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GORE'S "VISIBLE UNIVERSE."

The Visible Universe. By J. Ellard Gore, F.R.A.S.
(London: Crosby Lockwood and Son, 1893)

THE object of this book is "not to propound any new hypothesis, but simply to explain and discuss theories which have been supported by well-known astronomers and other men of science" as to the "evolution of the Solar System," and to give a popular account of the "construction of the Universe as we see it, and its probable development from pre-existent matter."

Mr. Gore has already acquired considerable success as a popular writer on astronomical subjects, and the scheme of the present volume is, as we might expect, a very good one. The first three chapters are devoted to a popular account of the hypotheses of Kant and Laplace, the principal objections that have been urged against them, and the modifications and additions suggested by recent research. In subsequent chapters such subjects as the fuel of the sun, the luminiferous ether, the constitution of matter, celestial chemistry, and the meteoritic hypothesis are dealt with. Mr. Gore then reaches the purely descriptive portion of his subject, and gives excellent chapters on the Milky Way, and on "the latest results respecting the distribution of stars and nebulae and their relative motions." Various theories of the construction of the Universe are then discussed, and in a final chapter the idea of infinite space and a finite universe is developed.

Although the general scheme of the book is excellent, the execution falls in many places far short of its promise and our expectations. When Mr. Gore confines himself to the historical and descriptive his work is, on the whole, well done, but in discussing theories he has in several cases obviously ventured out of his depth, and has consequently spoiled what would otherwise have been a valuable addition to popular astronomical literature.

For his chapters on the Nebular Hypothesis and Faye's theory of the formation of the solar system Mr. Gore has largely availed himself of M. Wolf's "*Les Hypothèses Cosmogoniques*." He has also introduced extensive quotations from "the late Mr. Jacob Ennis," but in considering Ennis as an authority, Mr. Gore is probably alone. Mr. Ennis was, on his own admission, not a mathematician, and certainly did not by "his own discoveries," place the nebular hypothesis on a firm mathematical basis. He proved Mars could not have satellites; that the heat of the sun was entirely due to chemical combination; that Sirius has twelve planetary attendants; and made several other equally important discoveries. His mathematical demonstration of the truth of the nebular hypothesis is about as sound as the well-known proofs that the earth's surface is flat. Mr. Gore would have done well to have omitted the quotations from Ennis, and to have filled the space with a fuller account of the recent mathematical investigations of the nebular hypothesis, especially those of Prof. G. H. Darwin.

Quoting freely from Young and Sir William Thomson, Mr. Gore is fairly safe in his chapter on the fuel of the sun, but he is in error in stating that "the

meteoric theory of the sun's heat must be abandoned." It is true that the larger portion of the solar heat is believed to be due to shrinkage, but it is generally conceded that a considerable fraction has its origin in falls of meteoric matter into the sun. A glaring case of the misuse of a scientific term occurs in this chapter (p. 52), where Mr. Gore is responsible for the statement that "the theory generally held by astronomers ascribes the heat of the sun to shrinkage of its *mass* caused by gravitation." Mr. Gore surely meant volume.

The chapter on celestial chemistry is meagre and unsatisfactory. It seems incredible that the application of photography to spectroscopic work is not even mentioned, and that no allusion is made to the Draper catalogue of photographic stellar spectra, to Rowland's photographic map of the solar spectrum, or to any of the recent photographic work. Mr. Gore is also in error in this chapter when he states (p. 79) that although the great nebula in Andromeda "has never been resolved into stars the evidence of the spectroscope shows it is not gaseous." Bright bands have been seen in the spectrum by Backhouse, Fowler, and myself, and these have been identified as probably due to carbon radiation.

The Meteoritic Hypothesis is dealt with in considerable detail, and here Mr. Gore is most seriously in error. He gives what is professedly "a review of the principal facts and arguments advanced by Lockyer," and carefully enumerates all the objections that have been urged by "his opponents," ending the account with the opinion that "on the whole, therefore, we seem bound to conclude that the weight of evidence is against the truth of the Meteoritic Hypothesis." The chapter bears internal evidence that Mr. Gore began his consideration of this hypothesis with the opinion which he enunciates as his final judgment, already formed.

The summary of Prof. Lockyer's book has not been made with the care that should have been bestowed upon it. There are at least two misquotations; on p. 91, the substitution of "periastron" for "perihelion" makes nonsense of what is otherwise an important paragraph, and on p. 113 the omission of the word "other" considerably modifies the meaning of the passage quoted.

There are several errors due to hasty compilation, observations and theories being attributed to Prof. Lockyer in cases where he only quotes the observations and adopts the theories. On p. 92 Mr. Gore says "he (Lockyer) also finds line absorption in Comet Wells and the great September comet of 1882." This is misleading, the observations of absorption having been made by Copeland, Maunder, and Vogel. On p. 93 we find the "theory that the light of comets is due to collisions between the component meteorites" attributed to Prof. Lockyer. The theory is due to Reichenbach, Tait, and Sir William Thomson; Prof. Lockyer's contribution being the demonstration that spectroscopic observations lead to and support the hypothesis. The results of Tait's calculations given on pp. 227-229 of the "Meteoritic Hypothesis" are also attributed to Lockyer on p. 93 of Mr. Gore's book. On p. 95 we read, "the spectra of the true nebulae consist of a very faint continuous spectrum crossed by one, two, three, or four bright lines." Lockyer gives seventeen bright lines in his table. Mr. Gore's footnote that "the complete hydrogen series of lines were

photographed by Dr. Huggins in 1890," in the great nebula in Orion is also a mistake.

Mr. Gore has evidently failed to appreciate the importance of several portions of Prof. Lockyer's book, and has consequently omitted to mention them in his summary. Thus the observations of meteoritic glows recorded on pp. 49-51 of the "Meteoritic Hypothesis" are entirely passed over. In these experiments it was found that on slowly warming meteorites in a vacuum tube through which electric discharges were passing, the spectrum of hydrogen was first developed, then carbon was added, and the first line due to any metal was the 500 line which is the characteristic nebular line. Further heating gave the 495 line and then the B magnesium lines. These experiments, omitted in Mr. Gore's summary, are an effective answer to the objections of Messrs. Liveing and Dewar given on p. 116 of this book, for we have here the 500 line developed in presence of hydrogen, and at a lower temperature than the B lines.

Mr. Gore believes that "one of the crucial tests of the meteoritic hypothesis" is the question of the identity of the 500 nebular line with the magnesium fluting at this wave-length. He says (p. 86) that "it is on the identity of this fluting (or rather its brightest edge) with the chief line in the spectrum of the nebulae that the meteoritic hypothesis mainly depends," and from pp. 118-121 it is obvious that he thinks the evidence conclusively against the hypothesis on this point.

In the first case the identity of the 500 nebular line with magnesium is not essential to the meteoritic hypothesis, although the latest observations have strongly supported the case for the identity. The main point is whether the 500 nebular line is due to high or to low temperature, and whether nebulae are high or low temperature phenomena. Previous to the publication of Prof. Lockyer's book all cosmical bodies were believed to be cooling. The nebulae were considered to be the hottest of all bodies, and on losing heat were supposed to pass into stars of the Sirian type. Further loss of heat converted them into stars of the solar type, and by still further loss they became red stars with banded spectra before reaching final extinction. This hypothesis was supplemented by Dr. Croll, who suggested that nebulae were formed by the complete and almost instantaneous volatilisation of these dark bodies on collision, the heat generated by impact being sufficient for the purpose. Lockyer's hypothesis supposes nebulae to be loose swarms of colliding meteorites. Condensation of these swarms by gravitation increases the number of collisions, and as the temperature rises we get stars with bright lines in their spectra. Further increase of temperature gives red stars of Secchi's III. class, which pass with still rising temperature into stars with fine absorption lines in their spectra, and so on until the Sirian type is reached, in which we have the highest temperature. Collisions have now ceased and the process of cooling begins, the stars passing into the solar type, then into red stars of Secchi's IV. class, and to final extinction.

The lines in the spectra of nebulae and bright line stars according to this theory may be due to three causes. (a) Radiating vapours filling the interspaces between the meteorites; the lines of hydrogen and the bands of

carbon being due to these. (b) *Low temperature* lines of metals, due to grazing collisions of meteorites. (c) *High temperature* lines of metals, due to direct collisions. It is essential to the theory that low temperature lines of metals should be found in nebulae spectra, and the low temperature origin of the 500 line seems clearly established. Its chemical origin is of quite secondary importance. That it is due to low temperature is shown by the experiments on meteoritic glows which Mr. Gore omits; by its presence in comets away from the sun, as observed by Huggins in 1866 and 1867 (this being the only line present), by Vogel in Coggia's comet, and Konkoly in the great September comet of 1882; and also by the fact that it persists in all temporary stars as the temperature falls and is the last line to disappear. Until these facts are explained away the foundation of the meteoritic hypothesis remains unshaken. Mr. Gore seems unaware that this main point is now generally admitted, for although the low temperature origin of nebulae was denied by Dr. Huggins as late as 1889, it was adopted in his Address to the British Association at Cardiff in 1892.

There is early evidence in the book that Mr. Gore has entirely failed to grasp this essential point of the hypothesis. On p. 41, discussing Croll's impact theory of the formation of nebulae, he says, "according to Prof. Lockyer the temperature of the original solar nebula was as high as that of the sun at present." Mr. Gore would have done well to have noted that on p. 528 of his book Prof. Lockyer explicitly states that "the temperature of the most prominent radiating vapours in nebulae is about that of the Bunsen burner."

Mr. Gore's misconception of the theory and the spirit in which he approached its discussion are also shown on p. 101, where he says, "All these conclusions rest, of course, on the supposed coincidence of certain lines in the spectra of comets, nebulae, and stars, with bright lines and flutings, a coincidence which has been disputed by other observers. Relying, however, on the accuracy of his experiments, Lockyer proposes a new grouping of cosmical bodies. He supposes some of these bodies to be increasing in temperature, while others—like our own sun—are cooling." To this he adds a footnote, "Lockyer's curve rests on this assumption, but it should be stated that some astronomers doubt that the sun is really cooling." We should be glad to know who these "astronomers" are. Mr. Gore himself is evidently not of their number, for he distinctly recognizes the sun as a cooling body in his chapter on the fuel of the sun, and specially mentions it as such on pp. 42 and 53. It is possible that Mr. Gore has misunderstood the apparently paradoxical fact that a body, in changing from a gas to a liquid, may rise in temperature while losing heat, but that will not justify the loose style which leaves it to be understood by the general reader that Lockyer's curve rests solely on his experiments, and the "assumption" that the sun is cooling, and that this fact is doubted by some astronomers. We are quite aware that Mr. Gore's expression will bear other interpretations, but this is the idea conveyed to several readers to whom we have shown the book.

Returning to the question of the coincidence of the 500 nebular line with magnesium, the evidence recorded by Mr. Gore is in favour of, rather than against, the identity.

His facts are:—Huggins finds the wave-length in the Orion nebula as 5004·75, the magnesium fluting being 5006·5, a difference of 1·75. At the same time, Huggins finds very little, if any, sensible motion in the line of sight. Mr. Keeler finds as a mean from 10 nebulae 5005·68, magnesium being, according to his measurement, 5006·36, a difference of ·68. These latter observations completely invalidate Huggins's evidence on this point, especially as Mr. Keeler recognizes a motion of recession for the Orion nebula of 10·7 miles per second.

Mr. Gore ought to have recorded the fact that in Keeler's observations the comparisons for different nebulae gave the magnesium sometimes more refrangible and sometimes less refrangible than the nebular line. Later observations of Keeler, "corrected for the earth's orbital motion and the sun's motion," give the nebular line a wave-length of 5005·93, *i.e.* only ·43 from the magnesium. Assuming Keeler's latest results as perfectly correct, and placing his position at Charing Cross, while representing the position found for this line by Dr. Huggins in 1868 at St. Paul's Cathedral, we find Dr. Huggins's limiting positions in 1889 as the extreme east and extreme west ends of Green Park, his 1890 position in the middle of Green Park, while the magnesium fluting will be at Cecil Street. When we consider that a motion in the line of sight of less than twenty miles per second will make the nebular line and the magnesium fluting absolutely coincident, that the rate of the sun's motion in space is estimated but not absolutely known, that these measurements are probably the most difficult of all astronomical observations, and that every increase of power and accuracy has brought the lines closer together, we are certainly *not* justified in stating that the "weight of evidence" is "against the truth of the hypothesis." The differences in recorded wave-lengths of well-known solar lines by experienced observers are in many cases greater than the difference in question here.

Mr. Gore regards the dispersion used by Prof. Lockyer as insufficient, and yet he records that sixteen prisms were used by Lockyer in some of his observations of the coincidence of the nebular line with magnesium, so that his dispersion was actually greater than that used by Dr. Huggins, and two-thirds that of Mr. Keeler, whose dispersion equalled twenty-four prisms.

The objections to that portion of the meteoritic hypothesis which deals with the meteoritic origin of the lines in the auroral spectrum do not in any way affect the main hypothesis. That this subject is unimportant is distinctly recognized by Prof. Lockyer, "Meteoritic Hypothesis," p. 97, where he claims that "certainly the coincidence is such as to justify us in regarding meteoritic dust as the origin of the spectrum *until a better and more probable origin is demonstrated.*"

We are told (p. 122) that Mr. Monck objects to Lockyer's hypothesis, because it contains no explanation of "why all the planets and asteroids and the great majority of the satellites revolve in the same direction, why the orbits of the larger bodies of the system deviate so little from the circle and why they are so nearly in the same plane." This was asked in 1890; and yet Prof. G. H. Darwin had in 1888 shown that a swarm of meteorites which, on the meteoritic hypothesis would form a nebula,

may be considered as a gas, and therefore any answer that the nebular hypothesis can give to these questions will also apply to the meteoritic hypothesis.

Such puerile suggestions as that the meteorites used by Prof. Lockyer "*may have been*" of terrestrial origin: "that meteor clouds dense enough to produce the requisite amount of light by their collisions would also be dense enough to intercept *a great part of it* again on its way to the earth" (the italics are ours); and objections based on Mr. Monck's interpretation of Prof. Newton's calculations, and on opinions to which Mr. Monck "*inclines*" as to the origin of certain comets, are evidence that Mr. Gore has not hesitated to avail himself of anything that in any way seems to disagree with the meteoritic hypothesis. The whole of the "objections" of the "opponents" of Prof. Lockyer recorded by Mr. Gore are on matters of secondary importance, and have been insisted upon by him owing to his complete misconception of the theory. As a guide to the meteoritic hypothesis his chapter is misleading, and utterly valueless either as exposition or as criticism.

After his account of the meteoritic hypothesis Mr. Gore abruptly turns to a comparison of the various drawings that have been made of the Milky Way, and gives an interesting and valuable summary of the present state of our knowledge as to star distribution and movement and the construction of the Universe. For this portion of the book we have nothing but praise. It is carefully written and copiously illustrated. Mr. Gore has evidently taken the word "visible" in its widest possible sense, for he includes not only things visible to the retina of the eye, but those visible to the retina of the camera; and six excellent reproductions of photographs of nebulae and stars clearly demonstrate the superiority of the latter for astronomical purposes. It is probable that the use of photography in the preparation of complete charts of the Milky Way will throw much new light upon many of the points discussed in this portion of the book, and may profoundly modify many of the views at present held; but in presenting a clear and concise account of the present state of our knowledge Mr. Gore has made a valuable addition to the literature of the subject. An appendix, in which are given various calculations and tables involved in the discussion of several points raised in the book, and a useful index, complete the volume.

A. TAYLOR.

THE IRON MANUFACTURE IN AMERICA.

On the American Iron Trade and its Progress during Sixteen Years. By Sir Lowthian Bell, F.R.S. (Edinburgh and London: Ballantyne, Hanson, and Co.)

IT is impossible, in the limited space at our disposal, adequately to review this remarkable book, in which no branch of a very comprehensive subject appears to have escaped the author's close attention.

So full of detail and so exhaustive of the subject-matter are the various sections into which the work is divided, that we can do little more than glance at the numerous subdivisions.

The first section, dealing with international trade, dis-