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ORDINARY MEETING.*

THE PRESIDENT, SIR G. G. STOKES, BART., IN THE CHAIR.

The Minutes of the last Meeting were read and confirmed, and the following Elections were announced :—

ASSOCIATES:—Rev. H. E. Bevan, M.A., Cantab., Gresham Professor of Divinity, Middlesex; Rev. G. B. R. Bousfield, B.A., Oxon, Middlesex.

The following paper was then read in the Author's unavoidable absence in the United States, by Mr. J. W. Slater, F.C.S., F.E.S.

THE MECHANICAL† CONCEPTION OF NATURE.

By GEORGE MACLOSKIE, D.Sc., LL.D., Professor of Biology in Princeton College, U.S.A.

MATTER and energy, which are distinct from and constantly acting upon each other, constitute, along with their various transformations, the stock-in-trade of physical science. The scientific investigator may not feel bound to go back of them, so as to ask whence they come and who gave them their qualities; he has not to philosophize, but only to *speculate* about them, testing his speculations by observations of phenomena. He may speculate about matter having been at first in the shape of scattered atoms, subject to the pull of gravitation, this pull being "energy of position," and as the atoms came together into molecules, and ultimately into worlds, the energy of position was transformed into other forms of energy.

The leading generalization of science is that neither matter nor energy is alterable as to the total amount in existence. But this is qualified by the facts that whilst matter is constantly collecting into masses, all kinds of

* 5th of 29th Session. Discussion completed November, 1895.

† The word "Mechanical" is understood as having the meaning of "Physical and Chemical."—G. M.

energy are changing into light or heat, and light and heat are being dissipated into space, with a tendency in the end to equalize the temperature of the universe. While energy is changing from one form to another, as while heat is passing between objects of unequal temperature, it may be made to do work which is measurable in units. A machine is a contrivance for getting some kind of motion or work out of it in the course of its transformations; and the mechanical conception of nature signifies that all the physical movements and phenomena of the universe have been derived from the interaction of the matter and energy which are its constituent factors.

This theory may be held in a theistic or an atheistical sense. The atheist may hold that the physical world is the only world, and that nothing else exists. The theist may hold that even admitting all that the mechanical theory asserts, there are ethical and orderly phenomena in nature, not coming under the measurable categories of matter or energy, yet proving that there is close to us an extra-physical world, with extra-physical beings, and that there is a God before all and over all.

Though energy is indestructible, its constant dissipation is a continual loss for all practical purposes. Fifty years ago scientific men supposed that the world had been going on at the present rate from everlasting. Lyell admired the "sublime" view of the past history of our globe being an eternal round of similar cycles of geological formations, never beginning and never to end; and this was the scientific view of cosmogony taught in the text-books and encyclopædias. But it is now omitted as belonging to exploded science; since it was shown by Thomson that our universe probably had a beginning, and with equal probability is moving towards its conclusion. This depends on the puzzling fact that whilst many processes in nature can be reversed, by calling in new energy from the environment, the mechanism of nature as a whole is not reversible. If a plant has its starch converted into sugar which is dissipated through the sap, it is able to reconvert the sugar and collect it again as starch. But why the cosmos is not a reversible machine we cannot tell. Clerk Maxwell somewhere suggests that as heat is only the general or average result of molecular movements, an inability to controvert the individual molecules puts the recovery of the general result beyond our reach. But how does it come that the process is never reversed

in nature, which has control over all the molecules? Why do we never see the dust of the graveyard come together into skin and flesh, and the bones reassemble, "bone to his bone," and the life and warmth return, so as to present us the living man, and the old becoming young again, reversing the process down to the ovum, and back through several generations? and why does our sun not receive back all the heat that it has scattered over space? This inverse process, though never observed, is, scientifically speaking, as easily conceivable as is the ordinary course.

The considerations which apply to the entire universe are with proper limitations applicable to any part, as to our earth or to the microcosm of our body.

The earth and our body are, in whole or in part, machines at work, and a great deal more, and the task of science is to watch movements, transformations, and developments, and to formulate them into "laws of nature." These laws appear to be absolutely uniform in their action, to amount in fact merely to transformations of energy. The objection taken to physical law in general and to the *uniformity of nature*, as being only working hypotheses and incapable of demonstration, is, we think, misleading. The uniform action of natural molecules and forces is the basis of all science and of all animal movements, and has never been known to play us false; so that the unchangeable behaviour of the laws of nature is as well established as human experience can establish anything. But a *uniformitarian* theory, holding that the sum total of activities in a particular place, as on the surface of the earth, has been the same at all times, is no part of science; such an assumption was helpful to Sir Charles Lyell, and within limits had an element of truth in it, but it very often led him astray. Most of the attacks on Christianity that profess to be based on the doctrine of uniformity of nature, really involve uniformitarianism.

The general outcome of scientific discovery has been not only to verify the uniform action of natural law, but to bring larger provinces of nature into the realm of mechanism; so that every new discovery becomes a contribution towards the mechanical theory. At the outset the search was random, often after what we now deem impossibilities. But though it never alighted on perpetual motion, or the elixir of life, or the philosopher's stone, it was not lost labour. One class of phenomena after another came to be understood relatively to their conditions and physical causes. The astrologers

sought for the horoscopes of their patrons, with exalted faith as to the superiority of the heavenly bodies above everything terrestrial. But to the surprise and disgust of some of them, their labours proved that the planets are not very different from the earth, and that celestial movements are mechanical; and they were compelled to settle down to observations and mathematics, as commonplace astronomers. When Newton investigated the forces that drive the machine, and Laplace finished off his *Mécanique Céleste* with his nebular theory, regarding the early development of the solar system as through a kind of physico-chemical embryology, and when their successors ascertained that gravitation-bonds and spectroscopic lines annex the movements and matter of distant stars to our system, the conquest of mechanism over the heavens was complete. At the same time the dreams of the alchemists by a singular metamorphosis grew into the science of chemistry. And chemistry has reduced all terrestrial things, living and dead, to the sway of its molecular and atomic sovereignty.

The stimulus given to inductive research by the writings of Francis Bacon, and by the establishment of the Philosophical Society in the time of the English Commonwealth, sent many inquirers to examine the minerals and rocks and the old puzzle of the fossils. There was a good deal of groping in the dark, and many theories arose to stir up controversy and at length to rock the cradle of infant geology. The sharp discussions attracted the public, who always enjoy seeing learned men set by the ears; the young science that excited so much controversy and feeling grew in favour, thriving on its difficulties; and when Lyell worked it out on the mechanical plan, discovering as Whewell has aptly said, "a new set of physical powers which we may call *geological dynamics*," men came to see that God's way of forming the stratified and other rocks of the earth's crust was by the employment of nature's machinery.

If for the moment we regard our world as devoid of living things, it is presented to us as mechanical throughout; its rocks, minerals, and chemical processes; its waters and meteorology; and the skies overhead with planets and suns. This starts the question whether such a world can bear testimony to God. Is the Psalmist justified when he declares that the heavens declare His glory? May we not suppose the order to be merely a result? What need is there of final causes where the efficient causes suffice? Recent writers on Theism

show a tendency to confine their arguments to the organic world, omitting the confessedly mechanical, which is by far the larger part of the universe; as if they supposed that a dead world is not sufficient to prove a living and intelligent God. But the order of the cosmos, the original characters and harmonies of the many millions and millions of atoms, and their relation to energy, their capacities for continuing in extraordinary yet definite and well regulated ways, all point to the necessity of going beyond them for their common origin. If the question of their origin does not properly belong to physical science, it certainly has an important place in philosophy and in the region of human faith, and thus has a claim on the attention of every man, and we cannot rest till we reach some unifying hypothesis, like that of the Divine Personality. Behind this hypothesis we cannot go, *since all genetic lines when traced backward lead to it as the ultimate cause.* The order of the universe may have been evolved according to Laplace's theory; but why were the molecules so constituted and so situated as to come naturally into this order? here the wisdom and will and power of the Author are all shown. So strong is this argument that all who reject it are compelled either to fall back on something which involves greater difficulties, or to evade the issue by pleading Agnosticism. The mechanical theory does not dispense with the argument for theism, any more than the successful working of a machine negatives its production by an inventor and its control by a superintendent. Even when it works imperfectly we may not in a dysteleological way argue from its defects that it had no inventor. Hence it does not exhaust the case to declare that a steam engine has a complete explanation of its going in its own mechanism, the fuel and water included, so that if these had all come together by accident it could still go, and if by similar accident rails were on the road, it could guide itself without having a horse in advance, not to pull it, but to direct its course, as (*vide* Lyell) the inventor of the locomotive at first proposed. Yet most surely the perfection of the mechanism would not debar us from endeavouring to find its inventor and director. It is objected that we should see the finger marks of the engineer in his work, and in rectifying its aberrations. But nobody has ever detected the finger marks by which our own mind governs our brain and our bodily organism; and it is improbable that God is more clumsy in His methods than is the spirit of man.

Francis E. Abbot condemns the application of the term *machine* to the cosmos, suggesting in its place the term *organism*, which he makes to be a machine and something more, the addition being that internal ends are provided for. We think that when regarded in this light, the term *organism* equally misses the mark; the physical world includes all organic nature as well as inorganic, and is higher than the highest of organisms, as the whole exceeds its greatest part. But here we meet the fact that there is a great deal of mechanical structure in the human as in any other organism, and that the diathesis of the contemporary scientific mind is to make us entirely mechanical. Living things dwell on a mechanical earth, are subject to gravitation, heat and cold, contain lime and carbon and much water, and thus have much community with their environment. For a long time it was supposed that the souls of plants and animals lifted them in a semi-miraculous way above natural laws, that their parts and powers were somehow created by the "vital force" within. Mental phenomena were supposed to have no connection with the body, save that of locality.

Another class of thinkers were bold enough to turn all the forms and functions of the body into machinery; to regard our frame as a large hydraulic machine with its accompaniments. Geometrical figures and algebraic formulæ were invented and applied to all organisms; to explain the parts of flowers, the arrangements of leaves, the forms of shells, the vertebræ of animals, the action of the heart, the affinities or homologies between distinct species. These speculations, though many of them now seem ridiculous, sustained the interest of students, and fostered research. The discovery of the embryological method of investigation, and of the method of representing heat by its mechanical equivalent, introduced a new order of work both in morphology and physiology. We have found that the plant manufactures food and stores up energy which it has got from the sunshine, a process that is probably mechanical, or at least physical, though it is not yet fully understood. The activities of our body are as completely explained by the food which we consume as is the work of a steam-engine by the coal and water which are its food. It is in this way ascertained that the daily food of an able-bodied man will give as much energy as, if converted into its weight-equivalent, would raise his body about nine miles high; this energy is used partly to keep up his temperature, replacing loss by radiation and evaporation, part of

it for moving the organs of his body, part of it in external work. We can, therefore, compare him economically with the efficiency of a steam-engine; it is only particular kinds of fuel that you can give to him; but a loaf of bread and a pound of beef will give you more work if used as food by man, than if you had applied them to heat the boiler of a small steam-engine. It is found that the activity of muscles and nerves is dependent on a supply of blood containing nutritious matter; that electrical phenomena are observed; and that the muscular activity probably depends on a series of explosions with oxidations, which may be compared to the action of a set of minute gas-engines. The sense-organs and nerves resemble very closely a system of telegraph wires with their terminal key-boards. The semicircular canals and organ of corti in the ear, though not yet fully explained, have a correlation with the wave-lengths of sound; and the eye includes in itself a whole system of optics, its lens giving fine exercise in determining focal lengths, with chromatic and circular aberrations and corrections, and the retina, with its rods and changing visual colours, suggesting that it must be an instantaneous photographic camera. The victory of the mechanical theory over these organs is only partial; but all the same it is significant.

As might be expected, theory at this part has run ahead of discovery. Some people venture to assert the mechanical (or at least chemical) evolution of life from dead matter. In ancient times it was the sceptics, like Lucretius, who denied spontaneous generation. Christian teachers were rather disposed to favour the idea of worms growing spontaneously within human beings, of frogs being within trunks of trees and rocks, of reptiles coming from the slime of the Nile. They have latterly come to oppose this doctrine, and the most advanced scientific investigators agree with them in their opposition. Professor Huxley, when before the British Association he threshed to death the theory of spontaneous generation, wound up with "an act of philosophical faith" that after all, life may have arisen spontaneously in early geological times.* This would help him against the theists who are continually tormenting him with their notions of the necessarily supernatural origin of life. Mechanism has not yet explained how life began, any more than how matter and energy began. So the theory is not entirely successful.

* Brit. Ass. Rep., 1870, p. lxxxiv.

But though life may have been of supernatural origin, its subsequent working and progress may be purely mechanical.

Mr. Darwin's theory of the origin of species was an attempt assuming some simple vegetable and animal forms as a starting point, to derive from them in a mechanical way all the forms and functions of existing vegetable and animal life. Without going into details on this subject, whilst acknowledging both the strength and weakness of Darwin's theory, and that it assumes many factors which are not known to be mechanical, we have to face the fact that it has convinced the biologists, securing the general, though not the universal, assent of the only men who are able to deal with its arguments, many of whom would be glad enough to subvert it, if they only knew how. Though not entirely mechanical, it has unquestionably been a great gain for the mechanical conception of nature, just because the existence of many thousands of distinct species was formerly the chief argument on the other side.

Assuming evolution of species to be true, the irreducible cases are, besides the origin of matter and energy, and the general order of the universe, the origin of vegetable and animal life, of sensation and intelligence in animals, and, furthermore, of self-consciousness and the moral faculty in man. We must also provisionally regard the origin of the human body as among the unreduced cases; for although the evolution of man can be deductively obtained from the general theory, and its advocates appeal for confirmation to anatomy,* and although such a doctrine is readily reconcilable with the scripture narrative of man's creation, all attempts to find geological verifications have failed; so that, if man was evolved, the process must have been very rapid, or must have occurred in some region not yet explored; and, indeed, it is hardly conceivable that such a being as Haeckel's *Pithecanthropus* would be viable in the struggle for existence. The attempt to reduce *mind* to a mere synonym for the functions of the brain is based mainly on the relation between insanity and cerebral disease; and is supported in some degree by the localization of functions. But Professor John Fiske's argument appears to us conclusive, that our inability to turn

* At the same time Topinard shows that it is impossible to derive man from the *Quadrumana*, and that it will be necessary on the hypothesis of his evolution to start from the lower level of the Lemurs. (*L'Homme dans La Nature*, ch. xxii.)

thought into exact quantitative equivalents of mechanical force negatives its homology with merely physiological functions.* Bain's rejoinder that we cannot reduce to such equivalents a man's constitutional vigour fails, because this vigour is the complex result of the working of all the organs and tissues, and its component factors may be measurable. Whilst the weight of evidence appears to negative the purely physiological explanation of mind, we should not only be tolerant of, but encourage investigations that look in a different direction, as we are indebted to them for large accessions to our knowledge of physiology.

The so-called "organic compounds" were at one time supposed to be obtainable only from living objects, but now many of them can be artificially prepared, some to economic profit. The study of "physiological psychology," that is, of the functions of the brain from the physiological side, has already proved valuable. Ryder has shown that the calcification of bone is comparable with the calcifications around encysted trichinæ, and is more of a physical process (depending on the behaviour of calcareous salts in colloids), than exclusively vital. Bütschli has found the movements of living amœbæ to be imitable by olive oil kept in moderately warm water, from which it is inferred that the movements of protoplasm are partly or exclusively physical. It is also now known that the non-coagulation of the blood sucked in by a leech is a physical phenomenon, which can be imitated by keeping blood in vessels lined with oil. These attempts to approach the problem of life and of mind from the chemico-physical side mark the limits of the mechanical conception of nature as actually established. There has long time existed deep apprehension among Christians regarding the tendency of this kind of science. What we have now to face is not a remote risk, but a state of facts. If the mechanical theory means ruin to faith, then the deluge is upon us, only a few fragments (very important ones indeed) remaining to carry us to land. Now it must be conceded that mechanism has often been associated with atheistic materialism, and that atheists have welcomed such mechanical explanations as promised to explain the world without a God. The same consideration has led Christians to fight shy of Astronomy, Geology, Physiology, and recent advances in Biology, and to discountenance investigations and theories which promised

* *Popular Science Monthly* (New York), Sept., 1891.

to explain the world too well, lest science should explain away our God, and leave us ignorant where to find Him. Even those who are liberal enough to concede the consistency of mechanism and theism, fear the effect of the new science on our faith in the Bible, and especially in the great miracle of the resurrection of Jesus Christ; a fear which has been intensified by attempts to account for all the miracles as natural occurrences or unfounded traditions. But whatever view may be held of the origin of mind, whether we regard it as a derivative under Divine direction from the material organism, or as a substance primitively created apart from matter, we are compelled by its actual phenomena to assign to it a certain measure of independent activity as to the moral quality though not as to the physiological quantivalence of cerebral action. We presume that the cerebration of the evil disposed is as great quantitatively as that of the well disposed, and that the cerebration of an idiot involves as much expenditure of blood and brain-tissue as that of Newton; but there are moral and intellectual scales by which brain-work must be weighed, independently of its chemico-physical value. In man as well as beast there is much of the mere machine or automaton; and some have gone so far as to accord to the lower animals some measure of intelligence and will and often of "social virtues" which are found more liberally in ourselves. There is no special evidence of a soul in the lower animals any more than in plants; but in consideration of man's moral endowments and aspirations, the science which has invented ether as a vehicle of light, regarding it as a specially active form of matter, ought not, even on a mechanical theory of mind, to reject the hypothesis of something that shall carry our personal identity, with our faith and our joys, into Heaven. This is a subject beyond the scope of inductive science; but there seems no ground for fear that our hopes of immortality are at stake, if we accept the mechanical concept in its entirety.

The problem of miracles is frequently brought into the case, though not strictly pertinent. We do not think that any conceivable amount of evidence would convince us that a man rose from the dead at Jerusalem within the past year, or that we could be led to accept any of the mediæval or modern so-called miracles in support of corrupt cults; and pure cults make no claims to miracle-working. Thus in the ordinary course of nature we have no dispute with Agnostics

as to the incredibility of miracles. The Bible-testimony for miracles is made to depend on the character of the Bible-revelation, with which they stand or fall. The believer in the mechanical theory of the physical world may be justified in acknowledging on appropriate evidence the existence of an extra-physical world, with hosts of spiritual inhabitants, as well as in God, the Author and Governor of all: and that there may be, not physical, but equally effective means of communication between that world and our minds. Now if we have sufficient evidence in the pure and holy teaching of scripture, that it is a revelation from God, and that His Son came down to redeem us from our sin, then the absence of miracles might prove a difficulty, evidence of their occurrence is admissible, and they may be consistent with and confirmatory of the religion with which they are associated. They are the suitable accompaniments of a unique manifestation of the Divine love; and we do not know whether they were accomplished by reversing, specially diverting, or expediting natural processes, or by supplementing them with other laws, or by pre-appointed combinations at the outset of the world. The Bible that records them warns us against strange miracles, and honours the laws of nature by designating them as "the ordinances of heaven." These laws and forces are all God's appointed instruments, which He uses according to, and not in violation of their proper character, for the execution of His purposes.

It still remains true that the more perfectly we establish the mechanical mode of viewing things the less prominence is given to their Maker. The old arguments of natural theology are said for this reason to have lost their vigour, and hence the excellency of the cosmic system becomes a hindrance to faith. This, however, is only apparently the case, for the mechanism requires the explanation which was once spent upon its products. Once we tried our hands on explaining how a watch was made; now we are asked to account for the machine that makes watches, and that is always improving on the quality of its products, which it does according to natural selection by producing them in large numbers and of different qualities, and then securing the destruction of all but the best. In the childhood of science we investigated particular objects; now we consider not the teleology of organs, but of the underlying dynamical principles which produce them and regulate their development.

Many attempts have been made to banish from science the consideration of *teleology*, or purpose in nature. Investigators were afraid to employ teleological language, and whenever they drifted into it, they soon backed out, apologising for its momentary use. Their shyness has often prejudiced their work, for as Gassendi said long ago (with the case of Harvey's teleological work on the circulation of the blood fresh in his mind), "the final cause often leads to the discovery of the efficient cause." Now, however, the advance of the mechanical view is forcing teleology upon our attention; for if the universe is a machine, it is by the same reasoning known to be a complexity of sub-machines, every one of which has its own purpose to serve. Hence we find Sachs, who has done more than any other man to apply the mechanical theory in botany, and who is not hide-bound by theology, pleading for the right to use the word *purpose*, calling it "a word which many fanatics of the theory of descent would, if possible, banish from our language," and adding that the whole of physiology is taken up with such questions. (Sachs' *Lectures on the Physiology of Plants*, Lect. I.) Huxley has made the discovery that physiological phenomena can be expressed in the language of teleology. (Huxley on *The Crayfish*, p. 137.) And though, like Sachs, he falls short of the theistic significance of this, he has more recently stated (in the chapter he contributes to the *Life of Charles Darwin*), that whilst Darwinism abolishes the commoner and coarser forms of teleology, it really reconciles teleology and morphology. In this sentence he adopts (perhaps unwittingly) the beautiful expression by which Asa Gray showed at once his Darwinism and his faith, viz., "Let us recognise Darwin's great service to natural science in bringing back to it Teleology, so that instead of Morphology *versus* Teleology, we shall have Morphology wedded to Teleology." (Asa Gray, Letter in *Nature*, June 4, 1874.) Weismann argues in his *Studies of Descent*, that the mechanical conception of nature favours teleology, thus, "The harmony of the universe, and of that part of it which we call organic nature cannot be explained by chance. Mechanism and Teleology do not exclude each other, but are rather in mutual agreement. Without Teleology there could be no mechanism, but only a confusion of crude forces; without mechanism there could be no Teleology, for how could the latter otherwise effect its purpose?" And quoting Von Hartman he says that, "the most complete mechanism conceivable is likewise the most completely con-

ceivable Teleology"; and adds Von Baer's definition of the laws of Nature, as "the permanent expression of the will of a creative principle." Charles Darwin's letter to Asa Gray, written in 1860, agrees with these views and with the stricter theology, though he knew it not. He wrote: "I am inclined to look at everything as resulting from designed laws—with the details left to the working out of what we call chance." The theologians say that under Divine Providence things "fall out according to the nature of second causes, either necessarily, freely, or contingently."* Darwin would save his use of the term *chance*, as only so relatively to our knowledge, and the theologians would explain that neither free will nor contingency is independent of the Divine bounding. The arithmetic of expectations and probabilities, as applied by actuaries to matters depending alike on free will and fortuity, seems to show that these things are somehow under law, though not in a fatalistic way, and that Darwin and the divines are at one with each other and with the truth: nor ought this argument to lose its value, if it appear that in later years Darwin's difficulties rather increased, for he was often bewildered, so that he could not see his way. As to his chief difficulty, of there being too much misery in the world, Bishop Temple has remarked that Darwinism itself has rather helped us to meet it, by showing that we are looking on a work not yet finished; and besides this there is no evidence that misery was the end in view for any part of nature's machinery. W. Thistleton Dyer briefly gives the verdict in which all these witnesses are agreed, when he writes to the Duke of Argyll thus: "No scientific man is so foolish as to suppose that, however completely mechanical may be our conception of nature, he is in any way competent to account for its existence. The real problem of all is only pushed farther back." (Dyer, Letter in *Nature*, Jan. 16, 1890.)

The bearing of the mechanical conception of the universe may thus be summarised: 1. It is actually or provisionally established, save as to the origin of matter, of energy, of life, animal intelligence, and the body and soul of man. 2. It will not weaken, but rather fortify the evidence for design in nature, for theism, and for universal providence. Thus it is not materialistic, though it is accepted by some in a materialistic sense. 3. It will not invalidate the Divine claims of

* *West. Conf. Faith.* v. 2; discussed in Cunningham's *Reformers and Th. of Reformation*, p. 493.

scripture; though it may favour naturalistic interpretations of the cosmogony, the deluge, and some other parts, in accordance with geological discoveries, and as suggested in the Bible itself. 4. It will fortify the proper miracles of scripture, by showing that whilst incredible as part of the ordinary course of nature, they may be a unique case, bound to stand or fall along with the Divine character of redemptive revelation. 5. It will not weaken faith in personal immortality, or in the operations within us of Divine grace, or in the existence of an unseen spiritual world; but it may favour the opinion that the human soul is derived from and dependent on some physical substratum. 6. Whilst recognising God's continued control over all parts of nature, we do not understand that His control involves any disturbance of natural order or movements (that is to say, the free acts of men are in some sense their own and not God's, though men are dependent on Him for the exercise and limitations of their liberty); nor that He is the only worker. Nor do we expect ever to understand how He is able to operate upon nature. We can operate upon our own bodily organism, and thence upon the external world; but we cannot tell how, except that we act in harmony with natural laws. The fact of the Divine intervention is equally credible, and its mode must for ever remain equally inscrutable.

The PRESIDENT (Sir G. G. STOKES, Bart., F.R.S.).—I am sure I may convey your thanks to Professor Macloskie for his learned paper. I must not forget also to ask you to thank its reader.

J. W. SLATER, Esq., F.E.S., F.C.S.—Of course all present will be more or less familiar with the speculations of the late eminent physicist, Siemens, on the return to the sun of the energy which it emits; but no one, I believe, has ever detected the existence of any such recuperation:—At the third page of the paper the author says: "The earth and our body are, in whole or in part, machines at work, and a great deal more, and the task of science is to watch movements, transformations, and developments, and to formulate them into 'laws of nature.'" These reservations "are in whole or in part machines at work and a great deal more" go far to exclude organism from the purview of a merely mechanical con-

ception of nature, as they include the characteristic attributes of life. In reference to page 222, the Egyptian papyri show that in ages past chemistry has had an existence prior to alchemy. This fact is precious as being fatal to more than one of the theories of Comte.

Rev. A. K. CHERRILL, M.A.—On page 227 the author makes the remark, “the same consideration has led Christians to fight shy of astronomy, physiology and recent advances in biology, and to discountenance investigations and theories which promised to explain the world too well, lest science should explain away our God.” Now it seems to me that with regard to the mechanical conception of nature, perhaps if one takes it in a very crude and superficial sort of way it might be thought to explain the world too well and to explain away the necessity for a Creator: but on the other hand I think that if you pursue the mechanical theory of nature into its minute details it rather has the reverse effect. An instance occurred to me which seems rather a strong one, in reading Weismann’s *Germ-plasm or theory of Heredity*. If one looks at the general theory of development and evolution in the light thrown on it by embryology in a somewhat vague and superficial way I suppose one gets hold of an idea something like this. Embryologists tell us that the life of the individual represents, on a small scale, the life and development of the whole race. We ask what is the starting point of life of an individual and they tell us, quite correctly, that it is the division of the germ itself, first of all into two cells which after further division gradually give rise to the various parts of the body. First there is the division of one cell into two cells, and those who wish to explain away the mystery of nature may think they have got hold of something very simple here—that the origin of life is just the division of one cell into two like the division of a single drop of oil into two drops; and then they may imagine that further development takes place by a continual repetition of the same simple process. It does not seem to require any great power to bring this about, and if we could start our conception of nature on anything so simple we might perhaps be able to build it up without appealing to any supernatural power. But when we come to look at the mechanism of nature in detail such a notion is at once upset. For what is this first process that brings about the simple division of a cell? Weismann gives a

description of it, which shows it to be a process of most extraordinary complexity.

First you have the nucleus of the cell forming itself into a sort of spiral coil, then the coil breaking up into eight separate little lobes, and then the formation of two spiral centres and a radiation from those centres of extremely fine fibres, these fibres getting hold of the lobes of matter and dividing the contents of the cell into two parts, and finally selecting those parts according to their nature, so as to divide the whole of the matter into two separate portions of equal size but of different properties, so as to make two cells out of one, not merely by dividing it in halves but into two cells of different properties, so that one develops in one direction and one in another. All this is extremely complicated and extremely wonderful, and all taking place within a minute cell which almost defies the power of the microscope to distinguish it. Where does all this wonderful mechanism come from? We can hardly suppose that it made itself. I do not see how we can say that it was evolved out of something simpler, because this is the beginning, the first step. So it seems to me when I look at the wonderful things we find in nature, they really do not lead us to suppose that we can explain the world too easily and find no need of a Creator; but rather, perhaps, on the contrary, that the world is not by any means so easy to explain as some think it is, and that the very simplest operation of nature—the very first germination of a spore—is such a very complicated operation, that it requires, if not Divine power, at any rate a power infinitely transcending anything that we can imagine, or that the human brain can conceive, to carry it out. (Applause.)

Rev. F. A. WALKER, D.D., etc.—There is a passage on page 228, where it is said, “we presume that the cerebation of the evil disposed is as great quantitatively as that of the well disposed, and that the cerebation of an idiot involves as much expenditure of blood and brain tissue as that of Newton.” I should like to know if this has been proved beyond dispute. We know at any rate that the brains of many distinguished men have been of exceptional weight. That of Cuvier, the naturalist, who has been mentioned to-night, was found to be over the average bulk or weight.

Dr. A. T. SCHOFIELD.—In reference to Cuvier’s brain, I may mention that weight is not always a sign of great intelligence.

There is a case known of the brain of a washerwoman in Germany which weighed 64 ounces (greater than Cuvier's), and she was known to possess no remarkable intelligence. I have to notice one or two points of interest in this paper. In the closing sentence of the first paragraph on page 220 the author says: "A machine is a contrivance for getting some kind of motion or work out of it in the course of its transformations; and the mechanical conception of nature signifies that all the physical movements and phenomena of the universe have been derived from the interaction of the matter and energy which are its constituent factors." "All the physical movements," and it goes on to say, "this theory may be held in a theistic or an atheistic sense." Then there is another sentence on the last page but one of the paper being summary No. 1. "It is actually or provisionally established" (it is the mechanical conception of nature that is being summarised), "save as to the origin of matter, of energy, of life, of animal intelligence and the body and soul of man." I presume those are the organs he is referring to.

The point I should like to bring out and emphasise is that life in its action, as well as in its origin, is not mechanical. Life is a power that directs the movement of bioplasm or protoplasm in a certain way. The very fact of saying "I am" at once transcends the mechanical conception of nature. The world and life are not mechanical toys of superior construction, but a great deal more; nor, on the other hand, though recognising a beginning and an end, is the recent description of the universe by Professor Huxley a correct or adequate one: "Natural knowledge tends more and more to the conclusion that all the choir of heaven, and furniture of the earth are the transitory forms of parcels of cosmos substance wending their way along the road of evolution from nebulous potentiality back to the indefinite latency from which they arose."

Law is not a force—only an observed sequence, and the reason why there is so little apparent change, and that these natural laws are so fixed, differing thus from human laws, such as the English common law, is because of the perfect wisdom that has the ordering of them. If we define motion it implies energy, and energy implies will, and will implies mind. Inertia is the property of all matter, but energy and action are the properties of all mind. Nothing *must* be; nor can we say that anything is supernatural. Natural laws may act regularly for any time and then change. An

inhabitant of the tropics who had never seen ice might think that water was always liquid, while an inhabitant of the North Pole might say that all water was solid because he had never seen it in its liquid state, but the change from the one state to the other is not supernatural. So with one who had not seen the transformation from the grub to the butterfly. It would be supposed by us, naturally, that a heart always beats in one direction and forces the blood in one channel; nevertheless the heart of some ascidians beats in one direction for some time, and then reverses the process and beats in the opposite direction. Even mechanical machines may be made to change irregularly with uniform forces acting on them. Babbage's calculating machine counted to 100,000,001 in perfect order, then jumped 100,000 (viz. 100,100,002) continued for 2,761 terms, then changed again for 1,430 terms and then again for 950 terms of the third order. I have merely adduced these instances to strengthen the conclusion at which I wish to arrive. I believe that all the phenomena of life we see, however irregular they may appear, are the result of the uniform action which we call natural laws. These are, as I have said, the active phenomena of life. But are they mechanical laws? If so under what branch of mechanics can they be ranged? Take the laws that govern reproduction. The codfish, for instance, lays millions of eggs. The male of another fish (the *Arius Bookei*) carries 12 eggs of the female in his mouth till they are hatched. What conception of mechanics is there in those two observed phenomena of life. I would suggest that although definite laws plainly regulate the ordinary course of animate nature, others equally definite may not yet be fully understood by us, and both certainly imply a law giver who has power not only to plan but to suspend or alter their action. I would therefore regard the laws of God as uniform rather than mechanical in their action, and that the law giver has power to suspend or to alter this action, and, moreover, that there is in man the power of mind, that can direct or modify some of these natural laws at will, and this in an entirely non-mechanical manner.

In conclusion I would emphasise the fact with regard to the evolution of species—that as far as we can understand, involution and evolution form a fixed equation, so that nothing can be ever evolved that has not first of all been involved by the Creator or Supreme Being. (Applause.)

Dr. C. COLLINGWOOD.—Many points in this paper afford matter

for discussion. The mechanical or physical conception of nature appears to me to have in it this difficulty, that there being a considerable analogy between the processes of nature and those mechanical acts which man is competent to perform, those who are in favour of the mechanical theory at once jump to the conclusion that there is nothing more in these apparently mechanical arrangements of nature than there is in those truly mechanical actions of which we are capable; whereas there appears to me to be an infinite difference between the two, inasmuch as, as has already been mentioned, all the processes of nature are of such an infinitely more subtle and beautifully arranged character than those comparatively clumsy processes which man carries out, and which are truly mechanical processes. But I think in all these cases we must remember the great distinction to be made between matter and mind, between the physical and the hyper-physical, the supernatural and the spiritual.

The PRESIDENT.—The author of this paper being a professor in a distinguished college in America has not been able to be present to-night, but we shall place in his hands the remarks made by the various speakers. From a first brief perusal of the paper, I cannot help thinking that he has well pointed out that there may be certain laws which we ordinarily observe in the course of things relating to certain natural phenomena; and that over and above that, there are the facts of consciousness and will which we cannot in any way reduce to mechanical conception. It seems to me that that is allowed all through the paper, and that there will be no difference of opinion on such a point as that between the author and any of those who have spoken to-night.

I may observe that I think the word *energy* has a perfect physical signification, and that it has one in ordinary life which is quite different. We may speak of a man of energy; but that is a totally different thing from energy in the physical conception, and if we use the word *energy* in the physical sense it by no means follows that we have any thoughts of something altogether different to what the term *energy* means as frequently applied in ordinary conversation. When we speak of *energy* in a physical sense, that has nothing to do with the exertion of the will when I move my hand to the right or left or use it in more energetic manner than that.

The meeting was then adjourned.

REMARKS ON THE FOREGOING PAPER.

The Rev. Professor J. H. BERNARD, D.D., writes :—

I have had but little leisure since I received the proof copy of Professor Macloskie's paper which you were good enough to send me; and fear therefore that it would be rash to make the comments you invite, as the subject is a difficult one and demands caution and precision of statement. The paper is most interesting, and with the majority of Professor Macloskie's conclusions I suppose that most members, like myself, will find themselves in cordial agreement. I think the note on the first page of the paper, as to the word "mechanical," is quite necessary; and indeed the comparison of the universe to a machine is, as the author is well aware, and as he points out, most misleading. I should be disposed to prefer Mr. Abbot's term "organism" to "machine" (page 224), though the force of the author's criticisms is not to be denied. Is it not the case that both elements have to be taken into account? On the one hand we may lay stress on God's transcendence, on His distinctness from, and superiority to nature, and this is the point where Christian Theism differs from Pantheism. But on the other hand it seems to be equally the demand of faith and of reason that God is the Life of the World, that He is *immanent* in nature as well as its author and governor. And this is where the formulated Theism of our day differs from that of Paley's. We recognise that the cosmos is not merely a machine once for all constructed and set going by the great artificer, but that it is an organism of which God is at every moment and in every part the Life.

I do not quite understand what is said about personal immortality "on a mechanical theory of mind" (page 228); but possibly no more is meant than this—that the Ego is in no way affected by the laws of space and time which it transcends, and that therefore we can in no wise infer its destruction from the fact or the analogy of bodily dissolution. And it may be true and useful sometimes to insist that we have thus no right to expect natural law *everywhere* in the spiritual world.

G. B. BUCKTON, Esq., F.R.S., writes:—

The Institute may be congratulated on the receipt of Professor Macloskie's thoughtful and very interesting paper. The following remarks are made only with a view to discussion. They make no claim to originality.

Perhaps it is inevitable that giants must be slain more than once in a generation. If premises alter, conclusions must be modified. Arguments *pro* and *con* on abstract ideas must recur with more or less novelty in them.

The conception of a Mechanical Universe as restricted to physical phenomena appears to be reasonable and in a measure compelling. Though the scientific man admits of no interruption of continuity, and the sequence of phenomena implies means to ends, the extreme links of causation are hidden to our conceptions.

For those who admit the necessity of a Supreme and beneficent Intelligence it seems difficult to see how reason can fail to assent to final purpose. Argument is not sensibly weakened by the knowledge that to us, in exceptional cases, the purpose seems to be thwarted or only in part carried out.

Objections have been made that the human eye is not strictly compensated for spherical and chromatic aberration by its humours. Yet its value to us for all practical purposes is sufficient, inasmuch as we are not aware of the eye's chromaticity, and we are not assured that the mind does not itself make its own compensation of the error, if there be one.

We may conceive physical phenomena as grouped under the two heads of matter and energy. Both of these finally resolve themselves into ultimate facts. They pass into abstracts which we all believe in, though their natures are unprovable, and their genesis in time and place is inconceivable. If the dictum of one of our chief thinkers be accepted, we learn that matter has stamped on it the marks of a manufactured article; yet no one has shown in a similar sense such to be a condition of intellect in the abstract.

Pascal says "I know" therefore I am superior to matter and to unconscious energy. Choice implies a power to select and to control one law through the intervention of a higher law. Thus will is before law, though in the human economy it is not independent of it.

The physical life of an organism is intimately bound up with the chemical changes involved with nutrition and other functions. Biologists have not helped us much as to the conception of

energies in the ultimate cell involving its apparent choice of materials suited to its multiplication and the reproduction of characters peculiar to itself.

Apposite to the law of economy of material it may be often seen that not one, but many organs which have been necessary to an animal during one stage of its existence are suppressed, or become rudimentary in a subsequent stage. So, in preparation for the exigencies of altered surroundings, perhaps many organs of the same animals simultaneously develop themselves, the functions of which were not required antecedently.

As may be seen in some other insects, M. Künckel Hercules has recently shown that germs of the wings, of the legs, of the mouth parts, and the eyes are to be traced in the larvæ of *Volucellæ* long before they can be beneficial to the two-winged imagoes which alone possess these organs.

This convergence of lines connected with the elaboration of useful parts towards the fulfilment of a particular economy has been considered under the theory of probabilities; and the evidence is overwhelming against the likelihood of such a convergence being the result of a purposeless variation.

The author of the above cited paper well remarks that the scientific investigator may not feel it necessary to ask from whence energy and matter proceed, or who gave them the qualities they have. Yet he may have scientific objections to urge against the philosophic speculation, that mind and matter are convertible and modifications one of the other; thereby excluding the possibility of extra-physical existences.

As one out of a thousand examples of the simultaneous correlation of parts in insect life, the interesting economy of *Eristalis tenax* may be cited. The imago of this handsome Dipterous fly is in habit a complete contrast to its larval condition. The former is furnished with large compound eyes and stemmata. It is vivid in its action whilst on the wing, either poising itself over flowers, or swiftly darting from one sunbeam to another. The abdomen is broad and flat, and only sufficient to contain the small, and often almost rudimentary, viscera of the insect. This form of abdomen we may well believe acts as an aerial rudder, by which the remarkable dodges on the wing are executed, in avoidance of the capturing net. The acuteness of this insect's vision, and the consequent instantaneous response made by its large wing-muscles on the approach of danger may be noted.

The keen vision of the male and his increased activity, may be

seen in the darts made by him in chase of the female. Food probably is not necessary to these flies. They however consume the pollen and honey of flowers. A rather complex but feebly constructed mouth leads to an attenuated stomach and small intestines.

But as to the habits of the larva, all here is changed, and new organs are developed suited to an aquatic life.

Where the egg of *Eristalis tenax* is laid is not yet certainly known, but it must be deposited in pools of stagnant water containing mud formed by the rotting of animal and vegetable matters of a disgusting character.

Baron Östen Sacken has shown that the distribution of this insect is connected with the migrations of the human race; and this would seem to have some reference to the interest it shows in human excreta, yet as the larvæ are found in tangled masses, in the shallow parts of ponds visited by cattle, its food is not entirely restricted to the former kind noted. The fat maggot-like larva buries itself in the slime, in places where ordinary gills would fail to allow of respiration. The singular modification of tracheæ to effect this purpose has been often shown, and the elastic character of the long compound respiratory tube at the tail end has been described by M. H. Viallaines and others. This long tube ends in a single opening, fringed with bristles, which, through their repellent action on the surface of the water, forms a kind of funnel or depression through which, free from mud, the air passes into the two somewhat capacious tracheal sacs in the semi-transparent body of the grub.

As the level of the water in these swamps rises and falls, a beautiful provision is made to allow these tracheal tubes to stretch some inches, or to contract, without kinking the double tubes within, and closing them.

The larva of *Eristalis* is eyeless, and at the later stages of its development it is capable of protruding seven pairs of serrated false feet, which enable it to crawl to the shore and to bury itself for pupation in the damp earth.

The larva shows no conspicuous mouth-parts, but its anterior end is furnished with three lobe-like lips (the labrum) plentifully studded with recurved horny hooks, with which the animal rasps up and reduces to a pulp the matters on which it feeds.

The respiratory tube is often tied by the insect into curious knots without interfering however with the internal calibration. This knotting may be commonly seen when the larvæ are compelled to rise to the surface of deeper water. Here they may hang

with their heads downwards for hours, showing their breathing tubes stretched like long threads. Some of the Tipulidæ have similar repellent hairs at the tails of their larvæ.

The life-history of *Eristalis* and its congeners *Helophilus*, &c., need not here be discussed. The foregoing remarks are only brought forward as an additional instance of the simultaneous correlation of several organs to one definite end; and of their elaboration, long before they can be looked upon as at all beneficial to the individual, the significance of which has been well pointed out by the Duke of Argyll under the head of prophetic germs.

Except under an adverse and unprovable hypothesis, the idea of purpose seems alone to be that on which the mind may rest, though in adopting it, we doubtless pass out of the test of experiment, and we concede that it is no explanation of "the How."

The Rev. R. COLLINS, M.A., late of Cottayam College, writes :—

Dr. Macloskie's paper appears to me to mark a great advance in scientific thought. The remarks on teleology, or final causes, are well chosen; the result being the conviction that we must ultimately get back behind energy to the will of an intelligent agent.

This leads me to note that energy is often spoken of as though it were an objective reality. But is it so? Does it not belong to the same category of abstract ideas, as force, weight, life? It exists, in short, nowhere but, as an idea, in the reasoning faculties, it is the ideal cause of work done, as force is of material movement. There is a passage in *The Unseen Universe*, by Balfour Stewart and Tait,—I am quoting from memory—in which I believe energy is claimed to be an "objective reality," although force is said to be "not a thing," but purely ideal. This seems inconsistent. If force be ideal, so also, surely, is energy. There can be no idea of energy, except as the manifestation of some substantive reality that is energetic. This does not invalidate reasonings upon energy: but is a necessary guard upon thought; and especially so, as it appears to me, amid present scientific modes of expression, through which men are sometimes betrayed into what Professor Huxley—speaking some time since on natural laws—called *Scholastic realism*.

The Rev. C. LLOYD ENGSTRÖM, M.A., writes :—

In my judgment the paper is particularly valuable, because in a very short space it makes very plain the tendency to view *all* phenomena from the “mechanical” point of view. The writer is evidently in the stream of much that is commonly regarded as anti-Christian in tendency. He therefore speaks with knowledge of both sides, and he helps us quite as much by showing us the trend of much scientific thought as by pointing out how we may yet believe in a spiritual world.

Mr. J. W. SLATER, F.C.S., writes :—

Page 224. The so-called iatro-mathematicians, such as Borelli and Sanctorius are, as it seems to me, too favourably spoken of. Their speculations directed research into wrong channels, and should serve as a warning. We all know of Professor Fleeming Jenkin’s mathematical argument against organic evolution based upon an assumption which would never have occurred to him had he been a biologist.

THE AUTHOR’S REPLY.

Princeton College, U.S.A.

October 21, 1895.

As the design of my paper on *The Mechanical Conception of Nature* was simply to submit to a competent jury my views on an important subject, I am gratified by the attention accorded, and now only ask an opportunity to dispel any misapprehensions as to the meaning and spirit of the production.

I have to thank Sir G. G. Stokes for his kind remarks as President.

Mr. Slater’s citation of the chemical knowledge of the ancient Egyptians falls in nicely with my observation (p. 222) about

alchemy developing into modern chemistry; for the continuity between the Egyptian and the modern science is through alchemy, which, as Myers shows, had its origin in Egypt. I may also set off against his exception to my reference to the iatro-mathematicians the facts that the hydraulic idea of circulation forms a valuable chapter in modern works on physiology, and that the mechanics of the bones and joints is now being worked out by our ablest "theoretical anatomists."

I hope that Dr. Schofield did not understand me to argue that life is only a physical force. My attitude is that of an earnest Theist. The point of my contention was, that *if* proof were forthcoming that vitalism was only a special kind of chemism, a doctrine very extensively held, still the argument in favour of Theism would be sound. I did not think it necessary to give my personal views about the nature of life. If I could make good the contention for which I argued, I believe that this would be a gain to our cause, for some people are prejudiced in favour of the chemical theory of life because of its apparently atheistical look, and others for the same reason are prejudiced against it. I think that chemistry as well as biology proves the Being and wisdom and power of an imminent God.

The same critic's remark that the laws of nature are laws of God will have no disclaimer from me. I think that they are the laws referred to in Scripture as "ordinances of heaven." But I entirely dissent from the position that they vary in their action; unless the meaning is that they are liable to perturbations from the interference of other laws. It would also appear that God has conferred on His creatures a certain measure of independence, just as our limbs are in a *qualified* way able to act independently of our will; and thus all of men's acts are not to be directly considered as Divine acts. But I regard God as not only initiating but as upholding and controlling all the processes of nature.

I am grateful to Prof. Bernard for the valuable remarks which he offered on the general question.

I may here remark that whilst I am not an advocate of evolution,

and I think that whatever truth may be in it, its real inwardness is still a secret, yet I regard it as unwarrantable to make the defence of Christianity rest on the assumption that the theory of evolution is wrong, as we find some do. Anybody is welcome to disprove that theory if he can; but declamation will not disprove it; and the arguments from facts in favour of some kind of evolution appear to me to be gaining in force. To make the argument for theism rest on an arraignment of evolution is, in my opinion, an illegitimate setting up of one's private judgment against what is nearly the consensus of men conversant with the subject, and only injures the cause one is trying to defend.