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500TH ORDINARY GENERAL MEETING.

MONDAY, JANUARY 10TH, 1910.

HELD IN THE LECTURE THEATRE OF THE ROYAL UNITED SERVICES INSTITUTION, BY PERMISSION OF THE COUNCIL, R.U.S.I.

LIEUT.-COL. MACKINLAY, CHAIRMAN OF THE COUNCIL, IN THE CHAIR.

The Minutes of the preceding Meeting were read and confirmed.

The following elections were announced :—

Associates : Miss A. Habershon.
Miss M. Spokes.
H. Wilson, Esq.

The Chairman congratulated the Institute on its having reached the 500th Ordinary General Meeting, an occasion which, besides being marked by the very valuable paper about to be read, would, he hoped, be made celebrated by increased efforts on behalf of the Institute by all its supporters.

The following paper was then read by the Author :—

MODERN CONCEPTIONS OF THE UNIVERSE.

By G. F. C. SEARLE, M.A., F.R.S., University Lecturer in Experimental Physics, Cambridge.

§ 1. *Introduction.*—In our discussion this afternoon, I purpose to follow the line of thought adopted in a paper on "The Modern Conception of the Universe," which I read before the Pan-Anglican Congress in 1908. I do so for several reasons. Many people who are anxious to know something of the relation between religion and science are so little acquainted with science that the common-places of physics come as a surprise to them. They are further astonished to find that these common-places of physics do bear a very distinct and definite testimony which is of great significance in religious thought. Many of my audience at the Pan-Anglican Congress were probably in this position. They had probably heard much of the supposed defeat of religion by science but comparatively little of the facts of science itself, and hence they were genuinely astonished at the profusion of the testimony which some of the simplest facts of science bear to the fundamental article of religious belief.

This astonishment is only what might have been expected, for during the last century the popular mind was more and more influenced by the impression that science had settled these questions, and had decided that there was little, if any, place left for a Creator of the Universe. This impression was largely due to the opinions held by some biologists, and to this cause we may, I think, attribute the fact that the supposed conflict between science and religion was generally regarded very much more as a conflict between biology and religion than as a conflict between physics and religion. But as physics was not supposed to be antagonistic to religion, the facts of physics were, quite naturally, less pressed upon the attention of non-scientific persons than the opinions of some biologists, and thus it is not surprising that such persons should have come to believe that physics has nothing to contribute either constructively or destructively to religious thought.

I felt that, in these circumstances, it might be profitable this afternoon to go over once more the ground covered by my Pan-Anglican paper, even at the risk of wearying those members of the Victoria Institute who may be familiar with the facts of science. I have, however, made some additions to that paper in the hope of making the argument clearer.

I trust that I may be able to make it plain that the progress of science has made it very much more difficult than it was in the last century for men to profess materialistic views as to the world and its meaning. The change which has come about can hardly be described more vividly than in the following words used by Mr. Sidney Low.* He was writing with reference to psychical research, but the words apply almost without change to our subject. He says:—

"It is a curious sign of the times, the absorption of one eminent man of science after another in the problems of psychical research. It points, I suppose, to that feeling of the unsatisfactoriness of mere physical science when brought into relations with ethical, spiritual, and ontological questions. We are in the

* *The Standard*, December, 1909.

rebound against the mechanical theory of the universe, which held imperious sway during the thirty years that followed Darwin's first great attempt at systematisation. The influence of Darwin, and Spencer, and perhaps even more, of Huxley and Tyndall, of Haeckel and Weismann, had led to a belief that physics and physiology between them solved everything. Now a good many people go to the other extreme, and assert that they have solved nothing. And the scientists themselves, though they have not abandoned the nineteenth century conceptions of force, matter, and development, are anxious to supplement them by pushing their enquiries into the psychic region. Science itself cannot deal with the facts it has discovered without travelling beyond force and matter and development. It has to postulate something else, something in the nature of mind, and something beyond that; something which is not matter nor force, and yet can act upon both. So it begins to join hands with religion, and reluctantly suggests that there may be such a thing as a spiritual power, operating outside the limits of space and time."

Before we proceed, let us pause to do honour to those men and women who, though ignorant of the facts of science, had heard what science was supposed to have proved and yet held steadfastly to their faith through years of storm. They were not dismayed at the supposed results of scientific progress because they had faith, and faith is so far above intellect that, unlike the latter, it never suffers confusion. We are not, however, now concerned to discover what information can be gained from the lives of saintly people; our business is to discuss what may be learned from scientific investigation.

§ 2. *Purpose of the Paper.*—In discussing the modern conception of the universe, I shall endeavour to examine how far that conception leads to or is consistent with the idea of an almighty Creator having a just claim to the obedience and worship of men. We must not expect that the testimony of science, unaided by spiritual insight, can lead to anything more than the simplest form of religion, but if it does go so far the testimony is of immense value. If men grasped no more than the idea of the existence of an almighty Creator and allowed its significance to have a place in their lives, the gain would be very great.

But this paper is not intended to be in any way an apology for religion. I shall merely endeavour to set down, as simply as possible, some of the conclusions to which modern scientific investigation unhesitatingly points. The survey will, however, be incomplete, for it will be necessary to omit all but a bare mention of the moral and spiritual feelings and experiences of men, though these are phenomena of the universe, just as much as any physical or chemical actions, and generally lead to actual events in the world of matter, as, for instance, when a call to the mission field leads to the transport of a human body, with clothes and books, across the ocean.

One of the greatest needs at the present day is, I believe, an insistence on the idea of God as the Creator of the universe. If this idea were more forcibly brought home to the minds and consciences of men, they would perhaps pay more attention to religion generally. If the influence of religion has appeared to suffer at the hands of science, it has been mainly because many have been led to an attitude of doubting through the suggestion that scientific investigation has left no place for a God as the Creator of the world. With this doubt in their hearts, it is easy for men to profess the opinion that there are no such things as God's laws to be obeyed or to be broken.

But it is becoming more and more plain that so far from science leading to any such conclusion, the facts all point in the opposite direction, and thus science is more and more bearing testimony to the fundamental article of religion. We may here quote Lord Kelvin's statement* that "if you think strongly enough, you will be forced by science to believe in God, which is the foundation of all religion."

§ 3. *The Universe and Human Thought.*—It should be noted, before we go further, that the essential character of the universe does not depend in the least upon our intellectual conceptions, for the universe remains the same whatever may be our individual views concerning it. It is important to bear this in mind, because some persons, who have not grasped the distinction between an hypothesis and a fact, are in danger of imagining that these great questions are settled by the pronouncements of the popular speaker who is fashionable at the time. The distinction between fact and hypothesis must be continually remembered in discussing scientific discoveries, for, apart from the inevitable errors of observation, the simplest experiment is in reality so complex an affair that we can do no more than frame an hypothesis which will account for its main features. Yet, if the hypothesis is verified when the experiment is repeated under a variety of conditions, it acquires a high degree of credibility. That is all that we can say.

* *Nineteenth Century*, June, 1903, p. 1068.

Those who are much occupied with literary work are exposed to the danger of treating realities as if they were merely subjects for academic discussion. In physics, however, there is so constant an appeal to experiment, either directly or through mathematical reasoning, that students of physics are to a considerable extent freed from this danger, and in biology experiment is now rescuing that science from the thraldom of opinion. But in regard to theological studies, it is perhaps true to say that mere opinion has in some cases been allowed a position which does not belong to it. Thus many assert that miracles never happened, the only ground for the assertion being their opinion that they are impossible. Much would be gained if it were realised that what occurred in the past is not in the least affected by the opinions of persons, however exalted, who live in the twentieth century.

There is a popular notion that some strange impersonal thing called Modern Science has examined the universe in the cold light of experiment and has arrived at infallible conclusions. But this is not a true picture. for there is no one of the conclusions of modern science which can be said to be absolutely established, and the utmost that can be said of any conclusion is that the experiments are in approximate agreement with it. It is true that some conclusions become more and more firmly established as the accuracy of the experiments is increased, but, on the other hand, an increase of accuracy sometimes requires us to modify a conclusion. A striking example is furnished by the discovery of the gas argon in the atmosphere. In spite of an old experiment of Henry Cavendish, it was believed that atmospheric air was a mixture of oxygen, nitrogen, carbonic acid gas and water vapour, with *very small* additions of other known gases. But the accurate work of Lord Rayleigh and Sir W. Ramsay showed that more than one per cent. of what was supposed to be nitrogen was the previously unknown gas argon, and this has led to the detection of other gases.

§ 4. *The Complexity of the Universe.*—In the earlier stages of scientific progress it was to some extent possible to divide science into branches and to confine attention to one branch at a time; it was possible to attend to the phenomena exhibited in one or more bodies without much regard to the relations between those bodies and the rest of the universe. But modern investigation makes it logically impossible to work any longer in water-tight compartments, and is gradually leading us to appreciate the fact that the number of actions to which every particle in the universe is continually subject is very great.

One instance will show how the progress of discovery compels a wider outlook. Newton accounted for the motions of the planets and their satellites by the law of gravitation, and the work of subsequent mathematicians and astronomers has abundantly verified his formula in the case of bodies of considerable mass. But recent investigation has verified the theoretical prediction of Maxwell that, when one of the bodies is intensely heated, as the sun is, the stream of radiant energy which falls upon the second body exerts a force upon it. As the second body becomes smaller, this force rises in importance relative to the force due to gravitation till at length it rivals and surpasses it, and it follows that the motions of those particles of cosmical dust, which are scattered through space, depend not only upon the action of gravitation, as was formerly supposed, but also upon the pressure of radiation.

Modern discoveries have led us to a point of view from which we are compelled to regard every particle in the universe as continually subject to a great variety of actions, though of course at any given instant some actions may be more strongly in evidence than others, and thus we realize that the history of even a single molecule, considered as a whole, is one of great complexity.

The evidence of the spectroscope indicates that each molecule has a very complex structure. Thus, each line in the spectrum of a substance corresponds to one mode of vibration of the molecules, and in the spectra of some substances, such as iron, hundreds of these lines may be counted. But the molecules are not merely complex in themselves; they have very complex connexions with their surroundings. Thus oxygen can combine with nearly all the other chemical elements either singly, as in the case of hydrogen in the formation of water, or in groups, as in the case of hydrogen and sulphur in the formation of sulphuric acid. The total number of such combinations is enormous. Thus we may say that each element is so constructed as to respond to the influence of each of the great majority of the other elements, and to a great number of their compounds. Of recent years the discovery of radio-active substances has greatly raised our estimate of the complexity of molecules.

When we combine the complexity of each molecule with the vastness of the number of molecules in the world of stones and trees and men and sun and stars, and consider that each molecule acts on every other one, the complexity of the conception is enough to make us despair of further progress. But science has not stopped here, and has not left us without some sign-posts to guide us in our perplexity. I shall now endeavour to indicate some results obtained from experimental work which lead to conceptions shedding a little light upon the nature and character of the universe.

§ 5. *Nature of Matter.*—In the bodies around us, on the earth or in the sky, whether they be inanimate or whether they be living organisms of any kind, we see a bewildering variety of substances. But the labours of chemists have led to the belief that all bodies are built up of a comparatively small number of elements, such as oxygen, carbon, or iron, and have shown that, if the elements be arranged in a series according to a certain law, there are very remarkable relations between the properties of an element and its place in this series. The existence of gaps in this series was thought to indicate that some elements remained to be discovered, and the theory of the series enabled the general character of the missing elements to be clearly described. The predictions have been confirmed by the actual discovery of some of the missing elements. These results of chemical science at once simplify our ideas about the material bodies around us, for instead of thinking of countless millions of different substances we need only think of about one hundred. That the elements found on the earth occur in the sun and stars is shown by the spectroscope and by chemical analysis, which proves that many meteorites which have fallen on the earth are almost identical in composition with the most deep-seated terrestrial rocks.

In the case of helium, the existence of the gas was first revealed by spectroscopic examination of the sun, in whose spectrum a line was found which did not correspond to any terrestrial element then known; the name of helium was given to the element causing the line. Helium has now been found in terrestrial minerals, and has been liquefied by Kammerlingh Onnes at Leiden, the temperature of the liquid being only three or four degrees above the absolute zero of temperature. This extremely low temperature, the lowest reached, so far, in any experiments affords a strange contrast to the temperature of 5000° Centigrade or more which prevails in the sun, where helium was first discovered.

The numerical relations between the elements suggest that they are all built up of some primordial substance. The most promising speculation is that which regards a molecule as consisting of a larger or smaller number of minute parts, separated by relatively large distances, these parts being associated with electrical charges or, possibly, being nothing else but electrical charges. The variety of the elements can then be accounted for by variations in the number and arrangement of these component parts. Even if the component parts were merely electrical charges, the inertia and momentum of matter could be explained by the principles of electromagnetism.

§ 6. *Radio-active Substances.*—It used to be thought that the molecules of all substances were absolutely incapable of any change, but now it has been found that some substances such as uranium, radium and thorium, which according to most tests behave as elements, suffer transformations into other forms which again appear to be elements. This, of course, only strengthens the belief that all matter is only a single substance under a great variety of forms. The theory that molecules are built up of minute parts associated with electrical charges promises to account for these transformations and for the remarkable effects which are found to accompany them.

Of the radio-active substances, radium is perhaps the most amazing. As radium is being transformed into its child, the radio-active gas known as radium emanation, it emits vast numbers of positively electrified particles. In a single second one milligramme of radium emits about thirty millions of these particles, that is, one particle for each inhabitant of England. The activity of the radium decays because some of the radium ceases to be radium and becomes emanation, which in its turn suffers further transformations, but 1,800 years would pass before half the radium would be transformed. In spite of the excessive smallness of the emitted particles, Rutherford has found a way of observing an effect due to a single one.

To say that these particles are emitted gives a very faint notion of the stupendous velocity with which they are shot out, for their velocity is about one-fifteenth of the speed of light or about ten thousand miles per second. Some of the other radio-active substances shoot out negatively charged particles whose speed rises, in some cases, to nearly the speed of light. The impact of these projectiles upon the surrounding matter produces heat and thus a radio-active substance, such as radium, maintains itself by self-bombardment at a temperature above that of its surroundings. In a single hour one gramme of radium produces enough heat to raise one gramme of water from the freezing to the boiling point.

These experimental facts of radio-activity have given us almost entirely new ideas as to the character of matter, and hence demand consideration in any account of what is known about the universe. Their bearing on our subject will be considered presently.

§ 7. *Abrupt Changes.*—The elements differ one from another by abrupt steps just as polygons of 3, 4, 5 . . . sides differ. We cannot pass from one element to another by an infinite series of infinitely small steps. If we could, there would be no science of chemistry. The idea has been held that living organisms have been derived from earlier forms by a continuous process of evolution, but nothing like this occurs among the elements, for there the steps are *abrupt*. The transformations of the radio-active substances appear to be due to *abrupt* changes in the number of electrified particles in the molecule. These abrupt steps and others we shall meet in our survey are of great interest. Thus the abrupt changes of the molecules of radio-active elements warn us that deductions based upon observed uniformity may be unsound, even though the period of observation may have extended over hundreds of years. If we start to-day with a gramme of radium, there will still be half a gramme left after 1,800 years, and if we were to observe for this period one of the molecules forming part of the remaining half gramme, we should naturally conclude that this molecule would continue for all time "unbroken and unworn." But, if we maintained our watch for another century, we might witness the catastrophe which results in the expulsion of a positively charged particle and our earlier conclusion would then be proved to be false.

§ 8. *The Universe as a single System.*—The view that all matter is built up of a single primordial substance is a great step in advance, but it does not at once replace complexity by simplicity, for the fact remains that the number of molecules in the universe is inconceivably great. You will not think the word inconceivable to be inappropriate in view of the estimate that a drop of water no larger than a grain of mustard seed contains enough molecules to supply each inhabitant of the earth with one molecule every second for many thousands of years. Who then shall grasp the number of molecules in the whole universe?

But the results of scientific investigation lead us to regard all these molecules in their vast array less as so many separate entities than as forming one great and indivisible whole. One instance will make this clear. We believe that if there were only two molecules in the whole universe the force of gravitation would still draw each towards the other. There is therefore some connexion or relation between the two molecules, and to speak of them as two separate systems is only a convenient mode of speech which does not express the whole of the conditions. If they were two entirely independent systems, the motion of one molecule away from the other would have no effect upon the latter. But the law of gravitation assures us that the second molecule would experience a distinct effect, for the attractive force acting on it would gradually diminish as the distance increased. An extension of this idea leads us to realise that all the molecules in the universe are so linked together by gravitation as to form but a single system. Yet gravitation is not the only link, for electric and magnetic actions between molecules produce their effects, whatever the distance between the molecules. In addition, there are other actions which are sometimes practically in abeyance, as when two molecules, one of oxygen and one of hydrogen, are too far apart for chemical combination to take place. Nevertheless, the power of combination remains ever ready to do its work, when the distance between the molecules is sufficiently reduced and certain other conditions are fulfilled.

We could, of course, suppose that these actions between molecules arise from something inherent in the molecules themselves, and that the intervening space has nothing to do with the affair. But the facts of optics and of electro-magnetism compel us to recognise the existence of an all-pervading medium to which the name of ether has been given. This medium is conceived to extend through all space, and there are good reasons for the belief that the forces between electrified bodies are in reality due to stresses in it. The ether enables radiant energy to be transmitted from one body to another, as when the earth receives heat from the sun, or telegrams are sent, with or without the aid of wires, from one station to another. There is thus a most intimate connexion between molecules and the ether, and hence the ether may be regarded as the substance, if it can be called substance, which binds the whole universe together.

The rate at which energy is supplied to the earth by radiation from the sun is very great. On each square yard of illuminated surface, energy is supplied at the rate of about one-fifth of a horse-power. For the whole of the illuminated hemisphere, this amounts to something like twenty million horse-power.

Thus we come to recognise that the whole tribe of molecules is linked together by the ether in such a way that they and the ether form a single indivisible system. The word *atom* was originally coined to express the belief that certain minute particles are incapable of a physical division into smaller parts. But in the light of modern science the whole universe is to be regarded as an atom, or in other words, as something which cannot be divided.

The conception of the unity of the universe, to which modern science leads us, must of necessity have a most important place in any speculation concerning the origin of the universe.

§ 9. *The Origin of the Universe.*—All the evidence is against the idea that the existence of the constituent parts of molecules is due to any physical or chemical actions occurring in the present state of the universe: we are thus compelled to believe that they have been created, unless indeed, we suppose that they are self-existent or in other words, that there never was a time when they did not exist in their present forms—a supposition which has no place in the conception of the universe in the minds of modern physicists.

The fact that all the molecules of any given element have absolutely identical properties makes it clear that matter has been made on some plan, and the certainty that there is no molecule which is not associated with energy indicates that both plan and energy come from the same Source.

The uniformity of the molecules of any given element is the basis of chemistry. The spectroscope also bears witness to this uniformity, for the lines in the spectrum would be broad and not narrow if among the molecules of the substance under examination there were appreciable difference of the periodic time of the particular vibration corresponding to each line of the spectrum. Schuster has illustrated in a very forcible manner the conclusion that if there are inequalities in the periodic time of thallium, corresponding to the green line in its spectrum, these inequalities must be exceedingly small. He states that the want of uniformity is greatly over-estimated, if we say that twelve per cent. of the molecules differ from the average by one part in two millions in periodic time, and he brings out the meaning of this statement in the following way :—"If you had a great many clocks and found that, taking their average rate to be correct, not more than one in eight would be wrong by a second in twenty-three days, that would represent the maximum amount of variation which our interpretation of the experiment allows us to admit in the case of molecular vibrations. But would any maker undertake to supply you with a number of clocks satisfying that test . . .

Though Sir John Herschel's saying that atoms possess the essential character of manufactured articles is still correct, yet no manufactured article approaches in accuracy of execution the exactitude of atomic construction. We may conclude with Maxwell that "each molecule throughout the universe bears impressed upon it the stamp of a metric system as distinctly as does the Metre of the Archives at Paris."

This exactitude of atomic construction is not merely of academic interest, but is of real importance in the very practical work of maintaining definite standards of length. The metre of the Archives has been measured in terms of the wave-length corresponding to a particular line in the spectrum of cadmium, and it is to the constancy of this wave-length that we now trust rather than to the constancy of the length of the metal bar known as the metre of the Archives.

In thinking about the creation of the universe, we shall perhaps be helped if we first consider what would be involved in the creation of a single new molecule at the present day. This event would not only require the creation of new matter but would also involve the establishment of relations between the new molecule and the countless millions already in existence, and this would change all those molecules to the extent of enabling each of them to act upon the new molecule. If we speak in terms of the ether, we may say that such a connexion must be established between the new molecule and the ether that the molecule is able to cause disturbances in it which produce effects throughout the whole of space.

The phenomena of radio-activity have disclosed far more of the skill of the great Architect and Electrician than was even suspected a few years ago. For the formation of a molecule of uranium involves not only the construction of the minute electrified particles which it contains, but the assembling of them together and the supply of that vast store of energy which will enable the molecule at the right moment, perhaps a thousand million years after the formation of the molecule, to shoot out an electrified particle at a terrific speed. But this is not all, for the design of the uranium molecule is such that the modified molecule, which remains after the expulsion of the particle, will after a few days in its turn shoot out a particle and so on for several stages, the time of halting in each stage being sometimes large, as with the 1,800 years of radium, and sometimes small, as with the four days of radium emanation.

The Power which is capable of creating a single molecule is able to originate effects extending through all space, and to this degree may therefore be described as bearing rule over the whole universe. We could, of course, suppose that the ether was created by one such Power and that each molecule had its own Creator, but the evidence of the unity of the universe leads to the conviction that the whole universe, the ether included, is the work of a single Creator, and that the energy in the universe is His gift.

§ 10. *Law and Order in the Universe.*—What has been said about the unity of the universe and its creation is surely enough to justify the expectation that the universe will be found to be the scene of the operations of laws of such a character as to appeal to the intellect as rational laws, or laws which have good reasons behind them. So far from modern science having any doubts on this point, one of the chief aims of scientific investigators is to discover laws. In fact, many of the greater advances have sprung from speculations and experiments inspired by the belief that the actions occurring in the universe take place according to some intelligible plan, while many of the laws which have been discovered are capable of being expressed by very simple mathematical formulæ.

One of the most conspicuous instances of belief in such a plan is furnished by the doctrine of the conservation of energy. According to this doctrine, the total energy in the universe is fixed in amount, and any chemical or physical change involves merely a redistribution of energy or a change from one form of energy to another. Such a law is obviously of the utmost significance, and it is not surprising that many of the modern advances in science are due to its recognition. Men would have been dull indeed if they had not seen in the law, as revealed by experimental investigations, an ordinance of an intelligent Power bearing rule over the whole universe. But to some extent the process took place in the reverse direction, and, instead of experiments leading to the doctrine of the conservation of energy, it was the expectation that the plans ordained by the Creator would be found to be intelligible to human minds which led the way to the establishment of the law as an article of scientific belief, for it was his faith in a Creator and his belief that the Creator had made energy subject to the law of conservation which led Joule to make the series of experiments which went far to secure the acceptance of the doctrine. His own words deserve to be quoted. "I shall lose no time," he says, "in repeating and extending these experiments, being satisfied that the grand agents of nature are, by the Creator's fiat, indestructible."*

§ 11. *The Beginning and End of the Universe.*—The modern conception of the universe sets before us a wonderful system working in a manner so regular and so orderly that we are almost tempted to believe that this regular working has continued not merely for many centuries or for many millions of millions of years, but that there never was a time when the universe was not guided by the same laws, neither more nor less, as are in operation to-day. This temptation must, however, be resisted, for if we yield to it we abandon the conclusion that the universe was created, since to assert that there never was a time when matter did not exist is equivalent to saying that it is self-existent.

If the universe consisted merely of the ether and of a single sphere of matter without any motion either of its centre or of the parts of its molecules, we could set no limit to its age, because no changes could occur in it. But the universe is not of this character; on the contrary, it contains matter in very vigorous motion—both in bulk, as seen in the earth's motion round the sun, and in detail, as seen in the molecular vibrations which give rise to light. Hence the state of the universe to-day differs from its state yesterday, and so on. We might, of course, conceive that all these motions are periodic, and that any particular state of the universe recurs continually, though perhaps at long intervals, and, apart from the difficulty of accounting for them, we might suppose that these periodic changes had occurred regularly for an infinite time, and that they would continue for an infinite time. But modern investigations prove such a view to be untenable. For they have shown that, while the total amount of energy remains unchanged, there is at present a progressive diminution in its availability, and they point remorselessly to a time when the energy will be so distributed that further redistribution will be impossible. The meaning of availability may be illustrated by reference to water in a reservoir on a mountain near the sea. The water in the reservoir represents available gravitational energy, and in its descent to the sea-level may be made to drive machinery and to produce electrical or other energy, but as soon as the water reaches the sea-level it ceases to be available for doing work.

When the further redistribution of energy ceases to be

* Joule's *Scientific Papers*, vol. i, p. 157.

possible, the universe will be physically and chemically inert in simple words we may say that it will be dead.

The power of chemical combination of the carbon of coal with the oxygen of the air is a great reserve of energy, but in a few generations this source of wealth for England will be practically exhausted, and then the humblest households will learn by the experience of hardships something of the meaning of the loss of availability of energy.

When the operations of the physical laws are traced backwards into past time, they lead to greater and greater availability of energy. But there is a limit to this process, for the total sum of energy is limited. Speaking generally, the rate at which redistributions of energy occur increases with the availability of the energy, but even if the rate of loss of availability had never been greater than at present we should, in going back, arrive in a finite time at a state in which all the energy was, so to speak, in one basket. We thus conclude that only a finite number of years has elapsed since the creation of the universe.

The existence of radio-active substances points to the same conclusion. For since uranium is continually being transformed into other substances, and since an appreciable quantity of uranium is still left, only a finite number of years has elapsed since uranium was first formed.

§ 12. *Life and Matter.*—So far we have considered matter apart from life. But on the earth there are living organisms ranging from lowly bacteria to stately trees and splendid animals and man himself. The bodies of these organisms are composed of some of those elements of which inanimate objects are formed, and to that extent living organisms are identical in nature with the inanimate world around them. But it is evident that there is a profound difference between life and matter, in that life involves individuality. Life is capable of employing the molecules of various elements to form the organism and to maintain it as the abode of life for a longer or shorter time, but the organism does not always consist of the same molecules, for it is continually taking in some molecules, and rejecting others. Thus, for instance, after the carbon which an animal takes in as a constituent of its food has been assimilated, it is combined in the body with the oxygen taken in from the air and the resulting carbonic acid gas is breathed out. Both the carbon and the oxygen form parts of the body for a time, but only for a time. Yet the life of the individual preserves its identity, though the body which it controls is never, for two minutes together, composed of exactly the same molecules.

At the death of an organism, no immediate change occurs in the materials composing the body, but it is evident that in the corpse something is missing which the living organism possessed.

Matter, such as oxygen or carbon, is often spoken of as "dead" matter, but this description is inadequate. Many of the chemical elements are capable of being absorbed into the bodies of living organisms, and though only a small part of the total sum of any one element, such as carbon, is associated with life at any given time, yet every molecule of that element is so far under the spell of life that, under proper conditions, it will be compelled to take its place as part of a living body. It thus appears that there is a very real relation between life and a great part of matter, and the statement may be extended to *all* matter if the elements are merely various forms of a single substance. We are led to the conclusion that the capability of most, if not all, matter to enter into association with life was provided for in the design and original formation of the molecules, and further, that life and matter have proceeded from the same source.

§ 13. *Origin of Life.*—Experiments have led to the conviction that in the present order of things the linking of life with matter can only arise from the action of living organisms, and thus we arrive at the conception that living organisms did not appear on the earth as the unaided result of actions between mere molecules. We therefore conclude that the first living organisms were created.

The question at once arises whether the creation of the first living things took place at the same time as the creation of inanimate matter, or whether inanimate matter was in existence before the creation of living organisms. The only guide with which science provides us is the existing order of things, and if we follow this in tracing back the history of the earth, we come to a time when the earth's surface was red-hot. Lord Kelvin made this conception more precise by estimating how many millions of years have elapsed since that time. The discovery that radium gives off vast quantities of heat in the course of its transformations makes it necessary to revise Lord Kelvin's numerical estimate, but it does not invalidate the conclusion that only a finite number of years has elapsed since the earth's surface was red-hot.

In addition to Lord Kelvin's method a number of quite independent methods of solving the problem have been devised, and they all indicate that, at the most, not more than a few hundred million years have elapsed since the red-hot stage. In one of these methods the mass of sodium in the sea is estimated as well as the mass of sodium carried to the sea in one year by the rivers. These data give us the time which has elapsed since rivers first began to flow.

Now the connection between matter and animal or vegetable life is destroyed when the organism is exposed to a red heat, and thus, if the existing order of things had prevailed without interruption from the time when the earth's surface was red-hot, there would be no living organisms on the earth at the present day. Hence we conclude that the creation of the first living things on the earth has occurred since the time when the earth's surface was red-hot.

It has been suggested that life first appeared on the earth in elementary forms carried hither on meteorites, but this is no explanation, for it merely pushes the difficulty one stage further back.

§ 14. *The History of Species.**—The history, as far as it can be ascertained, of the various species of creatures now inhabiting the earth, is of very great interest on account of the light which it may shed upon the nature of those most complex parts of the universe. This history demands consideration in the present paper because some of the speculations which were current in the last century, regarding this history, were used as arguments against religion. It is still widely believed that those speculations are fully accepted by all intelligent persons, and it therefore becomes necessary to give a brief account of the results reached in recent years.

The idea was at one time held, that each living species had been separately created, and that apart from small variations, such as occur in the height of men or in the colour of their hair, each species, whether living or extinct, is incapable of change. This idea involved acts of creation taking place at different points of time, and hence it was natural that some should suppose that all the creatures now living are descended in an unbroken succession, from those which first existed, and that there has been but one solitary act of creation of life. This idea, of course, requires the supposition that the present species are descended from those which are, in some cases, now extinct, and therefore required the further supposition that the descendants of living forms may differ greatly from their ancestors.

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* In this section I have been greatly helped by Mr. R. H. Lock's book on *Recent Progress in the Study of Variation, Heredity, and Evolution.*

Darwin endeavoured to account for the observed differences between forms which were supposed to be related as descendants and ancestors by the action of a kind of selection, operating upon the small variations to which each species is liable. He supposed that " there will be a strong tendency for those individuals which show slight modifications in the direction of a better adaptation to their environment to survive at the expense of those of their brethren which do not exhibit similar modifications. This was the principle called "Natural Selection" by Darwin, and by Herbert Spencer the "Survival of the Fittest." It was further supposed that under the influence of natural selection the small differences might in a sufficient time be accumulated and increased to almost any extent. Darwin* did not deny that many and serious objections might be advanced against his theory, but he thought that he had given them their full force. Of his theory he says, "nothing at first can appear more difficult to believe than that the more complex organs and instincts should have been perfected, not by means superior to, though analogous with, human reason, but by the accumulation of innumerable slight variations, each good for the individual possessor." In spite of this difficulty, " this suggestion of a natural means of modification had, within a few years, the effect of convincing practically the whole thinking world of the truth of the theory of organic evolution."

Darwin himself endeavoured to consider how far biological facts were in accordance with his theory, but " the more popular accounts since his time have dealt almost exclusively with theoretical considerations and with matters of opinion." Mr. R. H. Lock remarks that " if the truth must be told, the experimental method was given up for a long time by the majority of specialists themselves in favour of the controversial."

Of recent years there has been a return to experiment. The phenomena of variation and inheritance have been studied, and the result has emerged that improved features are not evolved by gradual selection. The theory of modification by selection has, when put to the test of experiment, very largely if not completely, failed.

The place of selection has been taken by an alternative process. " The evidence in favour of an alternative process has multiplied even faster than the evidence against the continuous accumulation of minute differences." "The new view is that the evolution of new species has taken place principally by the

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* *Origin of Species*, **chapter xiv.**

help of variations of the discontinuous kind. By this process there can arise at a single step new forms which have already the complete and definite character usually associated with a species specially adapted to particular conditions." There is nothing speculative about these abrupt variations or mutations, for they have been frequently observed and are more common than was formerly supposed. An example is furnished by the Shirley poppy. "In 1880 the Rev. W. Wilks, Vicar of Shirley, near Croydon, noticed among a patch of common wild field poppies growing in a waste corner of his garden a solitary flower with petals showing a very narrow border of white," and from the seeds of this flower the strain of Shirley poppies originated.

These mutations of living forms bring us back again to the idea of abrupt steps which we discussed earlier in the paper. No way, apparently, is known of causing these mutations to appear; all that can be done, and what is done by practical breeders, is to watch for them and to give them every chance when they do appear.

It was thought at one time that the value of an individual was as nothing compared with that of the race. But the facts of mutation show that this estimate needs revision. For any living creature may have an offspring which may exhibit mutation and so may be the progenitor of an entirely new race.

One of the most remarkable results of recent experimental work is the recognition of the fact that each living organism is no longer to be regarded as a unit but as a composite being made up of a great number of unit characters, each capable of separate description and all inherited independently of one another.

The manner in which these unit characters are inherited was discovered about 1865 by Mendel, first a member and then the Abbot of Brunn. The change which the recognition of unit characters and the discovery of Mendel have brought about has been described by Mr. Lock as follows:—"On the mind of a biologist familiar with what was known of heredity only ten years since, these facts must fall with a sense of complete novelty. The ideas current even so short a time ago are not so much extended, or even altered, as replaced by an entirely new set of ideas. And it may be remarked in passing that the biologist of fifty years ago and more was much nearer to our present line of inquiry.

§ 15. *The Fate of Living Organisms.*—From the creation of living organisms we may pass to their fate. Though they die one by one, life is handed on from parent to offspring in such a way that we might expect it to continue in an unbroken succession for all future eternity, provided the prevailing physical conditions are not destructive to it. But the present order of things, which is the only guide of science, points, as we have seen, to a future time when the energy of the universe will be no longer capable of further transformations, and without such transformations living organisms cannot continue to exist. Thus a time will come when there will be no longer any living organisms on the earth. The present order of things does not, however, suggest that the universe will not continue as a mass of inanimate matter after the death of the last organism.

What happens to its life when an organism dies, is a question to which physical or chemical science has so far given no answer, for the sufficient reason that life evades the measurement and analysis of those sciences.

§ 16. *Man and the Universe.*—A survey of the universe would be incomplete without an examination of the surveying instrument itself. That instrument is the human race, which has been so created and developed that it is able to make scientific observations and from them to discover laws obeyed by the universe. It is worth while to notice how those laws have been recognized. They have been established by experiment, and modern science, flushed with success, is steadily pressing its claims for more money and better opportunities for research in the hope of establishing further laws. But if we were to inquire why some man had made certain experiments or made certain calculations, the answer would often be that he had had an inspiration. The man is, however, conscious that it is the opening of his eyes which is the new thing, and not the fact or principle which he has perceived. The inspiration comes suddenly, like a flash of light, and makes an *abrupt* change in his intellectual conceptions. But no conclusions could be drawn from experiments unless it be admitted that some of the conditions can be varied in an arbitrary manner, and this amounts to a declaration of the power of free-will on our part. Thus, if we stroke a steel needle with a magnet, the needle becomes magnetized, but if the act of stroking was inevitable we could not decide whether the magnetism of the needle was directly due to the action of the magnet or whether other causes were involved. The power of free-will is of great significance, for the effects of a single act of free-will extend through the whole of space, and will last as long as the present order continues. Thus the voluntary motion of a man's hand not only affects the motion of the earth by a calculable amount, but also the motions of the sun and of the remotest stars, and the motions of all these bodies will differ for the rest of time from the motions they would have had if the man had not moved his hand.

But there are many other impressions received by man's consciousness, and all of them are undoubtedly phenomena occurring in the universe. Among them are the demands of conscience, the sense of temptation and the knowledge of yielding to it, the power of prayer and the consciousness of answers to it, and the other spiritual experiences of men. Our knowledge of these things did not arise from the recent work of a few scientific men; the whole human race, for many centuries, has been conscious of their reality. The universe is so clearly the domain of order that it would be strange indeed if spiritual things were not subject to laws, though it is to be expected that these laws will differ from those obeyed by inanimate matter, just as free-will differs from gravitation or chemical affinity. The unity of the universe makes it impossible to suppose that we can ever cut ourselves off from the operations of those laws. Did we but realize this, we should covet earnestly the spirit of holy fear. When men have this spirit they not only pay reverent attention to spiritual things, but also think and speak reverently of all the things of the material world, as, for example, of the weather. They are conscious that they are dwelling in the Temple of God and it is the joy of their lives to give Him their worship and their obedience.

The unity of the universe proclaims that there is absolute harmony between what is true in science and what is true in religion, and the fact that many of the greatest men of science have publicly acknowledged God in their scientific work shows the fallacy of the supposition that there is any antagonism between science and religion. Among these pioneers was Newton, who concluded his great *Principia*, or Mathematical Principles of Natural Philosophy, with a wonderful passage on the nature of God, "to discourse of whom," he wrote, "from the appearances of things does certainly belong to Natural Philosophy." Another pioneer has lately passed away from us in the person of Lord Kelvin, who for fifty-three years began the first lecture of each day by reciting a collect from the Prayer Book. In such lives as these there was wisdom and there was holy fear. May it not be that, after all, the fear of the Lord is the beginning of wisdom?

At the conclusion of the paper the thanks of the audience were unanimously voted to the lecturer on the motion of Professor ORCHARD.

Mr. SEARLE then dealt with a number of questions which were put to him, and the meeting adjourned at 6.15.