had observed certain phenomena and what they were. But what is memory?

Evidently we cannot be said to remember anything unless we are conscious that the thing we so remember has been present to our mind on some previous occasion. A mental image might present itself to our imagination a hundred times; but if at each recurrence it seemed to us something altogether new, and unconnected with the past, we could not be said to *remember* it. It would rather be an example of extreme forgetfulness than of memory.

By asserting the trustworthiness of our faculty of memory, I do not, of course, mean that we may not occasionally make mistakes about the past. It is quite certain we may, and do, make such mistakes. But, nevertheless, we are all of us certain as to *some* past events. Probably there is no single person now in this room who is not certain that he was somewhere else before he entered it. Memory informs us—certainly it informs *me*—as surely concerning *some* portions of the past, as consciousness does concerning some portions of the present.

If we could not trust our faculty of memory, the whole of physical science would be, for us, a mere present dream. But there can be no such thing as *proof* of the trustworthiness of memory, since no argument is possible without trusting to the veracity of memory. It is therefore a fundamental fact which must be taken on its own evidence, and from a consideration of the results of any real doubt about it—results I will refer to presently.

Yet it has been strangely declared, by a leading agnostic, that we may trust our memory because we learn its trustworthiness by experience. Surely never was fallacy more obvious! How could we ever gain experience if we did not trust memory in gaining it? Particular acts of memory may, of course, be confirmed by experience if the *faculty* of memory be already trusted, but in every such instance it must be confided in. The agnostic referred to has told us in effect that we may place confidence in our present memory because in past instances its truth has been experimentally confirmed, while we can only know it *has* been so confirmed by trusting our present memory!

But if we admit the trustworthiness of memory at all, a most important consequence follows—one relating to the

distinction between what is *subjective* and what is *objective*.

Every feeling or state of consciousness present to the mind of the subject who possesses it is "subjective," and the whole of such experiences taken together constitute the sphere of *subjectivity*. Whatever is external to our present consciousness or feelings is for us "objective," and all that is thus external is the region of OBJECTIVITY. Now memory, inasmuch as it reveals to us part of our own past, reveals to us what is "objective," and so introduces us into the realm of objectivity, shows us more or less of objective truth, and carries us into a real world which is beyond the range of our own present feelings. This progress, then, this knowledge of *objectivity*, is, through memory, IMPLIED in every scientific experiment the facts of which we regard as certain.

But our scientific observations and experiments carry with them yet another implication more important still: this is the certainty of our KNOWLEDGE OF OUR OWN CONTINUOUS EXISTENCE. Unless we can be sure that we actually made the observations and experiments, on our having made which we rely for our conclusions, how can those conclusions be confidently relied on by us?

This implication is so important—in my opinion so *fundamentally* important—that I must crave your permission to notice it, later on, at some length. But before considering it, I desire to call your attention to the fact that the propositions thus implied by physical science, run directly counter to a system of thought which is widely current to-day, and which has now and again found expression in this theatre. The popular views I refer to may be conveniently summed up as follows:—

- (1) All our knowledge is merely relative.
- (2) We can know nothing but phenomena.
- (3) We have no supremely certain knowledge but that of our own feelings, and therefore we have none such of our continuous existence.
- (4) We cannot emerge from subjectivity, or attain to real knowledge of anything objective.

Therefore, either I am very much mistaken, or those who uphold the views I have just summed up are much mistaken.

It may seem presumptuous on my part to come forward here to night to controvert a system upheld by men of such undoubted ability and so unquestionably competent in science, as are men who uphold the system I oppose. I feel therefore that a few words of personal apology and explanation are due from me.

For full five-and-thirty years I have been greatly interested in such questions. But when my intellectual life began, it was as a student and disciple of that school with which the names of John Stuart Mill, Alexander Bain, G. H. Lewes, Herbert Spencer, and Prof. Huxley have been successively associated—more or less closely. The works of writers of that school I studied to the best of my ability, and I had the advantage of personal acquaintance with some of the more distinguished of them. Thus, by conversation, I was much better enabled to learn what their system was than I could have learned it by reading only.

However, by degrees, I became sceptical about the validity of the system I had at first ingenuously adopted, but it took me not a few years to clearly see my way through all the philosophical fallacies—as I now regard them—in which I found myself entangled. I say "see my way through," for I did not free myself from them by *drawing back* but by *pushing forwards*—slowly working my way through them and out on the other side. These circumstances constitute my apology for appearing before you as I do. I have been a dweller in the country which I am willing to aid anyone to explore who may wish to explore it.

(To be continued.)