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ORDINARY MEETING, MARCH 1, 1880.

J. E. HOWARD, ESQ., F.R.S., IN THE CHAIR.

The minutes of the last meeting were read and confirmed, and the following elections were announced :—

MEMBER :—J. H. Salisbury, Esq., B.M.S., M.A., M.D., &c., United States.

ASSOCIATES :—Isaac Brown, Esq., F.R.A.S., F.M.S., Kendal ; W. Collet, Esq., London ; Rev. J. Joyce Evans, M.A., London ; E. Oakley Newman, Esq., London ; Rev. J. Strickland, B.D., London ; C. S. Webber, Esq., F.R.C.S., London.

Also the presentation of the following Works for the Library :—

" Proceedings of the Royal Society."	*From the same.*
" Proceedings of the Royal Institution."	*Ditto.*
" Proceedings of the United Service Institute."	*Ditto.*
" Proceedings of the Geological Society."	*Ditto.*
" Our Inheritance in the Great Pyramid." By C. Piazzi-Smyth.	*L. Biden, Esq.*

The following paper was then read by the Author :—

ON THE BEARINGS OF THE STUDY OF NATURAL SCIENCE, AND OF THE CONTEMPLATION OF THE DISCOVERIES TO WHICH THAT STUDY LEADS, ON OUR RELIGIOUS IDEAS. By G. G. STOKES, Esq., M.A., D.C.L., LL.D.Dub., F.R.S., Lucasian Professor of Mathematics at Cambridge University, &c.

IT is the constant aim of the student of science, who not only follows the labours of others, but seeks to extend his own researches into the region of the unknown, to refer observed phenomena to natural causes. Thus, the ocean is seen to

exhibit strange periodic movements, which have an evidently beneficial effect as tending to prevent stagnation. A study of the period of these movements shows that they have some mysterious connexion with the moon. Presently, Newton arises and shows that these movements are necessary mathematical consequences of the same law by which a stone, held in the hand and let go, falls to the earth.

As regards this particular phenomenon, it may be that the immediate effect of the discovery is rather to turn aside the mind from the contemplation of the useful results of the movement, and involve it in the intricacies of a very complicated hydrodynamical problem. The particular phenomenon is shown to be part and parcel of a vast system, and it may well be that the beneficial results of this system are not at first apparent; from its very vastness the mind's eye fails to take it in.

Yet surely the study of truth of one kind, rightly pursued, cannot conflict with our reception of truth of another kind, though from the imperfection of our knowledge and of our faculties temporary difficulties may arise. Doubtless, in the end our views will be enlarged, and in some respects, it may be, corrected.

To illustrate my meaning, permit me for a few moments to indulge in fiction. I will suppose then, that in some unfrequented part of the Pacific Ocean there existed an undiscovered island, which, for the sake of a name, I will call Irene. The Irenians were men of cultivated minds, intelligent, and deeply religious, but for centuries they had been cut off from all connexion with the rest of the world, and they were ignorant of the very rudiments of natural science. They delighted in poetry, and in the cultivation of the feelings; and being devout they contemplated the phenomena of nature in immediate relation to a supreme Being. That most wonderful of our senses, the sense of sight, buried to them in mystery in all that belonged to it, was a special object of admiration, and they loved to dwell on it as evidence of the beneficence of the Creator.

At last the island was discovered by the captain of a scientific circumnavigating expedition. The Irenians and their visitors were greatly pleased with each other; and the scientific men of the expedition, finding them apt pupils, took great interest in teaching them so much of the elements of physics as the length of their stay permitted. They taught them among other things something of optics, the existence of rays, the laws of reflection and refraction, the formation of images by lenses, the use of telescopes. They then dissected an eye,

and showed how an eye acts just as an optical instrument in forming images of external objects on the retina. At this the Irenians were taken aback. They had been used to regard the sense of sight as an immediate gift from the Creator, depending on no second causes, and now they saw part of their organs of vision acting like so much dead matter. They received a shock, at which some of them were staggered, and asked themselves the question, Is it possible that, after all, this beautiful scene around us, these trees and flowers and painted butterflies, are merely a casual result of the blind interaction of a few simple laws?

But when the expedition had sailed from their shores, and the Irenians were left to themselves, and the novelty of their new ideas had a little worn off, a more sober judgment was formed of what they had learned. It is true that human reason had broken in on what they had been in the habit of regarding as holy ground; and they had learned that up to the formation of images on the retina the eye behaves like a mere optical instrument. But how came it to pass that its parts were so strangely well-adapted to fulfil this end? The cornea smooth and transparent, and nearly spherical, yet somewhat prolate, which as we know would tend to destroy spherical aberration; the crystalline lens shaped much like the lens of an optician, yet becoming gradually denser towards the centre, in a manner that the optician cannot imitate; the iris regulating the quantity of light admitted just as the astronomer regulates the aperture of his telescope, but self-acting in a manner which the optician cannot imitate? Reflecting on these things they became overwhelmingly impressed with the evidence of design, and design must have had a designer. But they had learned to think of him differently in some respects from what they did before; to regard it as no derogation of his character to suppose that he accomplishes his ends in conformity with, rather than in supersession of, such natural laws as they can themselves investigate, and doubtless of many others which are beyond their ken.

Now the progress of science is continually placing us more or less in the condition of our imaginary islanders, by reducing to a result of the straightforward operation of natural laws processes, perhaps evidently beneficial in their effect, but which were at one time shrouded in mystery as to their nature. And it behoves us to keep our minds in a condition of sober impartiality, neither on the one hand being so carried away by the achievements of science as to forget how much there is which science holds out no prospect of ever being able to explain, nor on the other refusing to admit conclusions fairly

deducible from scientific evidence, on the ground that we had associated something contrary to those conclusions with truths which we hold it most important to maintain.

The alarm at one time felt at the conclusions of geologists that the antiquity of the earth itself, and even of plants and animals, was to be reckoned by something considerably exceeding a few thousand years, may pretty well be looked upon as a thing of the past. But instances in which scientific discoveries, or conclusions based on good evidence, run counter to our preconceived ideas occur from time to time, and are likely to occur in the future. In this connexion I would refer for a minute or two to a scientific doctrine which is now beginning to be pretty generally received, and which has, I think, given needless alarm to some who have the cause of religion at heart; I mean the doctrine of the conservation of force. I am not going to enter on any lengthy explanation of what the doctrine means; suffice it to say that for every development of *work* there must be a corresponding *expenditure of something;* and conversely, when work is apparently lost, its full equivalent must appear in some other shape, in quantity corresponding to the work apparently lost, and very commonly in the shape of heat. We have reason to believe that this law is no less applicable to living beings than to dead matter, and that, for instance, the work exerted by a labouring man is the equivalent of a part of the energy due to chemical combinations between the constituents of his food and the air he breathes. It is this last application of the law which seems to give rise, in the minds of religious men, to apprehensions which to me appear wholly groundless. We have long been familiar with the idea that living beings, no less than dead matter, are subject to the three laws of motion; and if we have now reason to believe that they are no less subject to the law of the conservation of force, I cannot imagine what religion has to fear from that. To aid our ideas let us adopt a rude analogy, and compare a living being to a railway train in motion. If we have now reason to regard the will, considered in relation to the exertion of muscular work, as something more nearly analogous to the intelligence of the engine-driver than to the coals under the boiler, that surely is not in any way derogatory to our idea of a living being, or of the wisdom and power involved in its first creation. Rather, as it seems to me, our ideas of what constitutes a living being tend to be refined and exalted.

If we allow the existence of,—say even if we adopt for trial the hypothesis of the existence of,—an intelligent Being above ourselves to whose Will the arrangement of Nature is due,

there are two ways in which we may draw a picture in our minds (however imperfect that picture may be) of the mode of exercise of that Will, namely (1), by a series of independent *fiats*; or (2) by adapting means to an end, and working according to established laws. Now, the ordinary course of Nature shows that such is at any rate an ordinary mode of operation of that Will; as, for example, where we see an apparatus adapted to the laws of reflection and refraction of light in such a manner as to produce images on the retina. What, then, should we expect *à priori* to find in our examination of Nature? Surely, as we must picture to our minds a skill of contrivance far beyond our own, we might expect that the greatest human intellect would be able to follow but a small portion of the contrivances actually existing; consequently, that at the boundary of what we have been able to make out there should be dim indications of something of the same kind stretching out into the unknown; but yet, at the same time, that there should be no indication that such a chain of causation would of itself alone suffice for the explanation of the system of Nature.

And this, it seems to me, is precisely what we find. To revert to our illustration of the eye: we have seen that as regards the formation of images on the retina it acts as an ordinary optical instrument in a way which we can fully follow; but when the images *are* formed, what then? We find the retina to contain an exquisitely delicate network of nerves collected into the optic nerve, and thence running into the brain. These nerve-fibres seem as evidently adapted to fulfil an end as the telegraph wires which run along a road or railway, though how they act in conveying an impression into the brain is as yet unknown; and how the impression so conveyed into the brain is capable of affecting our minds is shrouded in the deepest mystery. Again, the form and character of the cornea, crystalline lens, &c., are such as admirably fit them for their office of refracting the rays of light; but how came they to have this form and character? We perceive that there are vessels evidently subservient to their growth and nutrition, and that is pretty nearly all we can explain about it.

There is thus, as it seems to me, no inconsistency in accepting the theory of evolution as a guide in our researches, and yet rejecting it as sufficient of itself alone to explain the whole order of nature. The rejection of it as a guide, and the acceptance of it as an axiom of universal application, seem to me to be founded alike, though in different ways, upon an exaggerated estimate of the extent of human knowledge. To

say that what we cannot explain by the operation of natural causes must be directly referred to the *fiat* of the Author of Nature, and that it is presumptuous to attempt to explain it, is to measure His mind by our own, and to assert that where *we* are no longer able to recognise the adaptation of means to an end there contrivance ceases. To assume that because the doctrine of evolution is a useful guide in our researches therefore nothing more is required, is to perform a gigantic "extra-polation" (to borrow a term sometimes employed in mathematics); to conclude the form of a complete curve from the mere infinitesimal arc which alone is open to our observation.

The progress of science is continually bringing phenomena under the category of deductions from established laws, but at the same time it leaves barriers which it gives no indication that science will ever be able to get over; nay, sometimes it makes the existence of such barriers more apparent. This, I think, is the case with the principle of the dissipation of energy. I will endeavour to give some idea of what this principle means. Imagine a condensing steam-engine at work. For simplicity's sake, suppose the fire removed when the boiler has been well heated; make abstraction of all the surroundings; and suppose the work done by the engine to be that of turning round a paddle between fixed paddles, the fixed and the movable paddles being alike immersed in water belonging to the condenser. The engine would go on working for a time by virtue of the heat which it got from the coals before the fire was removed. The heat belonging to the steam which comes from the water in the boiler is in part conveyed into the condenser. I say in part, not entirely, even if we make abstraction of the solid materials of the engine; for a part is in appearance lost, and in lieu of it we have an exact equivalent in the shape of work done. But in the arrangement supposed this work is converted again into heat, through the friction in the water in the condenser. The upshot is, that while in different parts of the system there is a mutual exchange between energy of one kind and energy of another, the total energy of the system remains unchanged. But though this be so, the system is in a very different condition in its initial state from what it is in its final state, when the temperature has become uniform throughout. At first some parts were hot and some were cold; and it was in consequence of this unequal distribution of temperature that it was possible to convert energy in the shape of heat into energy in the shape of work, work which, though in the arrangement supposed it was expended, wasted we may say, within the system itself, might have been conveyed outside by a shaft, and turned to

useful account. But in the final state the whole system is in a condition of dead uniformity, lukewarm throughout, and no useful effect can be obtained from it.

Now this principle blocks out a supposition in which it is possible that a certain class of minds might rest content—the supposition, namely, that the present order of things has existed as it is, saving merely certain periodic fluctuations, from a past eternity. There is something so mysterious in the idea of *past* time, when considered as the seat of past events, and not merely as a mathematical abstraction, that if the uniformitarian doctrine could be scientifically maintained many minds might be content to take refuge in the mystery and inquire no further. But we are bound to face the problem of the existence of the state of things we see around us as something that had a beginning, or, at any rate, something that was preceded by a state entirely different.

There are some, indeed, who are content to take things as we find them, without recognising anything beyond the operation of natural causes such as those which we investigate, and who boldly accept the conclusion to which the principle of the dissipation of energy considered by itself leads us, that the present order of things is slowly tending towards a goal of universal death. But if this conclusion is true as to the future, the present order of things ought to be capable of being deduced in like manner from what existed at any anterior time, however remote. If our formula were general, the variable expressing the time ought to be capable of being made negative as well as positive, and as large as we please. The question therefore arises, Can we account for the existence of what we see by mere evolution from a state the most remote that science enables us to conceive, understanding by evolution the result of the operation of natural causes, such as those that we can investigate, and excluding the operation of will, unless it be with reference merely to men and animals?

There are several reasons for thinking that our earth was at one time in a molten state. There are not wanting indications of a condition more remote from the present than even this. Associated with the stars, which the telescope reveals to us in such overwhelming numbers, are those remarkable objects, the nebulæ, which have long excited the curiosity of astronomers. Laplace regarded them as remaining indications of a primæval condition of matter which he supposed to have existed in a state of diffusion, and to have given rise to the stars by concentration under the influence of the attraction of gravitation. These luminous films were supposed to be portions of that diffused matter that had not yet condensed. But as telescopes

were improved in power and definition many of these objects which had formerly appeared diffuse were seen to be resolved into clusters of stars, and a presumption seemed to be raised that if several still resisted all attempts to resolve them it was only because the stars of which they were composed were so numerous within a given angular space, and individually so minute, as to baffle—hitherto at least—all attempts of opticians to construct telescopes powerful enough to resolve them. The magnificent speculations of Sir John Herschel are perhaps known to most of those here present. He regarded a nebula as something like the system composed of our own sun, and all the stars we can see with the naked eye, and even those more minute, placed at such an almost inconceivable distance that the whole subtends only a minute angle; and that the individual stars, of which the system consists, can no longer be seen individually, even with telescopes, and we merely perceive a faint gleam of light emitted by the system as a whole. But a remarkable discovery made in recent years by Dr. Huggins rather leads us back towards the ideas of Laplace. Huggins found that, quite unlike the spectra of the sun and of the stars, the spectra of most of the irresolvable nebulæ consisted of a very few *bright* lines, a character which laboratory experiments show to belong to the spectra of incandescent gases and vapours. This leaves little doubt that such must be the character of the matter of which these nebulæ are formed. It would seem, *à priori*, that the matter of such masses must in time condense, and thus conceivably stars might be formed. And what strengthens this conclusion is, that many of these diffuse nebulæ exhibit within them stellar points, so related to them that the chances are enormously against their being merely fixed stars casually situated in the same direction, and that these stellar points exhibit spectra of the same character as those of stars in general.

Science, then, seems dimly to point to a fiery nebula as a condition of matter the most remote that we can go back to. Can we then deduce the existence of all that we see around us by the mere operation of self-acting laws from such a condition? Or to take a starting-point not quite so far back, imagine our own earth to have cooled down to a temperature at which it would be possible for plants or animals, as we know them, to have existed; can we imagine such springing into existence, so to speak, of their own accord? Or to take a still later stage, supposing such forms of a low order once to exist, have we any scientific grounds for supposing that all that is required for the gradual formation of the higher forms, including man himself, is a slow process of natural evolution?

No attempt worth mentioning has ever been made to adduce evidence of the spontaneous production of living from dead matter, unless it be with reference to low organisms whose minuteness almost baffles our means of investigation. Putrefying organic solutions are found to swarm with microscopic creatures, whose presence at first sight, and even after a great amount of careful investigation, is very difficult to account for on the supposition that they came from germs. But if the germs, if germs there be, of such creatures bear anything like the same proportion in size to the adults that they do in the higher animals, one can foresee that a full examination of the question must be beset with enormous difficulties. I think the immensely preponderating weight of evidence obtained by those who have most carefully investigated the question is, that if germs are excluded no life is found.

With respect to the answer to the second question, the weight of authority at the present day seems more divided. It would ill become me to criticise the labours of those who have worked in fields which I have not explored. Yet, looking at the thing from the point of view of an outsider, I cannot refrain from saying, that it seems to me that speculation as to the transmutation of forms has run utterly rampant. A certain amount of change yielding sub-permanent varieties no doubt presents itself to our observation, as in breeds of cattle and races of men, and it is likely enough that the same causes of variation operate beyond what we can actually prove. But, with all due allowance for such changes, is it conceivable that they could bridge over the enormous interval which separates the higher animals and man himself from some low organism?

I am no biologist, my own studies in natural science having lain in the domain of physics. But accustomed as I am to the severe demands for demonstration which in the physical sciences are made a condition of the acceptance of a theory, I confess that it is not without astonishment I have come across what seems to me the coolness of assumption with which mere speculations are spoken of as if they were established truths by many who, following in some respects in the wake of the great leaders of biological science, have not had time to acquire that vast store of knowledge which puts the mind in a condition properly to judge of the weight of evidence by which a particular hypothesis may be supported.

On the whole, while freely acknowledging the operation of natural causes, and thinking it probable that they extend far beyond the boundaries of our knowledge, and that accordingly we may seek to include the latest well-established scientific theory in some yet higher generalization, I see no

prospect of accounting for all we see around us by any such process as this. I see evidence of the operation of will and design, which cannot be eliminated even if we would wish to eliminate it; and that which we are obliged to admit as having operated in the past may yet operate in the future, may be operating in the present.

I have said that the principles of the conservation of force and of the dissipation of energy lead to the conclusion that the present order of things is leading towards a goal of universal death. Of course, this is only on condition that everything beyond the operation of the ordinary natural laws such as we can investigate is excluded. It becomes a curious question, is there any process which we can even picture to our minds, by which, without any violation of the principle of the conservation of energy, we can conceive the distribution of energy so altered as to make it again available for useful purposes, instead of having everything in a condition of dead uniformity? The only satisfactory affirmative answer that I am acquainted with to this question is contained in a suggestion made by the late Professor Clerk Maxwell.

Let us imagine a closed vessel, the sides of which we will for simplicity's sake suppose impervious to heat, filled with a gas in a uniform condition, and consequently at a constant temperature throughout. In the first place, what must we picture to ourselves as the state of things within the vessel? How must we think of the gas itself? The laws of chemical combination, embraced as they are in the atomic theory of Dalton, give us strong ground for supposing that a mass of ponderable matter is not a continuous plenum, but consists of ultimate molecules alike to one another in matter of the same kind. The laws of crystallography again seem hard to account for if we refuse to admit the supposition of ultimate minute molecules. If these exist, a gas like a solid of liquid must be thought of as a congeries of molecules. But what conception are we to form of it in relation to heat? What is the physical picture of a higher or lower temperature as measured by the thermometer? There is the strongest reason now to believe that heat is in fact a mode of motion; that radiant heat consists in a vibratory movement of that medium pervading space, at least to the distance of the furthest visible star, which we call the luminiferous ether, and whose existence we are obliged to assume in order to account for, as most marvellously well it does account for, the phenomena of light. When radiant heat is absorbed by ponderable matter, we have reason to believe that it is that the energy of the vibratory movement of the ether is transferred to the ponderable matter, of which

the ultimate molecules are thrown into a state of agitation, or rather of greater agitation than before, and that it is this state of agitation that constitutes thermometric heat. According to the molecular theory of gases, which is in great measure due to Maxwell himself, and which has now received such remarkable confirmations that it may be considered pretty well established, in a gas the molecules are for the most part free, provided at least the gas be not under a very high pressure, and are moving about with very high velocities, and occasionally coming in contact with one another, or, what comes to much the same, so close as powerfully to affect each other's motion. The velocity is not the same for the different molecules, and if it were it would not remain so, for as they came casually into collision some would be so struck as to be made to move faster, and others so as to be made to move more slowly; it is only a sort of average state of agitation that remains permanently unchanged so long as the condition of the gas remains the same.

Suppose now our imaginary vessel divided into two by a thin partition, and suppose this partition pierced with a vast number of very minute holes, each large enough to let through one molecule at a time, but not much larger than that. Imagine each little hole closed by a sliding shutter, and suppose each shutter presided over by a minute intelligent creature, that Maxwell called a demon. Suppose it were wished to have one, call it the right hand, compartment of the vessel filled with warmer and the left hand compartment filled with cooler gas. This might be effected by the demons by suitably opening or closing the shutters. When a demon saw a quickly-moving molecule approaching his hole from left to right, or a slowly-moving one approaching it from right to left, he would open the shutter to let it through. When he saw a slowly-moving molecule approaching the hole from left to right, or a quickly-moving one approaching it from right to left, he would shut the shutter to stop it. Thus after a time the right-hand compartment would be filled with molecules which on the whole were moving more rapidly, and the left-hand compartment with molecules which, on the whole, were moving less rapidly than the average. If the limits of speed which decided whether they should shut or open the shutters for the molecules moving to right or left were properly chosen by the demons, the pressure would be the same on both sides of the partition, and if the partition were then conceived to be away, no alteration would take place until the molecules had had time to diffuse among one another. Meanwhile, without any change in the total

energy, an unequal distribution of temperature would have been brought about, which is an imperative condition in order that the existing energy should be capable of being turned to useful account.

I have thought it worth while to mention this curious speculation because it presents a picture, however fanciful in its conditions, of how the natural tendency of a natural law may be averted without any disturbance of the law itself, provided, and only provided, we superadd the idea of will guided by design.

The CHAIRMAN (Mr. J. E. Howard, F.R.S.).—It is now my duty to call upon you to thank Professor Stokes for his able and interesting paper. It is enough for me to say that it does credit to his high position among the highest scientific minds of the age. His remarks in reference to the necessity of dwelling upon the idea of a designer, in order to comprehend design, remind me of the intercourse I had with one of the leading atheistic minds of the last generation, who, in his declining years, spent some time in my neighbourhood, and who, I am glad to say, died a true Christian, having by God's mercy been brought from his aberrations to a better mind,—I allude to Mr. Hone, a well-known author. I remember once asking him whether, in his atheistic days, he really did believe in design without a designer :—and I may here say that I never met with a person of his views who would fairly grapple with this question ; and who would say he really did absolutely believe in what evidently bears the marks of design, and yet does not come from a designer. I cannot detail to you the answer Mr. Hone gave, because it opened out a very serious state of mind and thought, resembling what is now called Nihilism, and would lead us away from the present subject. He, however, did not believe in design without a designer, but had another explanation to give. His atheism was inconsistent with itself.

Mr. J. BATEMAN, F.R.S.—I have been much struck with what Professor Stokes has said as to the comparatively safe position of the man who, uninfluenced by pantheistic abstractions, holds fast to the belief in a personal God. I confess I think that any one who does hold fast, in the strict and simple meaning of the term, to a personal God—including, of course, the idea of a personal Creator—has nothing to fear from the atheistic or pantheistic tendencies of the age. I know not how others feel or what their experiences may have been, but as my own experience ranges over nearly seventy years, I may be allowed to say how much I have been struck by the changes in public opinion, especially in the opinions of scientists on religious questions during this period. The satirist of the last century spoke of the scientists of his time taking the *à priori* road and arguing downwards till they began to doubt of God. But the case is precisely the

reverse in the present day. Certain scientists now start with ignoring the idea of a God, and, starting thus, it would be a miracle if they ever found Him. No attempt is made to reconcile the phenomena of creation with the idea of a personal God; on the contrary, they try to find the best explanation they can of natural phenomena without reference to any such idea. To this fact I attribute many, if not all, the crude ideas, so full of evil results, with which men vainly seek to explain the phenomena by which we are surrounded. How vain these attempts none adequately feel but those who are acquainted with the better way, and who, starting with the idea of a personal Creator, have found that the wider their view ranged the more perfectly everything fitted in. Some twelve or fifteen years ago my friend, Professor Owen, in one of his great works on Comparative Anatomy, concluded with a few noble words, in which he asserted, in opposition to the various theories which had begun to darken the scientific atmosphere, that "the highest generalizations in the science of organic bodies, like the Newtonian laws of universal matter, lead to the conviction of a great First Cause, which is certainly *not* mechanical" (Owen's *Palæontology*, p. 451). Such an admission from a man so able and so fair as Professor Owen well-deserves to be treasured up in all our minds. For my part, without professing to be more than a tyro in science, I confess I have watched the development of all these theories with great interest, though I cannot say with much anxiety. Nay, the discoveries of science have swept away many of the difficulties I used to experience in reading the Bible. I never was able, until geology began to claim its own, to understand many of the prophetical declarations of Scripture, *e.g.*, those in Isaiah and the Apocalypse regarding the "new heavens and the new earth," or where the Psalmist says, "As a vesture shalt Thou change them, and they shall be changed; but Thou art the same, and Thy years shall not fail." Without the assistance of geology I should never have been able to form a definite conception of the Psalmist's meaning; but when I found what marvellous transformations in its strata, or outer rind, this earth—and doubtless other orbs have all followed the same law—has frequently undergone, I saw at once what was meant by the "earth and the heavens" being "changed as a vesture" while awaiting that still greater and more glorious change when there will be entirely "new heavens and a new earth." If I might quote Luther, it was he who said that we now saw this earth only in its work-a-day dress, but that hereafter we should see it in its garments of "glory and beauty." It is only through geology that we can form anything like a clear conception of what awaits our planet *in the future*, because it is that science which alone supplies the means of comparing *the present* with the *past*.

Mr. D. Howard.—I hardly like to rise for the purpose of offering any remarks on Professor Stokes's paper, because I feel that to comment upon so valuable a contribution would, to a great extent, be diluting it. It is a paper we shall all be exceedingly anxious to read, and which we shall read

very carefully when we have it placed before us in print. I do not wish, therefore, to say anything that would tend to diminish its effect; but I must express my sense of its extreme value at the present time, and especially with regard to two points. One is as to the very interesting parable in which Professor Stokes has pointed out, in so vivid a manner, that the study of natural and scientific laws should not stand in the way of the acceptation of a belief in a Divine Creator,—that to believe that God has acted mediately is certainly no more atheistical from a Christian point of view, than it is to believe that He has acted immediately. Why we cling so much to this idea of the immediate action of the Creator is because our minds are unable to grasp the conception of creation at all, and thus we cling to what, in fact, is a negation, because, after all, the conception of immediate creation is a negation. We cling to it, not because it is the greater thing, but because it is the less. I am not desirous of expressing any opinion as to the ideas some persons have indulged in with regard to the supposed modes of creation, such, for instance, as the doctrine of evolution. I believe that the warning given to us against assuming to have been proved what, after all, is but itself a mere assumption in many cases, is one that is very much needed at the present time. And it should not be forgotten that the idea that because animalculæ are bred in putrid substances, all living things are developed by evolution, is not a new one. I was much interested in coming upon a passage which I found in a queer old book of Paracelsus, who says that a piece of serpent which was putrifying produced small worms or serpents, and therefore comes to the broad conclusion that those small serpents, if taken care of, would grow to the full size of the original, from which assumption he goes on to argue that all things are produced by spontaneous generation, especially metals. Now I really and seriously think that in saying this Paracelsus was hardly exceeding in breadth of assumption some of the theories we meet with now-a-days. What we want is patient examination accompanied by trust and confidence in what we ascertain. If we can only trust to our own belief we can afford not to make haste, and if we can afford not to make haste, the time will come when all our difficulties will disappear. One may well imagine that what happened in the time of Galileo,—it is, perhaps a rather hackneyed allusion, but it is nevertheless very true,—is true of the present day; and as we find that a belief in our views of astronomy in no way diminishes the firmness of our Christian faith or belief, why should we suppose that other modern discoveries, if they stand the test of real investigation, can do one whit more of injury to the truth than did the discoveries of Galileo?

Rev. C. L. Engström.—I think those who were present at the last meeting and heard me say how very reckless Professor Clifford was in stating that all scientific men who were competent to judge took up the views he had laid down, will be glad to have had this opportunity of seeing, in the living reality, one than whom we know no person in Europe stands higher as a man of science, but who does not draw from the realms of science the same

deductions as were drawn by Professor Clifford. That Professor Stokes, the successor of Sir Isaac Newton in his mathematical chair, should hold the views he has expounded, and that he should hold them not merely concurrently with his science, but that he should put the two side by side, affords to us one of the best means we have of refuting such reckless statements as those upon which I took occasion to comment. The paper read to us by Professor Stokes is a very just rebuke to the tendency of the present day to imagine that because we are subject to certain scientific laws we are practically *identical* with mere material existence. That we are most *intimately connected* with material existence is a truth laid down in the first chapter of the Bible, in which it is stated that man was made on the same day as the beasts. Surely that is a very remarkable statement. One would have thought that if, as we are told, man was made in the divine image of God, he would naturally have been put by himself, say on the sixth day, while the beasts,—the mammalia and reptiles,—would have been made on the fifth day. But for some reason, we find that man and the beasts were both made on one day, and it appears to me that here we have a statement which goes beyond anything science can lay down as to the fact of our being subject to scientific laws. There we have in the first chapter of Genesis two great facts placed side by side, namely, man's connection with nature as a natural being, and at the same time man being almost joined, as it were, to God by the fact of his being made in God's own image. There are some points in Professor Stokes's paper that I should like to notice. The comparison used by him as to man's body resembling a locomotive, and his controlling mind or will resembling the engine-driver, is beautiful and striking, but perhaps even a better comparison in a kindred sphere may be suggested. Suppose we were to take the case of the pointsman on a railway. The pointsman moves a lever, and the result is, either that the passing train goes on safely, or that there is a frightful collision. There is, of course, a certain amount of muscular energy exercised in moving the lever, but that is not transferred to the result,—by which I mean that the movement of the lever does not accelerate or diminish the progress of the train; it simply changes the direction in which the train is proceeding. Is there not here something very much like the action of the human will? All our energy comes from the outside, if you like, but there is still the controlling will which is represented by the pointsman. Speaking more generally, it is not well for us to be always taking the orthodox side, but where we see a difficulty we should lay it fully and fairly before ourselves, because we may be sure that if it is not thus laid before us here, it will be elsewhere, and it cannot be better examined than in this place. It is with this view that I venture to criticise some statements of Professor Stokes. In the matter of the dissipation of energy, we, of course, see in the vessel spoken of in the paper no possibility of work being done inside except by means of the shutters supposed to be moved by the demons; but supposing the walls of the vessel were removed, work might be done (by all the lukewarm heat

which they had previously confined), affecting something outside that was not even lukewarm. There is another view that may be taken of the dissipation of energy. What *is* this dissipation of energy? It is a change; but is it not accompanied by the production of a real something? You pull a weight up to a height, and it does a certain work, so that the final result is, that an equilibrium is produced, or, comparing the universe to a clock, atoms vibrating at different paces, all come to one uniform pace. Now that this inter-action of vibrations should take place at all is in itself a something—I cannot say what, I cannot even think what it is; but it is something. Is there not a something produced which exactly agrees with that? That is to say, if the dissipation of energy be like the running down of a clock, is there not a corresponding *permanent* gain in the universe? With regard to the nebular theory, this idea must be met. The nebulæ, or star-dust, noticed by astronomers, will, according to modern scientific views, themselves form into systems like this of ours. Well, suppose that a quadrillion of years ago this earth was in the nebulous condition, what was the condition of the present nebulous matter then? And, further, though scientific men generally regard the nebulous as the ultimate original state, we not only see that the now nebulous was once in a penultimate state, but that when this earth, still going back, was in its penultimate state the now nebulous was in its antepenultimate state, and so on. Thus, science alone finds itself lost in a hopeless "*and what then?*" In conclusion, I would urge one or two arguments on the orthodox side. Men of science hold that because a certain law—say with regard to atoms—has been verified for 200 or 300 years it should be accepted. What does this, in effect, mean? That the human mind constructs some theory, and if that theory seems to satisfy the facts connected with it, then it is laid down as a law. Now, I say there is a theory which on this principle has a claim to be regarded as a law of existence far beyond any other—far beyond the theories of gravitation, dissipation of energy, conservation of force, and all the other theories that are supposed to be true—and that is the wonderful theory of an infinite, paternal, personal Being. Why should not this be as likely to be true as any of the theories named, especially as it not only satisfies all the surrounding facts, but by its very nature it accounts for the creation? I say that that theory rests on as solid a foundation as any scientific law; because scientific laws, by the very nature of science as at present understood, do not exist except so far as they can satisfy the surrounding facts. This argument does not, of course, prove that there is a God: it only shows that He *may* exist, starting from the scientific basis. But it must be noted that, whatever matter and mind are, mind is much nearer than matter to our thoughts; therefore the above-stated theory of a Divine existence is more within our ken than that of material existence. Nor must we overlook the immense time, granting, for the sake of argument, the truth of the evolution theory humanity has had for testing and verifying the theory of Divinity, the persistent belief in which

is surely an enormous testimony to its truth. And if a belief in God seems, after all, to be most reasonable, surely a belief in the Incarnation is so also.

Rev. F. N. Oxenham.—I should like to refer to one statement in Professor Stokes's paper, and I may add that we ought all to be exceedingly thankful to him for that paper. I desire to put a question which I assure him I do not put in any invidious spirit. Having spoken of evolution and the difficulties in its way, I understood him to ask whether we can conceive the immense leap required from the very lowest forms of organisation to the highest. I should have thought—and I am here asking for information—that no evolutionist would ask us to conceive any such leap. I always supposed their theory to be that the immense distance between the two was reached, not by one huge leap but by an infinite number of small progressive steps. I should like to make one remark on a question that has been asked by the third speaker to-night. It is this,—Why should we adopt a new mode of treatment in dealing with the material speculations which meet us now on scientific subjects?—why should we be more afraid of them, and treat them in a manner different from that in which we have treated the speculation of Galileo?—I would say there is one very obvious reason for this. Galileo's speculation started with the full admission that there was a personal Creator, and he merely wished to explain in what way this personal Creator had acted with regard to his creatures, whereas there are a number of modern so-called scientific theories that have been started with the avowed principle that there is no personal Creator, and our modern scientific friends seek to give an explanation which shall take the place of the Creator: therefore, in dealing with these modern suggestions, we have simply to deal with a theory, the object of which is to show how we may get rid of the Creator. We are not more afraid of dealing with the one set of speculations than with the other.

Sir Joseph Fayrer, F.R.S.—It has afforded me great pleasure to be here and listen to Professor Stokes's paper. I never heard him to greater advantage than this evening,—certainly never with greater pleasure, and I think that this Society may congratulate itself very much on the paper which he has given us. I do not intend to detain you by any attempt to discuss the very important matters that have been brought before you, but I wish to say, especially as our Chairman seems to desire that I should take part in the proceedings of this evening, how very much pleased I am to state how entirely I sympathize with Professor Stokes's views, and how thoroughly I agree in everything that he has said. I may add that when such papers are read this Society is really fulfilling the objects for which it was designed, and I feel satisfied will do infinitely more good for science than where the object of the communication is to criticise and find fault with people who, while holding certain peculiar views, hold them honestly, and who ought rather to be enlightened and instructed than to be denounced. Therefore it is with great pleasure that I have listened to

this valuable paper, and I, for one, beg to thank Professor Stokes for the information he has given us.

Rev. R. W. KENNION.—Did I understand Professor Stokes to say, that it might be that life could be produced spontaneously, but that he felt there was vast and great difficulty in coming to the conclusion that the minute and low organisms in the germs to which he referred were spontaneously produced, and that still there would be great difficulty in believing how from these germs you could arrive at the higher and superior forms of life? It seems to me that, if you once take the immense leap involved in the admission of spontaneous generation, you have a comparatively small difficulty in taking the very much higher step of going by degrees up and up, until you get to the higher organisms. I am afraid I did not correctly gather the Professor's view upon this subject.

Rev. J. J. COXHEAD.—I should be glad to have some further explanation from Professor Stokes on the question of design. This is, undoubtedly, one of the most interesting and important questions that is now submitted to the scientific mind, and it is one of those positions on which there is the greatest determination to move forward from the quarter of scepticism and unbelief. As we trace the formation of the very highest organism, we undoubtedly see that certain limbs and organs are necessary to the existence of the particular organizations which are found to exist, and, on the other hand, in the process of ages these have been found useless and that they have decayed and been lost. This is the great problem of the present day, and I have never seen an altogether satisfactory answer given to the objections on the other side. Strongly as I object to them, I object to them on utterly different grounds from the so-called scientific grounds. It is not necessary that I should explain upon what grounds I am a believer in Christian revelation, but, at the same time, those grounds do not rest, in their first foundation, on principles of scientific theology. It seems to me that these kinds of truths present themselves to the human mind in different ways, according to the different classes of mind. There are some people who cannot see the necessity for what we call design, whereas others, as strongly, are unable to conceive how it can be that design should not exist in the universe.

Rev. S. WAINWRIGHT, D.D.—No one has yet drawn attention to one or two points in Professor Stokes's paper which I think demand some notice. I was particularly interested when Professor Stokes approached the point at which he put this question tentatively—is it a credible hypothesis, or is it hypothetically credible, that you may take the nebular theory as it has been laid down? In dealing with this it is necessary to see how it was in the first instance regarded by Herschel, and then how the whole theory previously entertained was blown into space by the first look through Lord Rosse's telescope, when it was seen that the nebulæ were not nebulæ, but were resolved into clustered stellar points; while, since then, as Professor Stokes states, through Dr. Huggins's discoveries by means of the spectro-

scope, we have been, to a great extent, led back to the notion that formerly prevailed as to the nebular theory, of which there are some half a dozen varieties. I for one never contest points of this sort if they seem probable. Let it be accepted that some form of the nebular theory has not yet been established, but some day will be,—nay, let us treat it as if it were established, and that we had to adjust or review our ideas of creation in accordance with it. After all you have gained nothing, you have established nothing in contradiction, on the ground of revelation. All you will have arrived at will be some indication of the way in which the various globes have been formed. The Bible says nothing about it, but that there was some one who created the *materia prima* out of which the stars were made ; that in the beginning God was. Take any of the atoms that are non-living, and which the nebular theory has to assume. You get them subject to certain laws of condensation and rotary motion, and you find them throwing off outer rings until you get an earth and various planetary relations ; but when you have got it you have got nothing that ever did live or that ever will. But the world we live in is not one of that sort. Here you must come to something beyond the nebular theory, and if you get in one case a world in which there is a moisture, and sea, and sky, but not a fragment of moss or lichen, while, on the other hand, you get a world in which there has come to be a little bit of vegetable fibre, although it be not more than an inch in length, there is between those two worlds a chasm which is to be measured only by infinity. You have here the evident design of God ; that He has done this ; that you have something you have not got in your laboratory ;—something no man can produce, and that if you say God does not exist it is necessary for you to invent Him. You are bound to assign a cause adequate to the production of the effect. Look at these gases ! They will not combine except in a certain way. The late Clerk Maxwell, who probably knew more than any other man now living on this subject of atoms and original molecules, has told us that the primary atoms bear all the marks of a manufactured article. I remember Dr. Carpenter writing to the *Athenæum* and dealing with the theory that, under certain conditions, from mud and slime and ooze, you could produce the living from the non-living. But Dr. Carpenter says,—let every condition of electrical or chemical or other force be granted, still the production of the living from the non-living is not probable ; and he adds, with our present knowledge on the subject it is absolutely inconceivable. Dr. Carpenter is admitted by Mr. Darwin to be one who probably knows more than any other on this subject, and I say that, for the creation of the original atoms, for the creation of the manufactured article, you may have got your world of atoms, but you have nothing that can live ; but when you get a vegetable fibre you have got something which is wholly different, something due to an unknown force, and I ask, what is it that makes that fibre grow ?

Capt. F. PETRIE.—I am sure I am expressing an opinion which will be

echoed by our members and friends at home and abroad, when I say that this paper must be regarded as being one of the most important ever brought before the Institute. It is eminently a scientific paper, by one in the very highest rank of scientific men, which tends to show "that there is no discrepancy between the book of Nature and the book of Revelation, if rightly interpreted." In the present day there are some few men of science, and many quasi-scientific men, who seize upon questions of philosophy or science said to militate against the truth of Revelation, and who use such in the most unscrupulous way to undermine the faith of the world. We hear of their publications, generally written with this purpose, many issued under the auspices of Secularist societies, reaching readers in every clime.* One of the main objects of the existence of the Victoria Institute is to stay this evil; to examine these questions of philosophy and science in a careful and impartial manner, and to give the results to the world. Such work in the cause of truth claims the highest talent that the Society and its friends can bring to it.

Professor STOKES.—Considering the lateness of the hour I will say but a few words. With regard to my illustration of the possibility of conceiving, in the manner shown by the late Professor Clerk Maxwell, the redistribution of energy, I should observe that the matter contemplated was thought of as contained in a vessel merely for the sake of clearness of conception. In application of the illustration, the contents of the vessel are supposed to represent the universe in the supposed ultimate condition to which it tends as a result of the dissipation of energy. One of the speakers asked me whether I contemplated a leap, at one bound, from a very low organism to a high one? It certainly never entered my head to do so. That is not what evolutionists suppose; on the contrary, thousands and millions of years have passed during which, as they say, these changes from one form to another have taken place with exceeding slowness. What I meant was, that I did not think that the minor changes of form of which alone we have any experimental evidence, such as those of varieties of animals or plants in what are deemed the same species, gave us any warrant for assuming, as a thing even probable, much less established by a fair amount of evidence, that the enormous interval which separates one of the higher creatures,—say man himself,—from some low organism, was, in fact, bridged over in the past by a succession of such changes. I was also asked whether I meant to say that I allowed the existence of life as springing from dead matter, and merely said I could not imagine the higher creatures as springing by the mere self-action of matter, even though organised matter of some low form were thus created. I certainly did not say I accepted the production of life from dead matter, but, on the contrary, expressed it as my opinion that the best experimental evidence

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* The Indian and Colonial press is also now much used by these societies.

on this difficult subject went the other way; but I did mean to say that even supposing that to be the case, for argument's sake, I could not accept the production of a higher form from mere molluscs or anything of that sort. I think there are insuperable difficulties in the way of those who would maintain that all creatures, the highest—man himself,—included, were produced from inorganic matter simply running into form of its own accord. As my mind is not of a metaphysical, but rather of a practical cast, I have not gone into the metaphysics of the question as to design in the existence of mathematical truths and things of that sort. The way in which I look on design is very homely. I regard it much in the same way that was mentioned long ago by Paley in his *Natural Theology*, when he spoke of the difference between a man's impression in picking up a stone on a common and in picking up a watch. Possibly the man would merely say with regard to the stone that it had been there for ever, but he would not say the same of the watch. With regard to one expression in reference to the molecules having all the stamp of a manufactured article, I should state that when Professor Clerk Maxwell used that expression, he quoted it, if my memory serves me rightly, as a saying of Sir John Herschel's. He adopted it, of course, but it was a saying of Sir John Herschel's. There are some other points, but as it is already so late, I will not dwell upon them, as I should only be wearying you.

The meeting was then adjourned.