

Returning to the suppositions upon which (7) was founded, we see that, if the bodies be all of one *shape*, e.g. spherical, the formula contains only two constants—one determining the size of the bodies, and the second the intensity of the cohesive force; for the mean kinetic energy is supposed to represent the temperature in all cases. From this follows the theorem of Van der Waals respecting the identity of the equation for various substances, provided pressure, temperature, and volume be expressed as fractions of the critical pressure, temperature, and volume respectively. If, however, the *shape* of the bodies vary in different cases, no such conclusion can be drawn, except as a rough approximation applicable to large volumes.

RAYLEIGH.

Terling Place, Witham, November 18.

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

#### II.

I MIGHT now at once return to further consider those implications of science to which I have called your attention, but I think it will be better to first briefly pass two important matters in review.

The first concerns our means of investigation as to such fundamental questions.

The second relates to our ultimate grounds for forming judgments about them. We have to consider how fundamental truth can be acquired and tested.

Evidently the only means of which we can make use are our *thoughts*, our reason, our intellectual activity. "Thoughts" may be, and should be, carefully examined and criticized; but however much we may do so, and whatever the results we arrive at, such results can only be reached by thoughts, and must be expressed by the aid of our thoughts. This will probably seem such a *manifest* truism that I shall be thought to have committed an absurdity in enunciating it. To suppose that by any reasoning we can come to understand what we can never think, may seem an utterly incredible folly; yet at a meeting of a Metaphysical Society, in London, a speaker, not long ago, expressly declared "thought" to be a misleading term, the use of which should be avoided.

Now I am far from denying that unconscious activities of various different orders take place in our being, yet whatever influence such activities may have they cannot affect our judgments save by and in thoughts.

If a man is convinced that thoughts are worthless tools, he can only have arrived at that conclusion by using the very tools he declares to be worthless. What, then, ought his conclusion to be worth even in his own eyes?

It is simply impossible by reason to get behind or beyond conscious thought, and our thoughts are and must be our only means of investigating problems however fundamental.

Even in investigating the properties of material bodies, it is to self-conscious reflective thought that our final appeal must be made.

For it is to our thoughts, and not to our senses only, that our ultimate appeal must be made, even with respect to the most material physical science matters.

Some persons may imagine that with respect to investigations about the properties of material bodies, it is to our sensations alone that we must ultimately appeal. But it is not so; anyone would be mad to question the extreme importance, the absolute necessity, of our sensations in such a case. Nevertheless, after we have made all the observations and experiments we can, how can we know we have obtained such results as we may have obtained, save by our self-conscious thought? By what

other means are we to judge between what may seem to be the conflicting indications of different sense impressions?

Our senses are truly tests and causes of certainty, but not *the* test. Certainty belongs to thought, and self-conscious reflective thought is our ultimate, absolute criterion.

As to the ultimate grounds on which our judgments respecting such problems must repose, as Mr. Arthur Baner has forcibly pointed out, that it is a question altogether distinct from that of the origin of our judgments, or from reasonings about their truth. Such matters are very interesting, but they are not here in point, since it is plain that no proposition capable of proof can be one the certainty of which is fundamental. For, in order to prove anything by reasoning, we must show that it necessarily follows as a consequence from other truths, which therefore must be deemed more indisputable. But the process must stop somewhere. We cannot prove everything. However long our arguments may be, we must at last come to ultimate statements, which must be taken for granted, like the validity of the process of reasoning itself, which is one of the implications of science. If we had to prove either the validity of that process or such ultimate statements, then either he must argue in a circle, or our process of proof must go on for ever without coming to a conclusion, which means there could be no such thing as "proof" at all.

Therefore the "grounds of certainty" which any fundamental proposition may possess cannot be anything *external* to it—which would imply this impossible proof. The only ground of certainty which an ultimate judgment can possess is its own *self-evidence*—its own manifest certainty *in and by itself*. All proof, all reasoning, must ultimately rest upon truths which carry with them their own evidence, and do not therefore need proof.

It is possible that some of my hearers may be startled at the suggestion of believing anything whatever on "its own evidence," fancying it is equivalent to a suggestion that they should believe anything *blindly*. This, I think, is due to the following fact of mental association. The immensely greater part of our knowledge is gained by us indirectly—by inference or testimony of some kind.

We commonly ask for some proof with regard to any new and remarkable statement, and no truths are brought more forcibly home to our minds than are those demonstrated by Euclid. Thus it is that many persons have acquired a feeling that to believe anything which cannot be proved, is to believe *blindly*. Hence arises the tendency to distrust what is above and beyond proof. We are apt to forget, what on reflection is manifest—namely, that if it is not blind credulity to believe what is evident to us by means of something else, it must be still less blind to believe that which is directly evident in and by itself.

And self-conscious reflective thought tells *me* clearly, that the law of contradiction is not only implied by all science, and necessary to the validity of all science, but that it is, as I said, an absolute, necessary truth which carries with it its own evidence. It must be a truth, then, applicable both to the deepest abyss of past time and the most distant region of space. But here, again, I think it possible that one or two of my hearers may be startled, and perhaps doubting how things in this respect may be in the Dog-star now, or how they were before the origin of the solar system. I fancy I hear someone asking: "How is it possible that we, mere insects, as it were, of a day, inhabiting an obscure corner of the universe, can know that anything is and must be true for all ages and every possible region of space?"

In the first place, I think the difficulty which may be thus felt is due to the abstract form of the law of contradiction. And yet, as I said before, it is but the summing up of all the particular instances, as to each one of which no difficulty at all is felt, but each is clearly

<sup>1</sup> Friday Evening Discourse delivered at the Royal Institution by Dr. St. George Mivart, on June 5, 1891. Continued from p. 62.

seen to be true. Any man who really doubted whether, if his legs were cut off, they might not at the same time remain on, would have a mind in a diseased condition.

There is, however, another reason which indisposes some persons to see the necessary force of this law. It is due, I think, to a second fact of mental association.

Things which are very distant, or which happened a long time ago, are known to us only in roundabout ways, and we often feel more or less want of certainty about them. On the other hand, we have a practical certainty concerning the things which are about us at any given moment. Thus we have come to associate a feeling of uncertainty with statements about things very remote. But nothing can well be more remote from us than "the most distant regions of space" or "before the origin of the solar system." It is not surprising, then, that this mental association should call forth a feeling of uncertainty with respect to any statement about universal truth.

It is, no doubt, wonderful that we should be able to know any necessary and universal truths; but it is less exceptionally wonderful, when we come to think the matter all round, than it may at first sight appear to be. It is wonderful; but so, deeply considered, is all our knowledge. It is wonderful that through molecular vibrations, or other occult powers of bodies, we have sensations—such as of musical tones, sweetness, blueness, or what not. It is wonderful that through sensations, actual and remembered, we have perceptions. It is wonderful that on the occurrence of certain perceptions we recognize our own existence past and present. So, also, it is wonderful that we recognize that what we know "*is*," cannot at the same time "not be." The fact is so, and we perceive it to be so; we know things, and we know that we know them. HOW we know them is a mystery, indeed, but one about which it is, I think, perfectly idle to speculate. It is precisely parallel to the mystery of sensation. We feel things savoury, or odorous, or brilliant, or melodious, as the case may be, and with the aid of the scalpel and the microscope we may investigate the material conditions of such sensations. But *how* such conditions can give rise to the feelings themselves is a mystery which defies our utmost efforts to penetrate. I make no pretension to be able to throw any light upon the problem "How is knowledge possible?" any more than on the problem "How is sensation possible?" or on the questions "How is life possible?" or "How is extension possible." But "*Ignorantia modi non tollit certitudinem facti.*" And we know that we are living, that we feel, and that we do know something—if only that we know we doubt about the certainty of our knowledge.

And *à propos* of such doubt, let me here put before you the intellectual penalties which have to be paid for any *real* and *serious* doubt with respect to the implications of science. I think we shall see that nothing less than intellectual suicide or mental paralysis must be the result. And such a result must also be logically fatal to every branch of science. The first implication I put before you was the *validity of inference*.

Now, no one who argues, or who listens to or reads—with any serious intention—the arguments of others, can, without stultifying himself, profess to think that no process of reasoning is valid. If the truth of no mode of reasoning is certain, if we can make no certain inferences at all, then all arguments must be useless, and to proffer, or to consider, them must be alike vain. But not only must all reasoning addressed to others be thus vain, the silent reasoning of solitary discursive thought must be vain also. Yet what does this amount to save an utter paralysis of the intellect? It is scepticism run mad.

But the implication I regard as one of the most important of all is the implication of *our knowledge of our own continuous existence*, concerning which I said I must crave your permission to speak at some length. It was the mention of this implication which led me to

refer to that system of thought it is my object here to controvert.

I have heard it proclaimed in this theatre by Prof. Huxley that we cannot have supreme certainty as to our own continuous existence, and that such knowledge is but secondary and subordinate to our knowledge of our present feelings or "states of consciousness."

Of course I am not thus accusing him of *originating* any such erroneous view. In that matter he is but a follower of that daring and playful philosopher Hume. I say "playful," because I cannot myself think that he really believed his own negations. He seems to me too acute a man to have been himself their dupe. But however this may be, I here venture directly to contradict Hume's and Prof. Huxley's affirmation, which is also adopted by Mr. Herbert Spencer, and to affirm that we have the *highest* certainty as to our own continuous existence.

It is, of course, quite true that we have complete certainty about our present feelings, as also that we cannot know ourselves apart from our feelings. But it is no less true that we cannot be conscious of feelings apart from the "self" which has those feelings. Now, it is assumed by those I oppose that we can know nothing with absolute certainty unless we know it by itself or "unmodified," or as existing "*absolutely*." But in fact nothing, so far as we know, exists apart from every other entity and unmodified—or "*absolutely*" as it is, in my opinion, absurdly called. No wonder, then, if we do not know things in a way in which they never do, and probably never can, exist. We can really know nothing by itself because nothing exists by itself. It is not wonderful, then, if we only know ourselves as related to our simultaneously known feelings, or *vice versa*.

It is quite true that we never know our own substantial essential being alone and unmodified, but then we have never for an instant so existed. Our knowledge of ourselves in this respect is like our knowledge of anybody and everybody else. Most persons here present doubtless know Prof. Tyndall, yet they never knew him, no one ever knew him, except in some "state"—either at home or away from home, either sitting or not sitting, either in motion or at rest, either with his head covered or uncovered—and this for the very good and obvious reason that he never did or could exist for a moment save in some "state." But this does not prevent your knowing him very well, and the same consideration applies to our knowledge of ourselves. When I consider what is my primary, direct consciousness at any moment, I find it to be neither a consciousness of a "state of feeling" nor of my "continuous existence," but a consciousness of doing something or having something done to me—action or reaction. I have always, indeed, some "feeling" and also some sense of my "self-existence"; but what I perceive primarily, directly, and immediately is neither the "feeling" nor the "self-existence," but some concrete actual doing, being, or suffering then experienced. We can, indeed, become distinctly and explicitly aware of either the "feeling" or the "self-existence" by turning back the mind upon itself. But to know that one "has a feeling" or is in a "state," or even that a "feeling exists," is plainly an act by which no one begins to think. It is evidently a secondary act—an act of reflection. No one begins by perceiving his perception a bit more than he begins by expressly adverting to the fact that it is he himself who perceives it.

Let us suppose two men to be engaged in a fencing match. Each man, while he is parrying, lunging, &c., has his "feelings" or "states," and knows that it is "he" who is carrying on the struggle. Yet it is neither his "*mental states*" nor the "*persistence of his being*" which he directly regards, but his concrete activity—what he is doing and what is being done to him. He may, of course, if he chooses, direct his attention either to the feelings

he is experiencing or to his underlying continuous personality. Should he do so, however, a hit from his adversary's foil will be a probable result.

But to become aware that one has any definite feeling is a reflex act *at least* as secondary and posterior as it is to become aware of the "self" which has the feeling. I say "*at least*," but I believe that of the two perceptions (1) of "feelings," and (2) of "self," it is the "self" which is the *more* prominently given in our primary, direct cognitions.

I believe that a more laborious act of mental digging is requisite to bring *explicitly* to light the *implicit* mental state, than to bring forward *explicitly* the *implicit* "self-existence." Men continually and promptly advert to the fact that actions and sufferings are *their own*, but do not by any means so continually and promptly advert to the fact that the feelings they experience are "*existing feelings*."

Therefore I am convinced that one of the greatest and most fundamental errors of our day is the mistake of supposing that we can know our "mental states" or "feelings," more certainly and directly than we can know the continuously existing self which has those feelings.

Our perception of our continuous existence also involves the *validity of our faculty of memory*, which is implied in this way, as well as in every scientific experiment we may perform. For we cannot obviously have a reflex perception either of our "feelings" or our "self-existence," without trusting our memory as to the past; since, however rapid our mental processes may be, no mental act takes place without occupying some period of time, and, indeed, nervous action is not extremely rapid. In knowing, therefore, such facts by a reflex act, we know by memory what is already past. Thus our certainty as to our own continuous existence necessarily carries with it a certainty as to our faculty of memory. Therefore, the mental idiocy of absolute scepticism is the penalty that has to be paid for any *real* doubt about our own existence or the trustworthiness of the *faculty of memory*, for all our power of reposing confidence in our observations, experiments, or reasonings, would, in that case, be logically at an end. On the other hand, the validity of our faculty of memory establishes once for all (as we have seen) the fact that we can transcend our present consciousness and know real *objective truth*.

Let us now see the consequences of the denial, or *real* doubt of the second implication of science—the "law of contradiction." Without it we can be certain of nothing, and it therefore lands us in absolute scepticism. And if we would rise from that intellectual paralysis we must accept that dictum as it presents itself to our minds; and the dictum presents itself to my mind, not as a law of *thought* only, but a law of *things*. It affirms, for example, that no creature anywhere or anywhen can at the same time be both bisected and entire.

An amusing instance of the way in which very distinguished men may be misled as to the question of our power of perceiving necessary truth is offered by an imaginary case which has been put forward by Prof. Clifford and Prof. Helmholtz. Their object in advancing it was to show, by an example, how truths which appear necessary to us are not objectively necessary. But the result appears to me to show the direct contradictory of what they intended. Their intention evidently was to support the proposition that we can know "*no truths to be absolutely necessary*," and the result is to show that, even according to them, "*some truths are absolutely necessary*." The necessary truths they propose to controvert are that "a straight line is the shortest line between two points," and that "two straight lines cannot inclose a space."

For this purpose, curious creatures, possessing length

and breadth but no thickness, were supposed, by them, to be living on a sphere with the surface of which their bodies would coincide. They were imagined to have experience of length and breadth in curves, but none of height and depth, or of any straight lines. To such creatures, it was said, our geometrical necessary truths would not appear "truths" at all. A straight line for them would not be the shortest line, while two parallel lines prolonged would inclose a space.

To this imaginary objection I reply as follows:—"Beings so extraordinarily defective might, likely enough, be unable to perceive geometrical truths which to less defective creatures—such as ourselves—are perfectly clear. Nevertheless, *if they could conceive of such things* at all, as those we denote by the terms 'straight lines' and 'parallel lines,' then there is nothing to show that they could not also perceive those same necessary truths concerning them which are evident to us."

It is strange that the very men who make this fanciful objection, actually show, by the way they make it, that they themselves perceive the necessary truth of those geometrical relations the necessity of which they verbally deny. For how, otherwise, could they affirm what would or would not be the necessary results attending such imaginary conditions? How could they confidently declare what perceptions such conditions would certainly produce, unless they were themselves convinced of the validity of the laws regulating the experiences of such beings? If they affirm, as they do, that they perceive what must be the truth in their supposed case, they thereby implicitly assert the existence of some absolutely necessary truths, or else their own argument itself falls to the ground.

But this same implication of science, respecting the objective absolute validity of the law of contradiction, also refutes that popular system of philosophy which declares that all our knowledge is merely relative, and that we can know nothing as it really exists independently of our knowledge of it, the system which proclaims the "*relativity of knowledge*."

Of course anything which is "*known to us*" cannot at the same time be "*unknown to us*," and so far as this, our knowledge may be said to affect the things we know. But this is trivial. Our "knowing" or "not-knowing" any object is—apart from some act of ours which results from our knowledge—a mere accident of that body's existence, which is not otherwise affected thereby.

Again, as I before remarked, nothing, so far as we know, exists by itself, and unrelated to any other thing. To say, therefore, that "all our knowledge is relative" might only mean that knowledge concords with objective reality. But this is by no means what the upholders of the "relativity of knowledge" intend to signify. They deny the objective validity, the actual correspondence with reality, of any of our perceptions or convictions—even, as Mr. Herbert Spencer tells us, our cognition of "difference."

Every system of knowledge, *however*, must start with the assumption, implied or expressed, that something is true. By the teachers of the doctrine of the "relativity of knowledge" it is evidently taught that the doctrine of the relativity of knowledge is true. But if we cannot know that anything corresponds with external reality, if *nothing* we can assert has more than a relative or phenomenal value, then this character must also appertain to the doctrine of the "relativity of knowledge." Either this system of philosophy is merely relative or phenomenal, and cannot be known to be true, or else it is absolutely true, and can be known so to be. But it must be merely relative and phenomenal, if everything known by man is such. Its value, then, can be only relative and phenomenal, therefore it cannot be known to correspond with external reality, and cannot be asserted to be true; and anybody who asserts that we can know it to be true,

thereby asserts that it is false to say that our knowledge is only relative. In that case some of our knowledge must be absolute; but this upsets the foundation of the whole system. Anyone who upholds such a system as this may be compared to a man seated high up on the branch of a tree which he is engaged in sawing across where it springs from the tree's trunk. The position taken up by such a man would hardly be deemed the expression of an exceptional amount of wisdom.

My time has expired, and I may say no more. The considerations I have put before you this evening, should they commend themselves to your judgment, will, I think, lead you to admit that, if we feel confidence and certainty in any part of any branch of physical science, we thereby implicitly affirm that the human mind can, by consciousness and memory, know more than phenomena—can know some objective reality—can know its own continuous existence—the validity of inference and the certainty of universal and necessary truth as exemplified in the law of contradiction. In other words, the system of the relativity of knowledge is untrue. Thus the dignity of that noble, wonderful power, the human intellect, is fully established, and the whole of our reason, “from turret to foundation-stone,” stands firmly and secure. If I have succeeded in bringing this great truth home to one or two of my hearers who before doubted it, I am abundantly repaid for the task I have undertaken. It only remains for me now to thank you for the kind and patient hearing you have been so good as to accord me.

#### EXAMINATIONS IN SCIENCE.

THE Committee of the Privy Council on Education have just announced an important decision with regard to the examinations of the Science and Art Department in science.

The number of candidates presenting themselves for examination in science is already so large—about 190,000 papers in various branches of science were worked at the examination in May last, besides above 14,000 practical examinations—that the machinery of examination and registration is already severely strained. These numbers will in all probability soon be so increased as to render it impossible to make satisfactory arrangements for the examination of the candidates at the local centres, or for the examination of the worked papers under any system of central examination.

At the same time the means recently placed at the disposal of local authorities for providing or aiding instruction seem to render it unnecessary for the Science and Art Department to continue to give direct aid for very elementary instruction in science. Such instruction can now be more effectually organized and maintained locally.

Under these circumstances it has been decided that after the May examinations of 1892 the payments of £1 now made for the second class in the elementary stage of each science subject shall cease.<sup>1</sup> An elementary paper will continue to be set in each subject, but the results will be recorded simply as *pass* or *fail*, the standard for passing being about the same as that now required for a first class, *i.e.* about 60 per cent. of the marks obtainable.

At the same time, with a view to encourage more advanced instruction, which does not seem to be adequately provided for at present, the payments for the advanced stage and for honours will be considerably increased. The payments on results will then be £2 for a pass in the elementary stage; £5 and £2 10s. for a first or second class respectively in the advanced stage; and £8 and £4 for a first or second class respectively in honours, in each subject of science, and in each subdivision of

<sup>1</sup> The payments on the results of the examinations in 1892 will not be affected by this Minute.

subject 6, theoretical mechanics, or of subject 8, sound, heat, and light, with the following exceptions:—The payments for practical chemistry will be £3 for a pass in the elementary stage, and £6 and £3 10s respectively for a first or second class in the advanced stage; the payments for mathematics will be £2 for a pass in stage 1, £3 and £2 respectively for a first or second class in stages 2 and 4, £4 and £3 for a first or second class respectively in stage 3, £5 and £4 for a first or second class respectively in stages 5, 6, and 7, and £8 and £4 respectively for a first or second class in honours. The payment for section 1 (geometrical drawing) of subject 1 will remain as at present, 10s.

The payment for attendance in an organized science school will be increased to £1 in the day school and 10s. in the night school.

As it is of great importance to prevent large numbers of wholly unqualified candidates being presented at the examinations, the examiners will be instructed to note the papers of all such as would not obtain above twenty-five per cent. of the marks, and a deduction will be made from the grant to each school for each such paper sufficient to cover the cost incidental to its examination.

The committee of a science school in a place in Great Britain with less than 5000 inhabitants which does not receive aid from the local authority, or of any science school in Ireland, will be allowed to continue until further notice on the present system, if they so desire it.

#### NOTES.

THE subject of an International Congress of Electricity, to be held at Chicago in connection with the World's Fair, continues to attract much attention in America. A report about the matter has been presented to the Director-General of the Exhibition by Mr. J. Allen Hornsby, secretary of the department of electricity. During a recent visit to Europe, Mr. Hornsby discussed the question with several leading men of science in England and on the Continent, and he was encouraged by them to believe that, if certain conditions were complied with, the success of the Congress would be certain. They all agreed that the Congress should be held under the auspices of the U.S. Government. Invitations, they thought, should be issued by the Government to individual scientific men through the Governments of the countries to which the individuals belong. “This course of action,” says Mr. Hornsby, “in the opinion of the authorities whom I consulted, will insure an official character to the proceedings of the scientific Congress, and will virtually pledge the various Governments to a recognition and adoption of the standards created.”

PROF. JOSEPH WOLSTENHOLME, whose name was well known to mathematicians, died on November 18 in his sixty-third year. He graduated at Cambridge as third wrangler in the Mathematical Tripos of 1850, and became a Fellow first of St. John's College, then of Christ's, where he was for many years a member of the tutorial staff. After vacating his Fellowship by marriage in 1869, he was appointed the first Professor of Mathematics in the Engineering College at Cooper's Hill—a position from which failing health compelled him to withdraw a year or two ago. With the Rev. Percival Frost, he wrote a treatise on solid geometry, published in 1863. He also collected many original mathematical problems, devised by himself, in a volume which appeared in 1867, and again in 1878.

WE regret to announce the death of Mr. S. F. Downing Principal of the Civil Engineering College, Seebpur, Calcutta, which took place at Coonoor, Madras, on October 16 last, at the comparatively early age of forty-seven. The *Englishman* of October 24 says:—“The deceased gentleman was educated at Trinity College, Dublin, and was a graduate of Dublin