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657TH ORDINARY GENERAL MEETING,

HELD IN COMMITTEE ROOM B, THE CENTRAL HALL, WESTMINSTER, S.W., ON MONDAY, JUNE 11TH, 1923, AT 4.30 P.M.

THE VERY REV. HENRY WACE, D.D., DEAN OF CANTERBURY (*President*), IN THE CHAIR.

The Minutes of the previous meeting were read, confirmed and signed, and the HON. SECRETARY announced the election of Henry W. Mackintosh, Esq., M.A., as an Associate.

The PRESIDENT then announced that the prize for the Triennial Gunning Prize Essay Competition, the subject being "The Historical Value of the Book of Jonah," had been awarded to E. J. Sewell, Esq., late I.C.S. He added that we might look forward to hearing the successful competitor read his paper during the next session, and he thought it would be a very interesting occasion.

The PRESIDENT then called on E. Walter Maunder, Esq., F.R.A.S., to read his paper on "The Two Sources of Knowledge—Science and Revelation."

ANNUAL ADDRESS.

THE TWO SOURCES OF KNOWLEDGE—SCIENCE AND REVELATION. By E. WALTER MAUNDER, F.R.A.S.

FIFTEEN years ago I was honoured by an invitation from this Institute to deliver the Annual Address of that year. I took for my subject, "The Bible and Astronomy," that being directly suggested to me, on the one hand, by the first of the three primary "Objects" for which the Institute was founded, and, on the other, by the particular science, to a branch of which my own life has been devoted. In short, I endeavoured to give some answer to two questions: "What has the Bible to say respecting Astronomy?" and "What has Astronomy to say respecting the Bible?"

I find before me to-day essentially the same subject as I did then, but I desire now to treat it more generally. For Science is not confined to Astronomy, nor is the Bible the only means which God has employed in His Revelation of Himself to men. Fifteen years ago my subject was "The Bible and Astronomy," and I tried to show how the two *illustrated* each other; to-day I would endeavour to deal with "Science and

Revelation," and to examine wherein, as sources of our knowledge, they *differ* the one from the other It is a question of fundamental importance ; it comes up for answer whenever there is active research into the structure of the Universe—the Creation ; whenever there is, at the same time, earnest seeking after God—the Creator.

I propose to take Astronomy as the science from which to illustrate my subject, because it is the only one with which I have had direct and practical acquaintance. But, at the time when I received your invitation to deliver this address, it chanced that I was reading a delightful book, *Pasteur and his Work*, by L. Descours, an English translation of which had been recently published.

Pasteur—the centenary of whose birth is now being commemorated in France—achieved his great results in a science completely removed from Astronomy as to its subjects and methods ; but no astronomer was ever more severe in his adherence to the principle that like causes in nature produce like effects—always. To Pasteur, therefore, the discovery of a definite fact meant the power to predict the future recurrence of that fact when its conditions should be repeated. A true discovery brings with it the power to make an assured prediction.

But Pasteur recognized that scientific enquiry has its limitations, and in his well-known address to the students of the College of Arbois he expressed his views on true freedom of thought in the following terms :—

> " But freethought which claims the right of forming conclusions with regard to what is not really understood, the liberty which implies materialism or atheism, that liberty let us emphatically repudiate.
>
> " I really admire the great philosophers of these nihilistic opinions which flourish nowadays ! What ? We poor, patient observers of Nature, rich in the discoveries of our predecessors, furnished with the most delicate implements, armed with the strictest experimental method, we stumble at every step in our search for truth, and we find that the material world, in the least of its manifestations, is nearly always different from what we expected. But they, given up entirely to fixed ideas, placed behind the impenetrable veil which covers the beginning and end of things what do they do in order to obtain knowledge ?
>
> " Believe me, in the face of these great problems, these eternal subjects of man's solitary meditation, there are only two attitudes of mind : one created by faith, the belief in a solution given by Divine revelation ; and that of tormenting the soul by the pursuit of impossible explanations, expressing this torment by

> absolute silence, or, by what comes to the same thing, by admitting the impossibility of understanding or knowing anything of these mysteries. Only a misguided mind tries to introduce religion into science. More misguided still is he who attempts to introduce science into rcligion, because he entertains greater respect for the scientific method. The man who has religious faith does not know, and does not want to know. He believes in a supernatural revelation. You will say that this is incompatible with human reason; I agree with you; but it is even more incompatible with human reason to believe in the power of reason to deal with the problems of the origin and end of things" (pp. 205–6).

I do not propose to express my subject for enquiry in Pasteur's words, though our underlying thought is, I believe, much the same. I would rather express our enquiry thus: "We desire to learn something of the Creation and of its Creator. Can we use the same faculties of our nature, the same methods, the same attitude, in the one search as in the other?"

To deal, first of all, with knowledge of the Creation. Let us consider the methods that have been used, and the faculties which men have employed in that search. Naturally it is from the science of Astronomy that I shall draw my examples.

That which distinguishes Astronomy from all the other physical sciences is this: It deals with objects that we cannot touch. The heavenly bodies are beyond our reach; we cannot tamper with them, or subject them to any form of experiment we cannot bring them into our laboratories to analyze or dissect them. We are confined to this earth of ours, and they are so remote; we are so shortlived and they are so long enduring. We can only watch them and wait for such indications as their own movements and changes can supply.

But it follows, therefore, that if in time past men have put on record observations that they have made of the heavenly bodies we can reason back and find how, when, and for what purpose such observations were made, knowing that the movements of the heavenly bodies have been unaltered by any thought or act of men concerning them.

There was a time when men knew nothing of Astronomy; there came a time when men noticed that there were two great lights in the sky—a greater light that shone by day, a lesser light that shone by night—there were the stars also. There came a time when men recognized, consciously or subconsciously, that the risings and settings of the sun divided for them their time, and that the succeeding intervals between one evening

and the following evening, between one morning and the following morning, supplied a measure of duration that was practically invariable in length.

The setting of the sun and its association with the coming of darkness, the rising of the sun again with the return of light, could not be overlooked. Still the sun itself always presented the same shape. Not so with the moon. On one evening it might be seen as a thin arch of light, seen only for a few minutes and low down in the western sky. On the next evening the arch would be seen for a longer period and would be somewhat broader, and so on evening after evening, broadening until the moon had filled out to a perfect circle and shone the whole night through. Then the moon began to shrink ; shrinking night after night, till at length all that remained of it was a very thin arch, seen in the east in the morning sky for a few minutes before the sunrise. Last of all, for two or three days in succession, no trace of the moon would be seen at all, either in the morning or in the evening.

The changes of the moon, therefore, provided men with a second means of measuring time. Men recognized not only the succession of days, they recognized the succession of months.

The very earliest astronomical observation of which we have a definite record, either in picture or in writing, relates to the recognition of a third division of time—the year.

If we go into the British Museum and into the Assyrian and Babylonian Galleries, we find numerous sculptures brought from Mesopotamia—" boundary " stones recording the sale or gift of plots of land, pillars in celebration of victory, votive tablets as thankofferings to the gods—and on these one device that occurs very frequently is threefold in character ; it consists of a crescent moon and two stars. The oldest sculpture of which I know bearing this device is the stele of victory of Naram Sin, supposed to be of about date 2600 B.C. The " boundary " stones range in date from about 1200 B.C. to 800 B.C.

What is the meaning of this threefold symbol ; the " Triad of Stars " as it has been named by Schiaparelli ?

The meaning of a crescent moon is unmistakeable. This is the appearance presented by the moon at the beginning of a new month ; the moon is then in the west, close to the horizon, above the place where the sun has just disappeared. The crescent, therefore, means that a new month has just begun.

The position of the crescent is also significant. Month after month throughout the year, the *slant* of the crescent, when first

seen at moonset, varies. Near the spring equinox the crescent makes its nearest approach to a horizontal position; near the autumnal equinox it makes its nearest approach to an upright position, as if standing on its southern horn. Since the crescent in the Babylonian Triad always floats like a boat on an even keel, it represents the new moon of spring time;—the new moon of no other time in the year.

The two stars which complete "The Triad" are also unmistakeable. There are two bright stars in the sky, standing near the path of the moon and to the north of it; two stars, only two, that can be seen together with the new moon just after sunset at the beginning of a new month. They are not now seen near the moon at the beginning of the month at the spring equinox, but near the summer solstice. But Castor and Pollux, the bright twin-stars, did set together with the new moon of the spring equinox 6000 years ago. At that epoch, year after year, the sign of the Triad of Stars was completed in the heavens, the sign which the Babylonian monuments have handed down to us throughout these many centuries, a token to those who watched the heavens of 6000 years ago that a new year had just begun, a picture of the earliest astronomical observation that has been preserved to us.

But as the long centuries passed by, the first month of the year, as identified by this observation, fell later and later in the season, and some 4000 years ago the watchers of the heavens found it more convenient to take as the first month of the year the month indicated by the nearness of the new moon to a solitary bright star, one much brighter than either Castor or Pollux; compared with them a solitary star, but so placed that it set together with the crescent moon of one month when the twin-stars set together with that of the following month. This star is the one which we now call Capella, but the Babylonians knew it as "the star of stars" (or *Dilgan*)—the brightest of all the stars that stand "near the path of the moon and to the north of it." Of that observation we have a record in writing which Professor Sayce and Mr. Bosanquet have translated thus:—

> "When, on the first day of the month Nisan, the star of stars (or *Dilgan*) and the moon are parallel, that year is normal. When, on the third day of the month Nisan, the star of stars and the moon are parallel, that year is full."*

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* *Monthly Notices, Royal Astronomical Society*, vol. xxxix, p. 455.

A "normal" year is one of twelve months, a "full" year is one of thirteen ; if "the star of stars and the moon are parallel," it signifies that the two are about the same distance from the horizon ; in other words, they are setting together. So this observation not only indicated that a new year had just begun, but itself foretold how long that year would last—whether an extra month would have to be intercalated or not.

But again, as the long centuries passed by, the years as marked off by Capella and the new moon had their beginnings later and later in the season until they no longer began with the spring-time and the boat of the new moon no longer floated on an even keel. There was no other star to take the place of Capella as the pointer, and so the method fell out of use.

Nevertheless the Triad of Stars was still preserved as the traditional symbol of the beginning of the year and therefore of the year itself. The tradition still remained of that which had prevailed long ages earlier, when the sunset marked the beginning of the day, the new moon, seen in the western sunset glow, marked the beginning of the month, the new moon, seen on its back in the sunset glow, together with the twin-stars marked the beginning of the year. It had been originally the simplest possible means for recognizing the commencement of the new year, and for synchronizing the month with the year and with the day, and the year it defined was a luni-solar-siderial year. The sun just set, and the crescent moon about to set, were brought close together at the same hour of the day, and in the neighbourhood of the same bright pair of stars. The observation required no instruments, no knowledge of Astronomy, other than the observation itself ; no recognition of particular stars, other than those used as sign-posts by which to measure out the moon's movements in its monthly circuit of the heavens. But it afforded the means for an important measurement, a measurement of time ; the year was marked by the return of the sun and moon to the twin-stars, and it was shown whether it would consist of twelve or of thirteen months.

The fundamental principle of Science has been stated in many forms : "The thing which hath been, it is that which shall be" (Ecc. i, 9). "Everything that exists, and everything that happens, exists or happens as a necessary consequence of a previous state of things. If a state of things is repeated in every detail, it must lead to exactly the same consequences.

Any difference between the results of causes that are in part the same, must be explainable by some difference in the other part of the causes." (Thiele, *Theory of Observations*, p. 1.)

The fundamental action of Science is "measurement"; by some method, one object, one series of observations, must be compared or "correlated" with another. Without some operation of this nature, which we term "measurement," we could never know whether one set of consequences were less, equal or greater than another set.

And in this sense, the Triad of Stars, as engraved on these ancient monuments, is the first recorded instance of astronomical measurement.

To-day we see the same heavens as our forefathers did 6000 years ago. Stars of many degrees of brightness are scattered, as it were, at random, while a band composed apparently of innumerable faint stars, too close to one another to be distinguished separately, makes a steep angle with the apparent path of the sun. This band we call the Galaxy, the Milky Way, and its form suggests that it has some fundamental relationship to the structure of our universe. Men have often desired to probe and measure the heavens—to find the distances of the sun, the moon, the planets and the stars; to count them; and, if possible, to find out of what they are made.

But how can we measure them, and to what can we compare them? It is only since the telescope was invented that we have been able to recognize that the sun is a star like the thousands of shining points above us; it is, indeed, the star of which we know the most, and we often find it convenient in our comparisons to take it as the very type of a star.

Our forefathers took as their unit of length, the average length of a man's foot, or, to speak more accurately, the average length of his stride. In effect we use the same basic units of foot and yard when we wish to measure the dimensions of an atom, or of a field, or of the stellar universe; though, in order that we may have manageable figures to work with, we multiply or subdivide our units to obtain a more convenient scale.

In Astronomy our first measurements were of the dimensions of the earth itself, next of the distance of the moon, then of the sun; and we express these distances in kilometres or in miles. The distance of the sun, we call "the astronomical unit" 149,500,000 km. = 92,900,000 miles), and use it as our unit

when considering the distances of the outlying members of the solar system. But when our task is that of measuring the distances of the stars, we find that this "astronomical unit" is inconveniently small, and it is usual to adopt as a greater unit a length 63,290 times as large—that is to say, the distance that light can traverse in a single year. Most astronomers nowadays employ as a unit the "parsec"—that is to say, the distance from us at which our distance from the sun would subtend one second of arc—206,265 astronomical units, or 3·259 light-years.

The present director of the great Harvard College Observatory in Cambridge, Massachusetts, U.S.A.—Dr. Harlow Shapley—is now the most daring explorer into the dimensions and structure of the universe. Just a year ago, when on a visit to England, he gave a very notable address to the members of the British Astronomical Association, and summarized his work up to that date. He began by pointing out that the principal types of celestial objects are three in number—stars, diffuse nebulæ and spiral nebulæ. What do these three types respectively connote?

If we look out on the heavens we see many stellar points of light, differing one from another in brightness. This brightness tells us, first, that the star is sending forth light, heat and energy, qualities which we sum up in the one word "radiation." Next, that the stars differ widely either in the intensity of their luminosity, or in their size, or in their distance from us, or in all three together.

Five years ago Professor Eddington gave an address to the British Astronomical Association on "The Constitution of the Stars," and he began by saying: "I am going to examine into the inside of a star in somewhat the same fashion as we examine the mechanism of a clock to find out how it works."

Last autumn he presented a further development of the same subject in a paper communicated to the Royal Astronomical Society, and this spring he delivered a discourse before the Royal Institution on "The Interior of a Star." This discourse was published as a supplement to *Nature* of May 12, 1923, and is one of special clearness and beauty.

Let us suppose that we have a globe of perfect gas, under such conditions of temperature and pressure that it is held together by its own gravitational attraction. Such a gaseous globe must contract, and although it will continually radiate heat, its temperature must rise, but the radiation-pressure from within presses the material outwards, and neutralizes to

some extent the force of gravitation which is responsible for holding the globe of gas together. Suppose then that we have a series of globes of perfect gas, the first being a mere bubble containing 10 grammes, the second containing 10^2 grammes, the third 10^3, and so on. Professor Eddington illustrates the fact that these globes "would mount up in size rather rapidly," by saying "No. 1 is about the weight of a letter; No. 5, a man; No. 8, an airship; No. 10, an ocean liner; after that comparisons are difficult to find."*

Let us calculate for each of these gaseous "stars," small and great, the theoretical ratio of radiation-pressure to gravitation. For the first 33 spheres—namely, those with masses of from 10 to 10^{33} grammes—the radiation-pressure is less than one-tenth gravitation; that is, it is trivial. From the 35th sphere onward, the ratio is more than eight-tenths; that is, it neutralizes the greater part of gravitation. The lightest known star comes just below the 33rd globe; the heaviest known star is just beyond the 35th globe. The vast majority are between Nos. 33 and 34, just where the æthereal pressure begins to be an important factor in the situation. As Professor Eddington says:—

> "The interesting case is the transition between the two conditions represented by the solitary sphere of mass 10^{34} gms. We should expect something to happen about here, and something does happen. The stars 'happen.' The sphere of 10^{34} gms. is the one which represents the usual masses of the stars, being, in fact, five times the mass of the sun. The material of the universe has become aggregated into bodies which are remarkably uniform in mass, perhaps because radiation-pressure, on the one hand, will tend to break up masses that are much larger, and, on the other hand, when the division and sub-division has proceeded so far that radiation-pressure is only a small fraction of gravitation, there is little chance of any further break-up. The outstanding facts are, that the material of the universe has formed primarily bodies closely similar in mass, and at this same mass the force of radiation-pressure makes a sudden leap into importance. The idea is irresistible that these two facts are related as cause and effect, and that radiation-pressure is indeed the prime agent which has fashioned chaos into stars."†

Let Dr. Harlow Shapley again take up the tale:—

> "Once stars have been gravitationally formed out of their chaotic pre-stellar states, with their masses limited in the manner Eddington has shown, they are largely organized into groups, a common, perhaps prevailing, form being the globular cluster."‡

* *Nature*, 1923, May 12, Supplement, p. vii.

† *Journal of the British Astronomical Association*, vol. xxviii, p. 149.

‡ *Ibid.*, vol. xxxii, p. 262.

The stars as a whole are so distant from us that only in the case of a very few of them can we measure their distance from us trigonometrically; that is, we measure their very small shift as regards other stars in the same field of view, as the earth moves from one point of its orbit to another point, 186 millions of miles away from the first, six months later. So we must, as a rule, resort to indirect methods of measuring, and these stellar systems called "globular clusters" afford us one such method out of many.

The globular clusters (some ninety in number) are highly organized systems, containing several tens of thousands of stars. On the photographic plate, the clusters, appear very nearly round, though not absolutely circular, and the stars concentrate almost uniformly from the periphery to the centre, as shots concentrate towards the bull's-eye of a target. Some present a larger circle than others, but the actual number of stars in the larger clusters does not appear to differ much from that given by the smaller. The obvious inference is that all the globular clusters are of about the same size; and that the bigger ones are simply those nearer to us, the smaller those further off. It is merely a question of perspective. If, then, we can find the distance from us of one or more, we have practically found the distance of all. Thus one cluster is comparatively close to us, being only 36,000 light-years away; another cluster is very distant, as far away as 220,000 light-years. These concentrated clusters—"close globulars" as they are called—are not found in the texture of the Milky Way itself, but all seem to lie along its borders, outlining it, so to speak. We can thus get some idea of the shape and extent of the Milky Way itself; its length and its breadth are about twenty or thirty times its thickness, so that it is extremely flattened, and its greatest diameter is something of the order of 300,000 light-years. Our solar system is situated in a somewhat sparse region within its ring, but not centrally within it.

There is one assumption made in all these investigations, the assumption that there is no general absorption of light in space. We do not know this absolutely, though the evidence tends that way, and if there is absorption, then the distances given for the clusters and the dimensions of the Milky Way will all suffer alteration.

There are two forms of globular clusters: the "close globular," in which the members seem densely concentrated, and the

"open cluster" in which the stars are loosely scattered. No close globular cluster has, as yet, been found in the Milky Way itself, but they never lie very far from it. No open cluster, on the other hand, has been found anywhere except in the band of the Galaxy. From these relative situations Dr. Shapley argues that the globular cluster is the prevailing form for original stellar organizations, and the presence in the Milky Way of all known open clusters indicates that the close globular system, if absorbed in it, does not remain intact, the forms and variety of the open systems showing forth the gradual dissolution of these secondary organizations.

The diffuse and planetary nebulæ, both appear to be members of the Milky Way system. In December last, Major Hubble, of the Mt. Wilson Observatory in California, published a study of the nebulæ in the Milky Way, in which he showed that particular stars are almost always associated with a nebulosity, and accordingly he measured the intensity of the nebular light at a series of points in it, and, in each case, he found that the intensity of the light at any point varies inversely as the square of its distance from the star and that each part of a nebula reflects—or re-emits without change in actinic value—*all* the starlight intercepted by it. In particular, he showed that there was a nebulosity made luminous by the star Rigel (in the foot of Orion), though the nebulosity lay at a distance that it took the starlight from Rigel, ninety-three years to cross.*

But it is over the spiral nebulæ that the chief controversy rages to-day. Are they "island universes" comparable in every way with our Milky Way, or are they integral parts of it, or outlying members federated with it? The trend of evidence to-day runs, on the whole, counter to the idea that the spiral nebulæ are "island universes"; that is to say, independent "galaxies." Of one great spiral, known as Messier 81, there have been two photographs taken by the same telescope under similar circumstances, but eleven years apart, and Mr. van Maanen, of the Mt. Wilson Observatory, measured them and found that they were not identical. The differences between them were of quantities so minute that a great deal must be allowed for errors of measurement; but, on averaging a large number of these, the individual errors of measurement tend to destroy one another, while the true motion remains. Mr. van Maanen

* *Astrophysical Journal*, December, 1922, pp. 400–438.

found, for instance, that the time that would be required for a condensation, in one of the arms of the spiral, to describe a complete revolution about the central nucleus is about 58,000 years.* In another spiral (Messier 33 in Triangulum) the period of revolution is 160,000 years, and by spectroscopic measures of its velocity in the line of sight, its distance from us is found to be about 6000 light-years, and the diameter of the whole nebula as 100 light-years. Since other spirals are of about the same order in distance and size, it is obvious that they are too small and too near to be independent of the Milky Way; indeed, we are ourselves as far distant from the inner border of the Milky Way as we are from Messier 33.

We have, then, obtained, some idea—imperfect certainly, yet with a definiteness confirmed in many ways—of the size and form of the main structure of the universe. We may not have probed it to its limits everywhere, or perhaps anywhere, but there are indications that it does not extend indefinitely beyond the extremity of our plumb-line. We have been able to distinguish between parts of its structure, and perhaps to determine in some degree their relationship to each other, and to the whole. But throughout, the stars have remained points of light, points without parts, unmeasurable. We have had, indeed, considerable knowledge as to the size of stars, but this was found by indirect calculation; it is only within the last two or three years that the accuracy of this knowledge could be tested by actual measurement.

But on December 13th, 1920, just three and a-half years ago, the Michelson Interferometer having been fitted to the great 100-inch telescope at Mt. Wilson, Dr. Pease and Dr. Anderson found "that the fringes on Betelgeuse were not present at 10 feet-separation." The deduced diameter was $0''{\cdot}045$—about the same size as a halfpenny, 50 miles away. Reduced to miles this means 240×10^6 miles, or slightly less than the *diameter* of the orbit of Mars.†

This is a very meagre outline of the state of our astronomical knowledge to-day. But if you think it over, you will remember that every generalization, every far-reaching conclusion, has been founded on observations, compared by means of measurements;

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* *The Nebular Hypothesis and Modern Cosmogony*, being the Halley Lecture, delivered on May 23rd, 1922, by J. H. Jeans, pp. 12 *et seq.*

† *Monthly Notices, R.A.S.*, vol. lxxxiii, pp. 314–315, February, 1923.

every hypothesis has been based on measurements; every theory has been tested by measurements. These measurements have in many cases been made by methods, direct or indirect, that had not even been thought of at the beginning of this century. They have revealed to us a universe vaster and more complex, and at the same time more evidently a single structure, than any one had dreamed of a generation ago. Comte, at one time, laid it down that it was not possible that man should ever ascertain what elements composed the stars; now the riddle of the universe is being read from our knowledge of the conditions of the elements in the stars—the stars themselves forming a laboratory more powerful than any we can build on earth—and the structure and internal motions of those elements are chief items in that knowledge. The number of their electrons are computed, and their velocities and the lengths of the paths they traverse are calculated. Firstly, lastly, and in between, every science rests upon measurement.

It was so with Pasteur's science. In all his numerous researches, many of them quite novel in their character, we find this same type of action; numerical expression is given to facts of observation. Fermentation is found to take place within certain degrees of temperature; certain intervals of time are needed to develop an infection, or to preclude it; virulence in the disease imparted by a culture from a particular germ may be attenuated by its staleness, or increased in proportion to its freshness. Pasteur's researches into the nature of fermentation, his conquest of anthrax, of puerperal infection, of chicken cholera, and of the two diseases of silkworms; his searching criticism of the alleged possibility of spontaneous generation, his campaign against rabies, all are full of examples of the same type of methods based upon the same root principles. The comparison of two groups of facts may be made in very different ways, and may be expressed in relation to very different qualities or conditions; but if the facts are expressed in numbers we may legitimately term them "measurements."

Yet all measurements are liable to error; for our instruments are inaccurate, our eyes are optically imperfect, our hands, and our wills that direct them, are imperfectly attuned to each other. Yet with all these imperfections the steady underlying tendencies emerge, and when we have one law fairly well established, we grope among the seeming inaccuracies, the deviations from this law, to search if there may not be some law also underlying these.

Let me read a paragraph from the first of six lectures on "Popular Astronomy," originally delivered at Ipswich by Sir George Airy in 1848 :—

> "Having now come to that result, as one that is generally established, I shall just mention a slight departure from it. Perhaps you may be surprised to hear me say, the rule is established as true, and yet there is a departure from it. This is the way we go on in science, as in everything else; we have to make out that something is true; then we find out under certain circumstances that it is not quite true; and then we have to consider and find out, how the departure can be explained."*

Thus the inaccuracies of observation, the departures from obedience to a supposed perfect law, serve as indications to men of science as to the direction in which further researches require to be made.

In sharp contrast with this attitude of mind may I quote what Plato in his dialogue, "Phædo," represents Socrates as saying on the morning of the day on which he died :—

> "Do sight and hearing convey any truth to men, or are they such as the poets constantly sing, who say that we neither hear nor see anything with accuracy? If, however, these bodily senses are neither accurate nor clear, much less can the others be so: for they are all far inferior to these. . . . When, then, does the soul light on the truth? For, when it attempts to consider anything in conjunction with the body, it is plain that it is then led astray by it. . . . Must it not then be by reasoning, if at all, that any of the things that really are become known to it? And surely the soul then reasons best when none of these things disturb it, neither hearing, nor sight, nor pain, nor pleasure of any kind, but it retires as much as possible within itself, taking leave of the body, and, as far as it can, not communicating or being in contact with it, it aims at the discovery of that which is."

I wish to draw your particular attention to this quotation, for the form of argument, which Plato here ascribes to his master, Socrates, bars the road to any knowledge of the physical universe whatsoever. He claims that our bodily senses are inaccurate, and implicitly denies that the reason has the power of dealing with the impressions produced on the senses, correcting their interpretation by testing and comparing them. But he claims that when the reason shuts itself up in itself and confines itself to self-examination it becomes infallible. It has no need for any of the requirements of a physical science; it is content to

* *Popular Astronomy*, by George Biddell Airy, Astronomer Royal. Sixth Edition, 1868, p. 13.

have "no units, no measurements, no controls, no precise definitions, no distinction between subjective and objective."

This same doctrine was adopted as guide in the Vedantic philosophy, and it was followed out with pitiless logic until it resulted in the denial of any reality in God, in Man, or in Nature; its ultimate achievement was nothingness; its consummation extinction.

I have tried to put before you in a few words some of the conclusions which the leaders of present-day Astronomy have reached, or are now foreshadowing, in their study of the universe of stars. Permit me now to take up the second part of my subject, and to turn from the knowledge of the creation to the knowledge of the Creator—to the knowledge of God.

From what, from whom, can we gain this knowledge?

We have learned this much from Astronomy, that if we wish to know about a particular star, we must look at that star; it is the light that comes from that star which will give us the information we seek. It is the light which comes from Betelgeuse that can teach us the brightness of Betelgeuse, its size and mass, its movements and its distance, the elements which it contains, and its surface temperature; the progress of its development, and its relative age.

The knowledge of God can be given us by Himself alone; it is in His Light only that we can see light.

But "no man hath seen God at any time." Yet—"the invisible things of Him from the creation of the world are clearly seen, being understood by the things that are made, even His eternal power and godhead." The vastness of the creation does indeed bear witness to the power and wisdom of the Creator.

> "When I consider Thy heavens, the work of Thy fingers,
> The moon and the stars, which Thou hast ordained;
> What is man, that Thou art mindful of him?
> And the son of man, that Thou visitest him?"
>
> —(Psalm viii, 3–4.)

In the presence of the vastness of Creation and the glory of the innumerable suns with which the Lord has adorned the heavens, what attitude is possible to man but that of profound humility and reverence?

The magnificent drama of the book of Job deals with this question. Twice God testifies concerning Job "that there is none like him in the earth, a perfect and an upright man, one

that feareth God and escheweth evil." Yet when the flood of suffering and sorrow overwhelmed him, and more especially when his three friends increased his pain by charging him with having committed some black and secret wickedness, Job, in resentment at their charges, went far towards imputing injustice even to the Lord Himself. The answer which the Lord made to him out of the whirlwind was to point Job to his utter weakness as compared with God :—

> " Canst thou bind the sweet influence of Pleiades,
> Or loose the bands of Orion ?
> Canst thou bring forth Mazzaroth in his season,
> Or canst thou guide Arcturus with his sons ?
> Knowest thou the ordinances of heaven ?
> Canst thou set the dominion thereof in the Earth ? "
>
> —(Job xxxviii, 31–33.)

The eighth Psalm, which I began to quote earlier, points out that God has highly exalted mankind :—

> " For Thou hast made him a little lower than the angels
> And has crowned him with glory and honour.
> Thou madest him to have dominion over the works of Thy hands ;
> Thou hast put all things under his feet :
> All sheep and oxen, yea, and the beasts of the field ;
> The fowl of the air, and the fish of the sea,
> And whatsoever passeth through the paths of the seas."
>
> —(Psalm viii, 5–8.)

But the Lord called Job to recognize that these same lower animals over whom God had given man the dominion, excelled man in beauty and strength and in their fitness for their place in Creation. He does not so much as refer to Job's complaint that he was suffering injustice :—

> " Hast thou an arm like God ? or canst thou thunder with a voice like Him ?
> Deck thyself now with majesty and excellency ; and array thyself with glory and beauty."
>
> —(Job xl, 9–10.)

Then Job answered the Lord, and said :—

> " I know that Thou canst do every thing and no thought can be withholden from Thee . . .
> Wherefore I abhor myself, and repent in dust and ashes."
>
> —(Job xlii, 2, 6.)

Thus Job was brought back to the recognition of the truth which he himself had uttered not long before.

> " Behold, the *fear* of the Lord, that is wisdom ;
> And to depart from evil is understanding."
>
> —(Job xxviii, 28.)

Thus from the very foundation of either search, the search after the knowledge of the Creation, and the search after the knowledge of the Creator, there is a fundamental difference in the attitude of the seeker. The first search lies in the natural sphere, and is carried on in the natural power of the man. The second search is only possible to the man who disclaims completely his own wisdom and merit ; it must be followed in humility and profound reverence before God and in full trust in Him.

So far as we know, the earliest knowledge of God that men possessed seems to have been this : " That God is " ; " That He is one God " ; " That He created all things " ; " That He is Almighty." But from the beginning God also made known to men that He had a purpose in His dealings with mankind ; for just as men have their plans and purposes which they make known to those whom they choose to make their friends and in whom they place their confidence, so God has His purposes ; especially He has His purposes with men. This is strikingly seen in His call of Abraham, whom He told beforehand of those things which He was intending to do ; not only to Abraham himself personally, but also to his descendants after him, and to all the families of the earth. " The Lord said, ' Shall I hide from Abraham that thing which I do ? ' " summarizes the general character of the intercourse to which the Lord admitted Abraham and the other prophets who succeeded him. Thus the prophet Amos cries : " Surely the Lord will do nothing, but He revealeth His secrets unto His servants, the prophets."

This is a second feature in which the knowledge of God differs essentially from the knowledge gained by scientific enquiry. Not only is God invisible and therefore not to be reached by our senses, but He has His secret purposes which none other but Himself can make known to us. Just as one man does not know what another is thinking or purposing unless the other divulges it in some way, so no man can know God's thoughts or purposes except the Holy Spirit of God makes them known to him.

"What man knoweth the things of a man save the spirit of man which is within him, even so the things of God knoweth no man but the Spirit of God." God's revelation of His purpose through His prophets, that is, through men, whom He uses as speakers for Him, marks a second stage in God's revelation of Himself. This was especially the purpose of God in His dealings with the "Chosen Race"; that is, with Abraham, whom He chose to be His friend and confidant, with Isaac and Jacob, the heirs with him of the same promise, and the nation of Israel, their descendants.

The way of science and the way of revelation lead to one and the same conclusion in their different spheres: "GOD IS GREAT." He is Almighty and All-wise.

But no man by his own effort can find out the secret purpose of God: neither from the stars, nor from the sentient animals, nor from the ultimate structure of the elements, nor from the physical structure of mankind. In all these, the limit to our natural knowledge, "the impenetrable veil which covers the beginning and end of things," as Pasteur describes it, closes us in. We, of ourselves, can know nothing of the beginning, nothing of the end. The revelation of God's will is, and must ever remain, God's free gift to man, whatever the manner in which it is made. The revelation must have its sole origin and source in God; it cannot be the outcome of man's internal reasoning.

We see how widely divergent are the two ways, how utterly different is and must be the attitude of man in the one and in the other.

Therefore there can never be any confusion, much less any conflict, between science and religion. The essence of science is that it is the orderly expression of our experience of material relationships. But religion is character manifested in conduct: "Pure religion and undefiled before God and the Father is this, To visit the fatherless and widows in their affliction and to keep himself unspotted from the world."

Take, for example, the old controversies of the science of Astronomy: "Is the earth a flat disc or a sphere?"—"Do the heavens rotate round the earth or does it turn on its own axis?"—"Does the sun revolve round the earth or the earth round the sun?" These questions have no bearing on the relationship of God to man, or the conduct of man toward man; only on the relationship of one thing, unconscious and inanimate, to another of like quality.

Science deals with things temporal and transient; it is essentially the study of changes in the material creation; changes of place, changes of condition, changes of form and structure; it is the study of the causes and results of change. Science deals with things that change and of their changes, and is the changing thought of man concerning these.

Revelation brings to us the knowledge of Him Who is the Eternal One and Who changes not.

So far this paper has referred to the revelation of the *power* of God, which He has given us in creation, and also to the revelation of His *purposes* toward mankind, given to us through His prophets. But God has made a Revelation of Himself higher still; full and perfect.

"God, Who at sundry times and in diverse manners spake in times past unto the fathers by the prophets, hath in these last days spoken unto us by His Son, Whom He hath appointed heir of all things, by whom also He made the worlds; Who, being the brightness of His glory, and the express image of His person, and upholding all things by the word of His power, when He had by Himself purged our sins, sat down on the right-hand of the Majesty on high; being made so much better than the angels, as He hath by inheritance obtained a more excellent name than they." (Heb. i, 1–4.)

I make no apology for refraining at this point from the use of my own thoughts and words in the remainder of this paper. My position here is that of a man of science. However limited the scope of my work may have been, that work, for the last fifty years, has been of a scientific character, and in respect to it I have the right to express my own thoughts in my own words. But, at the point to which I have now arrived, I feel that my fitting course is to discard my own words and to quote avowedly from that expression of the supreme revelation of God which has been given to us in the writings of the beloved disciple; writings which are so largely filled with the sayings of the Eternal Word Himself.

This, then, is the testimony of St. John:—

"That which was from the beginning, which we have heard, which we have seen with our eyes, which we have looked upon

and our hands have handled of the Word of life; for the life was manifested, and we have seen it, and bear witness, and show unto you that eternal life, which was with the Father and was manifested unto us; that which we have seen and heard, declare we unto you, that ye also may have fellowship with us: and truly our fellowship is with the Father, and with His Son Jesus Christ." (1 John i, 1–3.)

And these are the words of our Lord Jesus Christ Himself, as recorded by St. John:—

"Ye are My friends, if ye do whatsoever I command you. Henceforth I call you not servants; for the servant knoweth not what His Lord doeth; but I have called you friends; for all things that I have heard of My Father I have made known unto you." (St. John xv, 14–15.)

"These words spake Jesus, and lifted up His eyes to Heaven, and said, Father, the hour is come; glorify Thy Son that Thy Son also may glorify Thee: As Thou hast given Him power over all flesh, that He should give eternal life to as many as Thou hast given Him. And this is life eternal, that they might know Thee the only true God, and Jesus Christ, Whom Thou hast sent." (St. John xvii, 1–3.)

The knowledge of the Creation which is brought to us in the course of scientific enquiry is the work of man, in the exercise of his own natural powers; that is to say, of the dominion which God gave to him over the works of His hands. This knowledge, this dominion, is not to be despised because it deals only with material things.

The knowledge of God can only come to us as the free gift of God, and to it man can contribute nothing. But, in the beginning, God made man in His own image, after His likeness, in order that He might call men His friends, and make them His sons. This He has done in the Son of Man, Who is the Son of God, "the Image of the invisible God," "the First-born of every creature." "And He is before all things, and by Him all things consist."

Discussion.

The President (The Dean of Canterbury) said: Concerning the difference drawn between knowledge of material things and knowledge of God, there is one phrase which needs special attention—that of the "Conflict between religion and science." Between religion as such and science there can, of course, be no conflict; but there may sometimes be a conflict between science and faith, because some achievement of science may occasionally appear to be incompatible with certain beliefs. I may take as an example the subject of the Gunning prize of this year—the Historicity of the Book of Jonah. On such a point science and faith may *seem* to conflict for a time.

But I am more concerned to add a corollary to what has been said respecting our knowledge of God. It is unquestionable that we can know nothing about the beginning or the ending of things except by revelation. But we must bear in mind the saying of St. Paul that "the invisible things of Him from the creation of the world are clearly seen, being understood by the things that are made, even His eternal power and godhead." Modern science has increased immensely and developed our conceptions of the Creator's eternal power and godhead. One thing science has established. Heathendom thought that there are many gods because of the conflicting forces in Nature, and it was not unnatural to imagine that there was a separate god in and for each element. But science has shown that this is a mistaken imagination, for the whole of Nature is absolutely *one*. Science has also proved that Nature is reasonable, for it is developed on lines conformable to human reason.

The reference to the saying of Socrates in the Phædo reminds me of the different view taken by our fellow-countryman and great philosopher, Lord Bacon, who laid it down that there should be a constant "commerce between the mind and nature"—*commercium mentis et verum*. Few, perhaps, have realized that practically the whole of the life we lead to-day depends on the fact that about seventy years ago a great engineer measured an inch to less than a thousandth part. Were it not for the possibility of measuring to this degree of precision, we could not, for example, have the engines which drive our aircraft.

We are, indeed, unable by our own reason to attain to knowledge of the will and purpose of God, and of the beginning and the ending of things, but we do know, apart from revelation, that the universe is a moral universe, and that good and evil lie at the base of all intelligent life. It is an instance of the divine inspiration of the Book of Genesis that it lays down, first the principle of the unity of Creation, under one Creator, and then declares at once the principle of right and wrong in human nature, and thus teaches us that true religion must be founded on the essential difference between right and wrong as established by the will of God.

Lieut.-Colonel G. MACKINLAY said: Few, if any, besides Mr. Maunder have given us two annual addresses. Our author has also helped our Institute in many other ways. Some years ago, when want of funds prevented us from paying the salary of a Secretary, Mr. Maunder skilfully devised a plan by which the duties were shared by three unpaid members of the Council. This plan has worked very well from that time up to the present, and Mr. Maunder has taken his share of the work.

It is my very pleasant and happy duty to propose a hearty vote to our honoured President for taking the Chair on this occasion. His career is well known, and we rejoice that we have a President who is full of energy, alertness, tact and humour, but, above all, a man of steadfast Christian character. He has already supported the Victoria Institute for many years, and his Presidency is most welcome.

I have much pleasure in announcing that only a couple of hours ago he was unanimously invited by the Council to deliver the *next* annual address, and this he most kindly and readily consented to do.

I have, therefore, the greatest pleasure in proposing that a hearty vote of thanks be given to him.

This was seconded by Dr. PINCHES and carried unanimously.

The DEAN briefly replied and thanked the meeting.

Notes from Prof. T. G. PINCHES, LL.D.: It was with considerable interest that I listened to Mr. Maunder's valuable paper upon the two great Sources of Knowledge, and if we limit Religion to Christianity and the Scriptures upon which it is based, there is no doubt that the learned author has made out his case.

It is needless to say that I do not criticize or challenge either the statements or the conclusions contained in Mr. Maunder's Paper, but there is one point upon which I should like to ask for information, as it is connected with my own subject of Assyriology, and that is, the origin of the two discs, with stars and rays inside, which the author of the Paper we listened to with such great interest identified with the twins, Castor and Pollux. As he truly said, these are depicted on the boundary-stones and other antiquities of Babylonia and Assyria. On the cylinder-seals, however, there are found from time to time representations of what are regarded as the Twins. These are not in the form of discs, but are representations of two little men, apparently intended to be shown in a more or less grotesque style—as comic and dwarfish. These figures are engraved very much alike, and one would say that they were certainly intended to be recognized as twins.

The Babylonians identified seven pairs of stars as twins, those which head the list being *Maš-tabba-galgal*, "the great Twins," and *Maš-tabba-turtur*, "the little Twins." In all probability it was the former which was identical with Castor and Pollux.

As to the various positions of the star-centred discs on the Babylonian boundary-stones and other Assyro-Babylonian monuments, depicted in connection with the crescent moon, I will say nothing—there may be a meaning in this, or there may not. But there is one thing which strikes the casual observer of these emblems, and that is, that the discs in question are seldom or never alike, as we should expect stars regarded as twins to be. They are nearest to the same form and design on the Stele of Victory of Naram Sin, where the right-hand disc is made to contain an 8-pointed star with wavy rays between the points. The left-hand star-disc is similar, but is too mutilated to enable the true form of the rays between the points to be accurately made out—they may be wavy or they may be straight. On the boundary-stones, however, the two discs differ, and in the *Délégation en Perse, Mémoires, Tome I, Recherches Archéologiques*, by de Morgan, Jequier and Lempré, one appears as a 4-pointed star with wavy rays in between, and the other as a 4-pointed star superimposed upon another precisely similar. (*See* p. 168.) For the present, therefore, we ought to adhere to the generally-received opinion that these represent the sun and the moon. As pointed out by Prof. Garstang, the sun

within the crescent moon, so often seen on the cylinder-seals, has given rise to the Crescent and the Star, which forms the design upon the national flag of Turkey. The sun's disc on the cylinder-seals is shown with points like a star, and rays, often wavy, between them.

I have written thus at length because the new explanation conflicts with the statements made by our most honoured colleague, Lieut.-Colonel Mackinlay, in his book *The Magi—how they recognized Christ's Star*, and it is desirable that doubt should be removed—that it should be decided whether the two star-decorated discs are the sun and Venus, as was formerly thought, or Castor and Pollux. Other arguments as to the meaning to be attached to these reliefs might be adduced, but would here take up too much space.

Mr. W. Hoste wrote: We are grateful to the lecturer for personally conducting us through some of the marvels of the Universe, especially of the Galaxy, and incidentally introducing us to Prof. Eddington's latest lecture, "The Interior of a Star," which speaks with such charming simplicity of complicated problems as to make even a layman imagine he understands. Our lecturer, on page 236 of his Address, quotes Professor Eddington as saying that at 10^{34} gms. "the stars 'happen.'" Does "happen" mean become incandescent? I am very thankful that Mr. Maunder has nailed to the counter that muddling theory of Plato and his modern imitators, that the bodily senses are quite unreliable guides. We have been told that at the Victoria Institute before now, and assured that all we see or hear is unreal, the invisible alone is real. This seems to put a premium on blindness, deafness, and general inertness of the faculties. To whom all is visible, all must then be unreal, seems the pitiless logic of it.

The distinction the lecturer emphasizes between the principle underlying knowledge of the physical Universe and that by which we know God is very valuable. The man who seeks to find out God "scientifically" is as far out as he who would pretend to measure the stars "religiously."

Mr. Theodore Roberts wrote that personally he felt it hard to realize the enormous distances which the lecturer so glibly stated, and yet he implicitly believed in these conclusions of the scientific men who had given their lives to the study.

How much more readily ought we to credit the statements of Scripture with regard to things beyond our ken, although they might seem hard to realize !

He was interested in the importance which Mr. Maunder showed was attached to measurement in the world of science, and pointed out that it had a place in the subject of Revelation, for the angel who showed the apostle the heavenly Jerusalem had a golden reed to measure the City. (Rev. xxi, 15.)

Written Reply of the Lecturer.

I have to thank the Members of the Victoria Institute for the very kindly reception which they have given to my address. I feel that there is nothing before me of the character of adverse criticism, and that I need only point out that the greater part of my Paper consisted in supplying illustrations of the *general method* of scientific enquiry. These I sought to bring from the science of astronomy ; partly from the earliest instance of astronomical *observation* of which we have any indication, partly from some of the very latest. It seemed to me that the Victory Stele of Naram Sin presented us with a faithful picture of a certain astronomical conjunction, namely, of the spring new moon (the new moon "lying on its back") and two stars. Now at a period, roughly speaking, 6,000 years ago, the new moon nearest the spring equinox could have been distinguished from the other new moons of the year by the fact that it set together with the two bright stars, which the Greeks much later called "the Twins." This method of identifying the first new moon of the year by its position relative to a certain star, or certain stars, is expressly stated to have been used at a later period, when the star *Dilgan* had replaced the pair of stars as means of identification. The three emblems, later identified with the deities Sin, Shamash and Ishtar, and so widely distributed, do not picture any *astronomical observation.* The emblem of Sin—if it is intended to represent the actual crescent moon—could never be seen together in the sky with the emblem of Shamash—if that is intended to represent the actual sun ; nor if the emblem of Ishtar is the actual planet Venus could she have been suitably represented by a disc equal in size to that of Shamash. This Triad, so taken, is in nowise astronomical ; it represents nothing in the sky. It belongs only

to astrolatry, and Dr. Pinches has correctly given us its interpretation in that connection. But a "sun within the crescent moon," and a star on the unilluminated part of the lunar disc, are both unknown to astronomy.

With regard to Mr. Hoste's question, Prof. Eddington's quaint expression, "the stars 'happen'" is a playful, almost inverted, way of saying that the masses of stars are limited in two directions. A star will not be luminous, that is, it will not be a "star" in the ordinary sense of the word, if its mass is too small; it will tend to break up if its mass is too great.