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738th ORDINARY GENERAL MEETING,

HELD IN COMMITTEE ROOM B, THE CENTRAL HALL, WESTMINSTER, S.W.1, ON MONDAY, JUNE 16th, 1930, AT 4.30 P.M.

Dr. James W. Thirtle, M.R.A.S., in the Chair.

The minutes of the previous meeting were read, confirmed and signed, and the Hon. Secretary announced the election of Leslie M. Hopkins, Esq., as an Associate.

The Chairman then called on Sir Ambrose Fleming, D.Sc., F.R.S., the President, to give the Annual Address on "Creation and Modern Cosmogony."

ANNUAL ADDRESS.

CREATION AND MODERN COSMOGONY.

By Sir Ambrose Fleming, F.R.S. (*President*).

1.—Astronomical Progress.

IN the last 30 or 40 years or more there have been vast additions to our knowledge of the structure of the Universe of Stars, and of the nature of those celestial bodies which appear to the eye merely as points of light on our nocturnal sky. This advance has been due to various instrumental achievements and to the progress generally of physics.

In the first place, it has been the result of great improvements in the optical arts, whereby we have been able to build immense telescopes with very great space-penetrating power.

In the next place, to the employment in connection with these telescopes of the photographic dry-plate in place of the human eye.

The eye does not see more or better by prolonged gazing through a telescope, but the impression on a photographic plate is cumulative and increases with the time of exposure.

Thus, a celestial object too faint to make any impression on a plate in a few minutes or even in an hour, will, after an exposure of several hours, reveal details or objects which never have been seen, nor can be seen, by the human eye even assisted by the most powerful telescopes in the world.

Then, further advances are the consequence of the association of photography with the spectroscope. When a ray of light from a star or from the sun is passed through a prism or wedge of glass, the white light is expanded into a rainbow-coloured band called a spectrum. Under proper conditions, this is seen to be crossed by many dark or bright lines or bands. This spectrum can be recorded on a photographic plate.

We have learnt by degrees to interpret the meaning of these lines. They are primarily due to the chemical nature of the incandescent substances which are emitting the light and heat of the star. But these lines tell us more than this. They inform us whether the star is moving to us or from us, and at what rate. They tell us the temperature and pressure in the star, and also can be employed in some cases to determine the distance of the star from us.

For the sake of those not familiar with the subject, it may be mentioned that there are two types of telescope in use.

One type, called a refractor, comprises a long metal tube having at the outer end an achromatic lens which collects the light and forms an image of the star at its focus. This image is then examined by other lenses forming a sort of microscope which is called the eye-piece. The cost of making large lenses is very great, because the glass must be without the least flaw, but object glasses nearly up to 3 feet 6 inches in diameter have been made and are in use. Such are the great Lick telescope (36 inches) at California, and the Yerkes telescope (40 inches) at Chicago, U.S.A.

The other type of telescope is called a reflector and collects the light of the star by means of a large concave mirror of glass or quartz, silvered on the surface. The image of the star formed by this mirror is examined with an eye-piece as in the case of a refractor.

In both cases the tube of the telescope is attached to an axis which lies in the direction of the Poles of the heavens, and this axis is caused to rotate by a motor or by clockwork, so that when once a star has been brought into the field of view, it is kept there by the mechanism, which, as it were, nullifies the motion of rotation of the earth. This is called an equatorial mounting.

Hence, when a celestial object is brought into the centre of the field of view or on to a photographic plate, taking the place of the eye, the equatorial motion of the telescope keeps it there for hours at a time, if necessary.

The largest reflecting telescope in the world is at present at Mount Wilson Observatory in the United States of America. The mirror is 100 inches, or 8 feet 4 inches in diameter. But another of double the size, or 200 inches diameter, is being built for this observatory. Such a telescope will have one million times the light grasping power of the unassisted human eye.

2.—Astronomical Measurements.

When we look at the clear sky at night from hour to hour, we notice a general movement of all the stars over from east to west, which is due to the rotation of the earth. A careful examination of the sky reveals, however, that certain stars move slowly but irregularly relatively to the general number of the stars. These are called the Planets, *i.e.*, the Wanderers. The moon, in addition, appears to move over much more quickly from west to east, in addition to that diurnal motion of which it partakes in common with all the other stars and planets.

The great bulk of the stars, however, retain their positions apparently with respect to each other and are collected in groups called the constellations. These groups, such as Orion, the Great Bear, Cassiopeia, the Square of Pegasus, Andromeda, or the Pleiades have been known to man in the arrangements familiar to us for nearly 4,000 years and appear to retain their forms unchanged from age to age. In addition to these constellations, we notice on clear moonless nights a faint cloudy streak of light which stretches right across the sky and is known to us now as the Milky Way. This extends round the southern as well as northern hemisphere. The good eye can detect as well certain faint cloudy patches in Orion and Andromeda, which are called nebulæ.

It is usual to denote the stars in each constellation by the letters of the Greek alphabet. Thus, the brightest star in the constellation of Orion is called *Alpha Orionis,* otherwise named *Betelgeuse,* whilst *Beta Ursæ Majoris* is the second brightest star in the Great Bear. In addition, we distinguish stars by their difference in apparent brightness. This is called their visual magnitude and is denoted by numbers which extend from 1 to 18 or more. A star of the 1st magnitude is just 2·512, or, say, two and a-half times as bright as a star of the 2nd magnitude, and so on for succeeding magnitudes. The good human eye can detect stars up to the 6th magnitude, which are only one-hundredth part as bright as the 1st magnitude stars. Since some stars, such as *Sirius,* are even brighter than the 1st magnitude, they are denoted by negative values. Thus, the magnitude of *Sirius* is — 1·58, whilst *Aldebaran* is just about the 1st magnitude. On this scale the magnitude of the sun is — 26·72. The apparent brightness of a star depends on its absolute brightness, or as we may say, on its candle-power, and on its distance. Thus, a faint star may be faint because it has small candle-power, or else because it is very far off. It is agreed that the absolute brightness of stars shall be measured by their apparent brightness if we were to suppose them all moved to the same distance from us, viz., about 200 billion miles. This distance is called 10 *Parsecs* or 32·6 *light-years.*

3.—The Distances of the Stars.

The problem, therefore, of determining the distances of the stars and their absolute brightness is fundamental in questions of cosmogony.

As regards near bodies like the Moon and some planets and even the nearer stars, the method adopted is that of trigonometrical surveying. When a surveyor requires to measure the distance, say, of a church far off, he measures off on the ground a base line, and observes with his theodolite the angles between this base line and the direction of the distant object at both ends of his base line. Then a simple calculation gives him the distance of the object.

In the same way the astronomer knows from the size of the earth the straight line distance, say, between the Greenwich and the Cape of Good Hope Observatories, and then by measuring simultaneously the angles between that line and the lines to the centre of the Moon observed at both places he can calculate the distance of the Moon. Its mean value is 238,857 miles. This method is also applicable to the planets, but the distance of even the nearest of the so-called "fixed stars" makes it necessary to employ a much longer base line.

The earth in its annual motion round the Sun changes its position in space (if we disregard for the time the motion of the Sun itself through space) by a distance of about 186 million miles. By photographic observations taken, say, at Midsummer and Midwinter, we can detect the slight displacement of some stars with this change in position of the earth. This is called the star's *parallax*. From it we can calculate the distance of that star. By this method of surveying we have been able to find the parallax and distance of many stars. This was first accomplished in 1838. The distance of about 1,400 stars has been measured in this manner which are at distances from about 4 to 100 light-years or more. The distance called a *light-year* is the distance a ray of light would travel in a straight line in one year. It is equal to 6 million million miles. But beyond that last-named distance the parallax method, even used with the enormous base line of the diameter of the earth's orbit, fails us entirely. Nevertheless, two other methods have been found for plumbing the abyssmal depths of space. One of these is adapted for the greatest possible distance. It is as follows: In the northern sky there is a constellation called *Cepheus* and the fourth brightest star in it, called *Delta Cephei*, is peculiar in that its light is variable or pulsatory. It brightens up and then slowly fades away, the whole cycle taking 5 days 8 hours. There are many stars of this kind, called short-period variables, whose time of pulsation varies from 3 to 40 days. The apparent magnitude or brightness of these Cepheids has been measured. In 1912, Miss Leavitt, employed in the Harvard Observatory, U.S.A., noticed that there is a close connection between brightness and period of certain Cepheids, the brighter stars having the longer period.

The distance of some of these Cepheids, which occur in all parts of the sky, has been measured by the parallactic method. Hence, an American astronomer, Dr. Harlow Shapley, was able to determine a relation between the absolute brightness of these Cepheids and their distance. The very important outcome of this was that when we can measure the periodic time or time of waxing and waning of the light of a Cepheid star, we can tell its distance at once. Since many globular clusters of stars and other constellations or nebulæ have variable stars of the Cepheid type mixed up with them, these become plumb lines by which we can ascertain the distances of these objects even when their real distance is measured in thousands of light-years. Thus, by this method Shapley found that a certain globular clusters of stars in the constellation of the *Centaur* is at a distance of 22,000 light-years. Whilst another similar one is ten times that distance.

Hubble used the same method to determine the distance of the great nebula in *Andromeda,* which is just visible to the eye as a small faint misty patch of light, and he found it is at the stupendous distance of 950,000 light-years. Hence, the light by which we see it at present started on its immense journey through space nearly a million years ago, long, long before there was any human life on the surface of this earth at all.

Far outside the region of those stars which compose the Milky Way, also called "our galaxy," because our sun is a member of it, there are an enormous number of globular clusters of stars and nebulæ which later, as we shall presently notice, are the birthplace of stars. Sir James Jeans, who is a great authority on this subject, tells us that the Mount Wilson 100-inch telescope shows us there are about two million of these clusters or nebulæ, their average distance apart being about 2 million light-years and their distance from our solar system some 140 million light-years. The imagination falters in the effort to grasp the full meaning of these gigantic numbers or the stupendous scale on which we now know the Universe of stars is constructed.

There is another method of determining star distances which depends upon the relative intensity of certain lines in their spectra, but it would require rather more time to explain it than can be afforded at present. Suffice it to say that we have now at least three methods on which we can depend to give us a fairly correct estimate of the distances of the stars. The conclusion that comes out most clearly from all these facts is that vast as are the distances which separate the stars and great as the number of them is, they populate the infinity of space very sparsely. Large as some of these stars are in size, the empty intervals which separate them are even still larger. But before we enter on any description of the general arrangement of stars in space, it will be best to consider first what the latest astronomical researches tell us about the nature and structure of the stars themselves.

4.—The Structure of a Star.

One of the most remarkable of recent discoveries is that, broadly speaking, the stars may be divided into two classes which are called respectively *giants* and *dwarfs*. The giant stars are immense masses of rarefied gas, often hundreds of millions of miles in diameter and intensely hot, yet so expanded in bulk that they are not denser in many cases than the residual air in the interior of an incandescent electric lamp bulb which we call a high vacuum. The temperature at the surface of these masses of gas may rise to 15,000° C., or 20,000° C. or more, but at the centre, owing to the enormous compression, it reaches millions of degrees. The diameters of some of these giants have been measured by an instrument called an Interferometer, and it has been shown that for such giants as *Betelgeuse* or *Antares* the size is large enough to contain even the whole orbit of the earth or more, viz., over 200 to 400 million miles. Dr. Harlow Shapley considers, however, that in some distant clusters there are giant stars of over 1,000 million miles in diameter.

On the other hand, the dwarfs are of size comparable with that of our Sun or less, and have mean densities exceeding that of water. They contain at least in their outer layers numerous metals in a state of vapour, such as iron, sodium calcium and many others.

At the centre where the temperature reaches millions of degrees, the atoms are completely stripped of all their orbital electrons and the nuclei are compressed so as to give very great density to the material, though it still retains the property of a perfect gas, in that additional compression can squeeze these nuclei even still more closely together. At a certain level the state of the material in a star is such that it sends out a great proportion of eye-affecting radiation called light, of an infinite number of wave-lengths. This level of the star is called its photosphere, and when that light is examined with a spectroscope, we find present in it rays of every colour, forming a so-called continuous spectrum. Above the photosphere, though not sharply divided from it, there lies in stars resembling our Sun in structure a layer of metallic vapours called the reversing layer, because it absorbs some rays of light from the photosphere and causes the continuous spectrum to be crossed by a multitude of black lines. Over this reversing layer is another layer of gases mostly hydrogen and helium which give rise to the red flames or prominences seen round the Sun's edge at a total Solar Eclipse. Beyond this Chromosphere is another more tenuous garment of our Sun called the Corona ; in part formed of very fine dust. Stars such as *Arcturus*, which are like our Sun in their general structure, are called Solar stars.

It has been found convenient to classify all the varieties of stars into certain groups distinguished by the letters O, B, A, F, G, K, M, N, and even to subdivide these classes into decimal fractions, such as G1, G2, etc., which mean 1/10th, 2/10ths, etc., on the way from G to K class.

The stars of the O class are noted for certain bright lines which cross their spectrum and they are called from their discoverers Wolf-Rayet Stars. Classes B and A are very large and hot stars of a bluish or white colour, and since the star Sirius or the Dog-Star belongs to this class they are called Sirian. Their spectra are characterized by black lines due to hydrogen and helium. Stars of classes F, G, and K are yellow stars like our Sun, and of lower surface temperature than Sirian stars. Stars of class M are red stars of still lower surface temperature, in fact, only red hot, and these M stars occur both as giants and dwarfs.

Stars of the yellow or Solar class have numerous black lines, due to metallic vapours in their spectra. All those stars are in rapid motion; some moving towards and some away from the earth. Part of that motion is due to the fact that our Sun with all his attendant planets is moving approximately at 20 miles a second, but each star apart from this common apparent motion, due to the Sun's movement, has a proper motion of its own.

The radial star velocity, that is its motion to or from the earth, can be measured by a general shift of all the lines in its observed spectrum which is produced thereby. The curious fact has emerged that the hotter and larger stars of classes B and A are moving more slowly than the cooler and smaller stars of classes G and H. There is clear evidence that great groups of stars move together, the directions of these group motions being in some cases in opposite directions.

One of the remarkable facts connected with star structure is that the stars differ not only enormously in bulk as between giants and dwarfs and also in surface temperature, but also vary greatly in luminosity or candle-power, from a mere fraction of the Sun's candle-power to 20, 50 or even 1,000 or more times that of the sun. The most luminous star is *S. Doradus*, which emits 300,000 times the light of the sun, whilst the least luminous is called *Wolf* 359, and emits only one fifty-thousandth part of the Sun's light.

Yet, notwithstanding these differences, the stars are all very nearly of the same mass or weight. The stars seem to be made out of chunks of matter, not differing very greatly in mass, but differing immensely in bulk. Some are swollen giants like great balloons of very rarefied gases, and some are very small and dense, so that as much of their material as you could put into a match-box would on our Earth weigh a ton or more.

One fact that should be mentioned is that a large proportion of the stars are double, that is, consist of two stars which revolve round their common centre of gravity.

Before discussing the general arrangement of stars in space, it is necessary to mention some important facts connected with the so-called nebulæ. As soon as large telescopes began to be made it was discovered that many wisps of filmy light like the Milky Way were seen to be made up of countless millions of stars. Hence, the opinion grew up that with sufficient telescopic power all such nebulæ would be revolved into stars. But that is not the case. The application of the spectroscope to the telescope by Huggins first showed that many nebulæ were glowing masses of gas, because their spectra consisted of only bright lines. These nebulæ exhibit themselves in all parts of the sky in different forms. There are first, the so-called planetary nebulæ which are more or less spherical and often have a star at the centre. Then there are irregular masses of gas; and some of these are self-luminous and some more or less dark.

Outside of the Milky Way and far beyond the region occupied by it, we find, however, innumerable nebulæ of spiral form, which are generally thought to be the birthplace of stars; not of one star, but of multitudes in a group. We are able, as it were, to trace the mode of development of their spiral nebulæ stage by stage.

If a mass of gas were isolated in space without rotation, it would assume a spherical form. If it rotates it would be compressed at the poles and stretched out at the equator into a bun or lens-shaped mass. As such a mass radiates at the surface it would contract, and as it contracts, its speed of rotation would increase, and at the same time it would become hotter at the centre. Then various actions might cause streamers of gas to be thrown off at the equator and these would be folded round the central part in spiral arms. We see such nebulæ sometimes edgeways, like flat disks, but in some cases, when viewed in the direction of the axis of rotation, we see the spiral form well developed, as in the great nebula in the constellation of the Hunting Dogs (*Canes Venatici*).

As the arms of such a spiral nebulæ stretch and cool, they would break up, as Sir James Jeans has shown, into discrete masses, each one of which might become a star.

5.—The Structure of the Universe.

One of the great objects which the eminent astronomer, Sir William Herschel, held before himself in all his observations was the discovery of the structure of the Universe, that is the general arrangements in space of that enormous multitude of stars visible in the telescope. He had no means of measuring, as we can do, the distance of these stars, but he managed by indirect means to anticipate some modern conclusions on the subject.

Broadly speaking, the Universe appears to be composed of an immense number of more or less isolated galaxies or immense groups of stars in rotation, some of which are in a more advanced condition of development than others. The main mass to which we give the name "our galaxy," because it contains the group including our solar system, appears to be composed of a number of such clusters, which have been drawn together by their mutual gravitation, whilst other outlying galaxies which are called "island Universes" lie far remote from our galaxy. This last or main mass of the stars is collected into a galaxy, which is lens-shaped or like a bun in form, that is, roughly, circular, but thicker in the middle than at the edges, and various estimates of the dimensions seem to show that it may be about 300,000 light-years in diameter and 4,000 light-years in thickness at the centre.

It may possibly contain some 30,000 million stars, some giants, but most of them more or less dwarfs. Then, far away, and in the space above and below this disc of stars, are the spiral nebulæ and clusters without number which are individually separate galaxies in process of creation.

The idea which we thus obtain of the grandeur and magnitude of the stellar Universe is one which far transcends any of our previous conceptions. The old Ptolemaïc, or geocentric, astronomy which made the earth the centre of the Universe, was replaced 300 years or more ago by the Copernican or Heliocentre theory, which transferred the centre to the Sun, but our modern cosmogony makes a far greater step forward and lifts us into a position in which we see our Sun and all its attendant planets as a mere insignificant speck of matter amongst an infinity of stars.

A question which is very closely related to the structure is the age of these stars we see. Here we enter a region of investigation which is much more difficult, and, to a large extent, more speculative than the question of arrangement or size. Yet, even here observation and calculation have been able to give some help. We know that in a gas, our atmosphere for example, the molecules or atoms are moving in all possible directions and with all possible speeds, some fast, some slow, and colliding with each other continually. As far back as 1869, Clerk Maxwell showed by mathematical reasoning that the result of these collisions would be that after a certain time all the molecules would have the same energy of motion. It is measured by the product of their mass and half the square of their respective velocities. This is called the Law of Equipartition of Energy. We can also calculate how long it would take for the equipartition to be reached.

Sir James Jeans has applied the same kind of calculation to the stars. We have stars of very various known masses and velocities and we can, therefore, calculate their energy of motion. When this is done we find that they have very nearly identical energy. The heavy stars move more slowly than the lighter stars.

If we ask how has this equipartition been brought about, the answer is by the mutual gravitation or pull the stars exert on each other. The next and most important question is : How long has it taken to produce this equality, assuming that the stars have been left undisturbed except by their mutual gravitation ? The answer Sir James Jeans gives is : From 5 to

10 million million years. Nearly the same result is arrived at by two other lines of reasoning, and the result is to give us something like the same age roughly determined. Hence, we see that in comparison with these vast periods of time all durations with which we are concerned in human history are about in the same ratio as fifty years are to a single second of time, or an average human life to a single tick of a clock.

One more point remains to be mentioned which is intimately connected with the structure of stars, and this is the source of their Light and Heat.

There has been much discussion in the past on the source of the Sun's Heat and Light. The Sun cannot be merely an incandescent ball left to cool or else it would long ago have become a cold and inert mass. At one time it was supposed to be supplied with energy by meteorites falling into it, and later on its heat was supposed to be maintained by a gradual shrinkage in size. But neither of these sources would supply its heat for the required time. From each square inch of its surface our Sun sends out heat enough to keep a 50-horse-power engine continually at work.

The new knowledge on atomic structure has, however, supplied the key to the mystery. The chemical atom is built up of a nucleus composed of far smaller atoms of positive electricity called protons and of negative electricity called electrons. Owing to the exquisitely small size of these electric atoms a direct collision between protons and electrons is very infrequent. But it does sometimes happen, and then the proton and electron colliding disappear as Matter and produce a flash of Radiation which may pass into the form of Light and Heat. The masses of the sun and stars are thus melting away into their Radiation. Our Sun loses every minute 250 million tons of its mass to supply the light and heat radiated by it. This conclusion is supported by the fact that the stars in the early stages of development have on the average more mass than older stars. The old ones have wasted part of themselves to supply the light by which they are seen.

Matter and radiant energy are thus different aspects of the same entity. Matter can be converted into radiation spontaneously, but we have no knowledge that the reverse effect can take place. If not, then the material Universe is slowly vanishing away, and more, this fact shows us there must have been a beginning to it in an Act of Creation.

6.—Cosmogony.

By this term is meant the processes or stages by which the Cosmos, that is the whole entirety of the material Universe, has arrived at its present condition and form. These processes as far as we can fathom them may certainly become the subject of scientific enquiry, just as are those by which an animal or a plant is developed from a minute germ or a seed.

The view has been held by many philosophers that if we could go back far enough in the history of the stars we should find an origin in a universally-diffused and rarefied material or medium.

After Newton had enunciated his law of gravitation, Bentley, Master of Trinity College, Cambridge, asked him if the force of gravitation would account for the concentration of such diffused matter into stars. Newton replied that if the amount of the original fluid or material was finite, it would collect itself into a single sphere. If it was infinite in amount, it would segregate itself into an infinite number of spheres. But there are good reasons for the belief that the amount of matter in the Universe is not infinite, and Einstein has furnished some arguments for the opinion that space itself is not infinite in volume, though it may be unbounded in the same sense the surface of a sphere is limited but unbounded.

In his remarkable book, *The Universe Around Us*, Sir James Jeans has expounded in detail the possible process of star development. He has shown that such a universal and uniform gaseous mass would be in unstable equilibrium, and that if from any cause such an unequal cooling, condensations above a certain size were produced, this would result in the break up or segregation of the whole into parts. In short, it would tend to break up into portions of about equal mass and the mathematical discussion shows that these masses would be about of the order of those of the spiral nebula and these, in turn, would give birth to clusters or large groups of stars. The full details of the process or the proof of it are far too long to repeat here. These star groups would in certain cases draw each other together by their mutual attraction, and aggregation may have given form to the Milky Way or our own galaxy.

Jeans shows in a very striking way the manner in which the rare event of the near approach of two stars might give rise to immense tidal waves in each, drawing out long streamers of gas which would ultimately form a system of planets. He thinks that in this manner the system of planets surrounding our Sun, including our earth, may have been formed.

Whether there are any other planets or worlds suitable for habitation by such beings as ourselves, we have no means of discovering. The stars themselves are all too high a temperature to permit the existence on them of material bodies such as ours, which can only live within narrow limits of temperature. But there may be planets circulating round other solar stars, which planets may be like our earth and suitable for physical life such as ours.

On all these questions our ignorance is complete, and it is vain to speculate as to the ultimate end and object of that innumerable multitude of worlds without end which are scattered like dust through the infinity of space.

7.—Creation.

The view that our modern astronomy thus compels us to take of the awe-inspiring size and immense age of the stellar Universe is one which some have held to be inconsistent with the idea of Creation in any sense of the word as generally understood. In the light of this new knowledge some have asserted that all human affairs seem to shrivel up into insignificance and to become mere transitory phenomena on one of the smaller planets revolving round a star of no particular size. But this is altogether a mistaken idea. Spiritual values have no connection with physical size or duration. This small globe on which we live may yet be the arena and place of events of unspeakable importance, not merely to the family of mankind, but possibly also to great, yet unseen, intelligences who have cognizance of them in regions far above this mortal state.

The objection that so many now take to the word Creation seems to arise from an imperfect definition of it, namely, that it necessarily implies making something out of nothing instantaneously. The proper signification of it is that the visible and tangible material Universe has not existed from all infinite past time, nor has reached its present state by automatic impersonal agencies, but has had its origin in the Will and Purpose of a Supreme Intelligence, Infinite in Wisdom and unlimited in Power, which seems to have been manifested or exerted in gradual stages. This, however, need not necessarily involve any abolition of the law of causation nor of the absence of stages or steps on the way to perfection.

Creation is none the less Creation, even if the slow development of the stellar Universe from some primordial nebula is the direct and necessary consequence of the properties of the atoms of which it is composed. The atom itself is then the true wonder, and it is essentially stamped in its structure with overwhelming evidence of adaptation and design.

We have clear proof along three lines that the physical universe cannot have existed from infinite past time, but must have had a beginning in a creative act. These lines, briefly, are the irreversible and spontaneous transformation of radioactive matter into non-radioactive matter. Next, the similar transformation of matter into radiant energy, and, thirdly, from the diffusion of heat, so as to produce finally equality of temperature in all material substances.

Matter and energy are, therefore, not self-produced, but imply and demand a creative act in their origination. We know nothing about the processes by which mind or spirit can express itself as matter, but the borderland between the two realities may not be sharply marked. Nevertheless, all order, numerical relations and adaptation or step-by-step advance, involving classification require thought and intelligence on our part to apprehend them, and therefore demand thought in an infinite mind to produce them.

The Universe exhibits in all its parts thought, and that necessitates a Supreme Intelligence. The highest scientific investigation is therefore not atheistic, but its last word on the subject of beginnings agrees with the first word of Revelation that "In the beginning (Heb., *Bereshith*) God created the heaven and the earth." Much futile controversy has taken place in former days concerning the degree of scientific accuracy of the Genesis account of Creation. It has been futile, because it was not always recognized that the Biblical narrative is not expressed in language solely appropriate to one age or one class of mankind, but conveys its insistent and important lessons in words which are true for all ages, and appeal to every branch of the human race. Its lessons are mainly spiritual, not scientific, and are true because they convey truth, though not in the vocabulary of this scientific age. If we compare it, for instance, with the early efforts of the unassisted human mind to penetrate into the origin of all things, we see at once how incomparably superior is the Biblical record.

Between the years 1848 and 1876 numerous clay tablets, inscribed in cuneiform characters, were discovered in the ruins of the palace of Ashurbanipal at Nineveh, and deciphered by Sir A. H. Layard, Hormuzd Rassam, and George Smith. Amongst them were found certain tablets, seven in number, identified by George Smith to be Babylonian legends of the Creation.*

At one time some persons supposed we had in these Babylonian legends the source of the Hebrew Cosmology. But the slightest comparison between the two shows the astonishing difference between them. The Babylonian creation story is merely an allegorical description of the contest between Light and Darkness, Order and Chaos. The story is one of struggle between imaginary gods and demons. The gods are deifications of the Sun, Moon, and planets. The demons of darkness and evil. It is characterized throughout by a debasing polytheism and demonism, and never rises above the level of thought engendered by the worship of astronomical bodies, the irregular movements of which across the sky caused them to be considered as living beings. There is no trace of the pure and elevating Monotheism of the Mosaic record, nor of creation by definite stages of the material world.

The Genesis narrative has been criticized as being entirely geocentric and, therefore, antiquated in idea. If, however, we take certain words in an enlarged and quite permissible general meaning, it is at once seen to be consistent with our scientific discoveries, as far as these are fact. The words "heaven" and "earth," in verse 1, may be taken as meaning the whole of the invisible or spiritual world and the whole of the visible or material universe. The word "light," of verse 2, may be taken to mean radiation of any wave-length and not merely that single octave of it which affects our eyes. In the same way the word "day," of verse 5, and the following, may be understood to be an unstated and perhaps prolonged period of time.

On this point I sought the advice of our honoured Vice-President, Dr. Thirtle, and he tells me that the Hebrew word Yôm (= day) is susceptible of three meanings, just as in the case of our English word "*day*," or the Latin "*dies*," or the Greek "*hemera*."

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* An illustrated pamphlet describing them and giving a translation can be obtained at the British Museum Bookstall, price 1*s*. 6*d*.

It may mean the period of daylight as opposed to night, or it may mean the astronomical day of 24 hours, or it may mean an undefined period of time, as in such expressions the "day of the Lord," or the "day of Jesus Christ." The particular meaning has to be decided by the context. There is nothing which does violence to the essential teaching of Genesis i, if we take the word "day" to be an indefinite and perhaps very prolonged period of time.

In this sense the word is used merely to state that the Creation of the material world proceeded in stages of time, marked by increasing complexity and perfection, and in alternating periods of activity and repose. It was crowned by the advent of an intelligent being, Man, possessed of the power of free choice and made in the image of God in the sense that he had faculties which were a faint copy of some of those of his Creator which enabled him in some degree to comprehend His Works and to glorify Him for them.

The scientific study alone of those works as they at present exist can never give us true information as to their origin. For this we need a Revelation, such as is given us in the Scriptures of Truth and from them, "Through faith we understand that the worlds were framed by the Word of God so that things which are seen were not made of things which do appear" (Heb. xi, 3).

Sir Isaac Newton concludes his epoch-making book, the *Principia*, allowed to be one of the greatest productions of the human mind, with a Scholium or Appendix, in which he declares his conviction that the whole diversity of natural things can have arisen from nothing but the Ideas and Will of a Being necessarily existing, Supreme and most Perfect in all His works.

Countless others who, like Newton, have been students of the wonders displayed to us in the material Universe, have followed him also in asserting them to be, not the result of an impersonal Evolution, but the Creation of the Everlasting God.

On the call of the CHAIRMAN, a hearty vote of thanks was accorded to Sir Ambrose for his address.