THE STORY OF HELIUM.[1]

PROLOGUE.

DURING the last decade, as most of you know, our literature has been enriched by a recrudescence of the short story, generally dealing with very modern human affairs of various kinds from many different standpoints.

But these modern stories, and others that might be referred to, are not the only ones now available. During the last sixty years Egypt, Babylonia, and other countries which might be named, now here and now there, have supplied us with other stories—most precious indications which enable us to study, into a far-reaching past, the beginnings of man's history. These stories, as you also know, were not very easily deciphered—they were all of them hidden away in strangest script; but the hieroglyphics and cuneiform characters, which at first seemed to have absolutely no meaning whatever, have bit by bit been unravelled by the genius of linguistic explorers, until at length we may say that the students of Archæology are in possession of more or less complete histories of the most ancient peoples of the world.

All these histories have not yet been completely written; but my point is that they have been begun, and that even for the beginning of them the greatest skill has been required to transmute the strange hieroglyphics which were first employed by ancient peoples into modern equivalents, so that we can understand what they wished to convey. Here we are in presence of man's earliest attempt at any language; but the story which I, your President, have to tell you to-night, has a very different origin to this, for the reason that, although it is a story, and written, it is true, in hieroglyphics, the hieroglyphics are of nature's invention, and not man's.

The story or fairy tale of science, which has placed us in possession of the most precious truths regarding every star which shines in space, is a story written in nature's hieroglyphics in every ray of light which reaches this planet of ours from the tiniest star.

Now, of course in the hour at my disposal to-night it is impossible for me both to tell you a story, and spend much time upon the alphabet in which the story is written, but there are just one or two words about the alphabet that may be useful. One key to these hieroglyphics, this light story, which is hidden in every ray of light, is supplied to us by the rainbow, which teaches us that the white light with which nature bountifully supplies us in sunlight, is composed of rays of different kinds or of different colours. Many of you know that there is an almost perfect analogy between these coloured lights and sounds of different pitches.

The blue of the rainbow may be likened to the higher notes of the key-board of a piano, and the red of the rainbow, on the other hand, may be likened to the longer sound waves, which produce the lower notes; and as we are able in the language of music to define each particular note, such as B flat and G sharp, and so on, so in these celestial hieroglyphics we are enabled to do exactly the same thing with perfect definiteness, by considering the wave-length of the particular colour with which we have to deal, so that having these wave-lengths we may determine the quality of every kind of light which reaches the human eye, whether from a terrestrial light source, the sun or any other celestial body, including the shooting stars which some of us are hoping to see to-night.

Well, the result of the study of this hieroglyphic language has been that we can in that way determine the chemical source of every light of different colour which can be thus examined in any celestial body, provided always we can obtain the same light-note from some terrestrial substance when we experiment upon them at temperatures high enough to set them glowing in our laboratories. We can determine therefore, by such means, whether in different parts of space we have the same chemical substance, or whether in different stars we are dealing with substances perfectly and completely distinct.

Imagine these hieroglyphics, then, more or less translated, on the principle I have indicated to you, by the labours of Kepler, Newton, Fraunhofer, and other later workers; so that in the case of anything shining anywhere, we can eventually find out something about its chemical and its physical constitution.

Another part of the prologue, before I begin my first chapter, brings us to another line of study, that is to say, the telescopic and visual observations of heavenly bodies.

I take you back to the year 1706, when there was a total eclipse of the sun, visible in Switzerland, and there was one Stannyan, who gave an account of what he saw at Berne. After describing the phenomena of the eclipse he wrote, referring to the sun: "His getting out of his eclipse was preceded by a blood-red streak of light." Of course, in the prephotographic days no autobiographical record of that particular eclipse was obtainable, but we possess photographic records of other similar later eclipses, which may be taken as representing what Stannyan saw, for, in all, the blood-red streak referred to by him has been seen.

The phenomena photographed in all eclipses now-a-days indicate to us Stannyan's observation, for in all, certainly the sun, in getting out of his eclipse, is preceded by a blood-red streak of light, which we now know to represent one of the solar envelopes to which I gave the name of chromosphere in 1868.

Here then ends the prologue, and I begin the first chapter of my story.

CHAPTER I.

In the year 1868, the new alphabet to which I have referred was first utilised in endeavouring to unravel the message which was conveyed to us by a most interesting eclipse observed in India. The "blood-red streak" was now subjected to minute analysis, because practically the spectroscope was now first utilised. The diagrams will indicate the kind of record with which we have to deal in studying these celestial hieroglyphics. We are in one part dealing with the long waves of light, the red; we are in the other dealing with the shorter waves of light, the blue. The work done in that eclipse is indicated by the bright lines—the hieroglyphics—which, when translated as they have been, describe for us the chemical nature of the particular stuff in the sun, which made him put on a blood-red appearance "on his getting out of his eclipse." Taking the notes in the light scale which are lettered in the ordinary spectrum of light, chiefly sunlight, in order that they may be easily recognised and remembered, we learn the particular qualities of the light emitted by the blood-red streak.

We have one quality represented by the line D, another at C, and another at F. Hence the observers in 1868 could tell us very much more about the particular chemical substances which were present in that blood-red streak than Stannyan could, because spectroscopy had not been invented in his day. According to the diagram (Fig. 1), one of the lines is in the position of D. One observer said it was "at D, or near D," and almost the whole of my story depends upon that distinction.

Soon after this eclipse was observed in India, a method, long before suggested, of studying the blood-red streak surrounding the sun without waiting for an eclipse was brought into operation.

By this method it was quite easy to make observations, whenever the sun was shining, perfectly free from any of the difficulties attending the hurry and the worry and the excitement of an eclipse, which lasts only a few seconds.

Further, as the method consists of throwing an image

[1] Presidential Address, Vesey Club, Sutton Coldfield, November 12, 1895, by Prof. J. Norman Lockyer, C.B., F.R.S.

of the sun, formed by a telescope, on to the slit of a spectroscope, so that the spectrum of the sun's edge and of the sun's surroundings can be seen at the same time, exact coincidence or want of coincidence between the bright and dark lines can be at once determined. I may

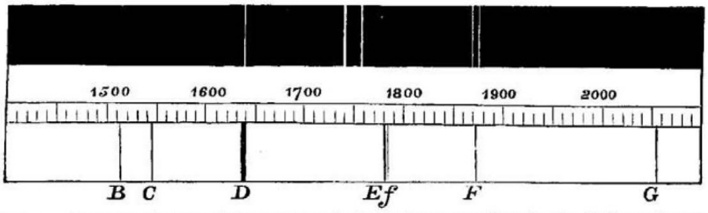


FIG. 1.—Pogson's diagram of the spectra of the sun's surroundings in the Eclipse of 1868. The bright lines seen are shown in the upper part of the diagram; the chief lines in the solar spectrum, red to the left, blue to the right, are shown in the lower part.

remind you that during an eclipse this is not possible, as the ordinary spectrum of the sun, with its tell-tale dark lines, is invisible because the sun, as we ordinarily see it, is hidden by the moon.

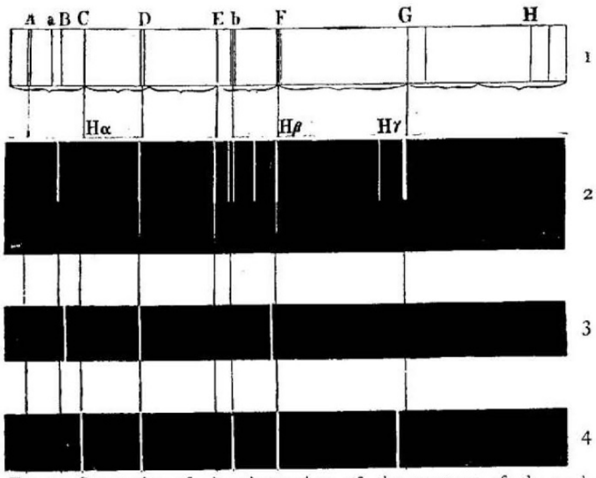


FIG. 2.—Summation of the observations of the spectrum of the sun's surroundings in the Eclipse of 1868. (1) Solar spectrum showing the position of the chief lines (2) Rayet's observations of bright lines. (3) Herschel's observations of bright lines. (4) Tennant's observations.

Working, then, under such very favourable conditions, it was seen that there was certainly a red line given by this lower part of the solar atmosphere coincident with the very important line in the solar spectrum which we call C.

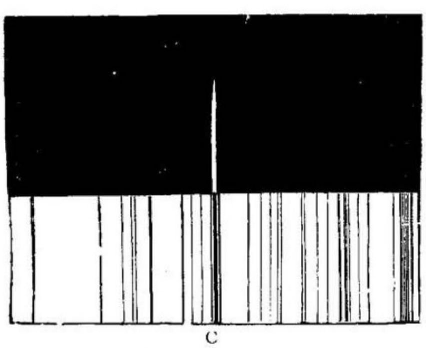


FIG. 3.—The exact coincidence of the red line with the dark line C determined by the new method.

Another part of the spectrum in the blue-green was examined, and there again it was seen that the parts outside the sun gave us a bright line exactly in the position of the obvious dark line in the solar spectrum which is called F; so that with regard to those two most important lines, there was no doubt whatever that we were dealing with the substance which produces these dark lines in the solar spectrum.

Fig. 5 is a diagram of the yellow, or rather the orange, part of the solar spectrum, showing two very important lines, which are called the lines D, due to the metal sodium, the investigation of which was just as important in solving these celestial hieroglyphics as the Rosetta stone was important in settling the question of the Egyptian ones.

Pogson, in referring to the eclipse of 1868, said that the yellow line was "at D, or near D." You will see from this diagram that the new method indicated that "near D" was the true definition. The line in this position in the spectrum, unlike the other two lines which I have indicated, has no connection at all with any of the dark lines in the ordinary solar spectrum. We were therefore perfectly justified in attaching considerable importance to this divergence in the behaviour of this line, taking the normal behaviour to be represented by the two strong lines in the red and the blue-green. The new line was called D^3 to distinguish it from the sodium lines D^1 and D^2.

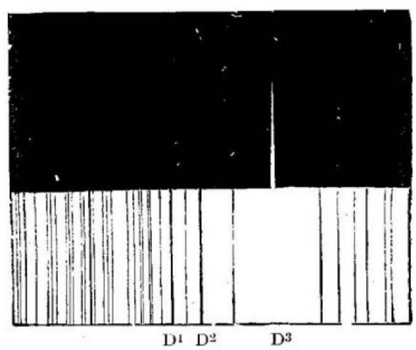


FIG. 5.—The want of coincidence of the range line, D^3, with the dark lines D^1 and D^2.

A considerable amount of work was done with regard to the yellow line. It was found that there was no substance in our laboratories which could produce it for us, whereas in the case of the line D we simply had to burn some sodium, or even common salt, in a flame to produce it, and the other lines in the red and the blue-green were easily made manifest by just enclosing hydrogen in

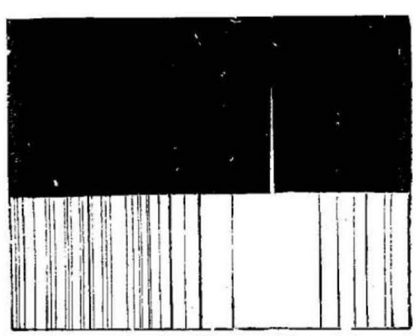
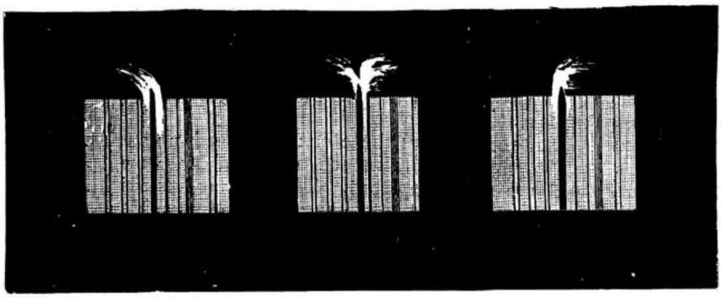


FIG. 5.—The want of coincidence of the range line, D^3, with the dark lines D^1 and D^2.

a vacuum tube, and passing an electric current through it, or observing the spectrum of a spark in a stream of coal-gas.

Now at the first blush it looked very much as if this line was really due to the same element which produced the others at C and F, and it was imagined that the reason we did not see it in our laboratories was because it was a line which required a very considerable thickness of hydrogen to render it visible. That was the first idea, and Dr. Frankland and myself found that there was very considerable justification for this view, because a simple calculation showed that the thickness of the solar atmosphere, which was producing that yellow line under the conditions which enabled us to see it in our instruments by looking along the edge of the sun, was something like 200,000 miles.



A B C

FIG. 6.—Changes of wave-length of the F hydrogen line when a solar cyclone is observed. A, the change towards the red indicates the retreating side of cyclone. C, the change towards the blue indicates the advancing side. B, the whole cyclone is included in the width of the slit, and both changes of wave-length are visible.

Hence, in order to get a final decision on this point, there was nothing for it but to tackle the question from a perfectly different point of view, and the different point of view was this. The work had not gone on very long before one found minute alterations in the positions of these lines in the spectrum; the blue line, for instance, might sometimes be slightly on one side, and sometimes on the other of its normal position. Further work showed that in these so-called "changes of wave-length" we had a precious means of determining the rate of movement of the gases and vapours in the solar atmosphere.

Fig. 6 indicates how these changes of wave-length are shown in the spectroscope. The lines are contorted in both directions, and sometimes to a very considerable extent, indicating wind-movements on the sun, reaching, and sometimes exceeding, 100 miles *a second!*

Well, then, you see we had here a means of determining whether the yellow line was produced by the same gases which gave the red and blue lines, because if so, when we got any alteration in the position of the red and blue lines, which always worked together, we should get an equivalent alteration in the position of the yellow one.

I found that the yellow line behaved quite differently from either the red or the blue line; so then we knew that we were not dealing with hydrogen; hence we had to do with an element which we could not get in our laboratories, and therefore I took upon myself the responsibility of coining the word helium, in the first instance for laboratory use.

This kind of work went on for a considerable time, and what one found was, that very often in solar disturbances we certainly were dealing with some of the lines of substances with which we are familiar on this earth; but at the same time it was very remarkable that when the records came to be examined, as they ultimately were with infinite care and skill, it was found that not only did we get this line in the yellow indicating an unknown element associated with substances very well known, like magnesium, but that there were many other unknown lines as well. Within a few months of my first observations, several new lines about which nothing was known were thus observed. The place of this orange line I determined on October 20, 1868. Among many other lines behaving like it, two at wave-lengths 4923 and 5017 were discovered in June 1869, and afterwards another at 6677, while Prof. Young noted another in September 1869, at 4471. He wrote:

"I desire to call special attention to 2581·5 [Kirchhoff's scale], the only one of my list, by the way, which is not given on Mr. Lockyer's. This line, which was conspicuous at the Eclipse of 1869, seems to be *always present* in the spectrum of the chromosphere. . . . It has no corresponding dark line in the ordinary solar spectrum, and not improbably may be due to the same substance that produces D^3."

This same line was noted also by Lorenzoni, and named *f*.

Then with regard to solar disturbances. Let me refer in detail to a diagram indicating some results arrived at by the Italian observers. We are dealing with the spectroscopic record of two slight disturbances in a particular part of the sun's atmosphere. The spectroscope told us that in that region there was a quantity of the vapour of magnesium which was collected in that place. Then we find that another substance, about which we again know nothing whatever, is also visible in that region, and then we get the further fact that in those particular disturbances we get four other spectral lines indicated as being disturbed, and of those four lines we only know about one.

In that way it very soon became perfectly clear to those who were working at the sun, that in all these disturbances, or at all events in most of them, we were dealing to a large extent with lines not seen in our laboratories when dealing with terrestrial substances; this work went on till ultimately, thanks to the labours of Prof. Young in America, we had a considerable list of lines coming from known and unknown substances which had been observed under these conditions in the solar chromosphere, and Prof. Young was enabled to indicate the relative number of times these lines were visible. For instance, the lines which are most frequently seen under these conditions he indicated as represented by the number 100, and of course the line which was least frequently

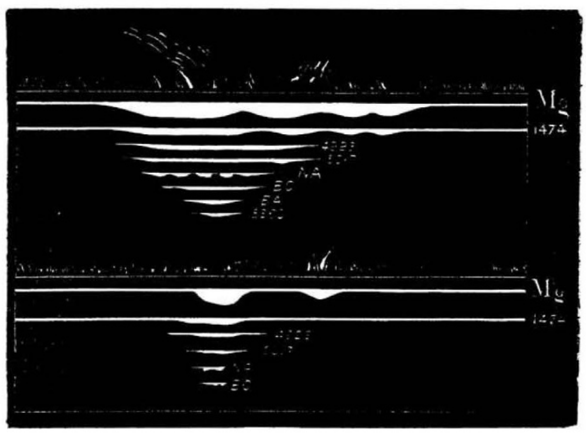


FIG. 7.—Tacchini's observations of two slight solar disturbances showing the height to which the layers of the different gases extend. Magnesium vapour is highest of all, and is furthest extended; next comes a gas of still unknown origin, indicated by a line at 1474 of Kirchhoff's scale, and so on.

seen would be represented by 1; and therefore from these so-called "frequencies" we got a good idea of the number of times we might expect to see any of these disturbance-lines, when anything was going on in the sun.

It was this kind of work which made Tennyson write those very beautiful lines:

> "Science reaches forth her arms
> To feel from world to world"

And then he added:

> "and charms
> Her secret from the latest moon."

I mention this because Tennyson, whose mind was saturated with astronomy, had already grasped the fact that what had already been done was a small matter compared with what the spectroscope could do; and now the prophecy is already fulfilled, for by means of the spectroscopic examination of the light from the stars we can tell that some of them are double stars, that is to say, in poetic language, stars with attendant moons. Although we can thus charm the secret from each moon by means of the spectroscope, to see the moon it would require a telescope not 80 feet long, but with an object-glass 80 feet in diameter, because the closer two stars are together the greater must be the diameter of the object-glass, independently of its focal-length and magnifying power.

(*To be continued.*)

THE CAMBRIDGE NATURAL HISTORY.[1]

THE second volume of this series (vol. v.) to make its appearance is devoted, with the exception of articles on the Prototracheata (pp. 3–26) and Myriapoda (pp. 28–80), to the Insecta, which will occupy also the whole of vol. vi.

Mr. Sedgwick gives a concise account of *Peripatus*, which, being derived mainly from his own well-known papers, does not call for extended notice; the descriptions of anatomy and development are written in a somewhat technical style, but are not over-elaborated. If it were thought necessary to reprint an easily-accessible list of the known and doubtful species, it should certainly have been revised. No records are noted since 1888; *P. juliformis* is given as a doubtful species, whereas at most it is incompletely characterised, and *P. trinidadensis* actually figures as "n. sp." A map, serving as frontispiece, shows the distribution; but the records from Peru and Chili seem scarcely to justify the inclusion of so much of the arid western littoral of South America.

Myriapoda are not a fascinating subject, but Mr. Sinclair's article, though slight and somewhat wanting in style, gives many particulars of interest about them. The author is clearly a morphologist rather than a systematist, and has made a serious mistake in employing a classification so antiquated as that of Koch, who knew little of extra-European forms, and whose characters, if rightly transcribed, are far from accurate. Mr. Sinclair prefers to disregard the work of systematists who have dealt with separate families only; but a system by Bollman of the whole class (or classes, according to some specialists), published in 1893 in *Bulletin* xlvi. of the United States National Museum, has been overlooked. In the section on development no mention is made of the reversal of the embryo referred to on p. 216 of the work. This was a matter for the editors, as is indeed the whole subject of embryology. The details of early embryonic development are so similar, that there is a risk of useless repetition and of insufficient stress on points of difference unless some co-operation is instituted among contributors. The figures of species are copied from Koch's "Die Myriapoden," and, though the fact is not stated, that of *Cermatia variegata* was drawn from an example which had lost six pairs of legs!

In no branch of zoology has the influence of modern morphological and biological research been of slower growth than in entomology; the subject is so complex, so dominated by taxonomy and an unwieldy literature, that few entomologists have the energy to leave their immediate field of study in order to gain any general knowledge of the natural history of insects. For this the responsibility rests largely with the authors of the many text-books on entomology, who for the most part have been content to follow an antiquated method, basing their work on a substructure of classification, and ignoring families of the highest interest from all points of view except those of the collector and systematist, in order to fill their pages with a tedious procession of names and useless details.

For many years there has appeared no such valuable or original work on insects as this of Dr. Sharp promises to be, when completed. The author has rid himself of the chains of the systematist, and has endeavoured, in the most thorough and catholic spirit, to give a just view of the many points of interest, whether in structure, development or habits, which attach to this, the richest class of the animal kingdom.

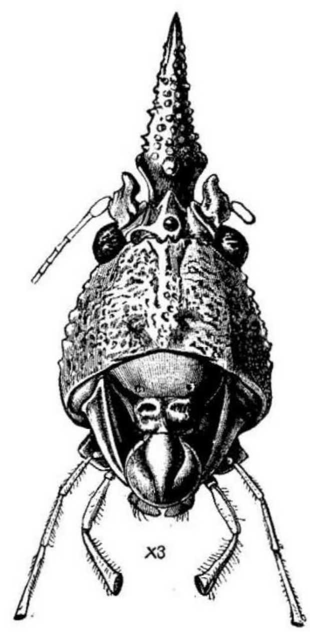


FIG. 1.—Front of head of *Copiophora cornuta*, female. Demerara.

In such a task, one does not look for novelty in facts or theories, though there is ample evidence of independent thought and investigation. It is in the selection and treatment of subjects that Dr. Sharp's originality is shown, and in these the book stands absolutely alone. It is a real and new pleasure to read a work of so broad a scope, in which so much is entirely unknown except to the closest students of recent literature, in which families such as *Thysanura*, *Hemimeridæ*, *Embiidæ*, or *Termitidæ* are adequately treated, and where due regard is paid to the writings of students such as Brauer, Grassi, or Cholodkowsky.

Though familiar insects are by no means neglected, and much that is interesting and new is said even about the earwig and cockroach, the number of strange and rare forms discussed is quite extraordinary. No one knows the literature of the subject better than the author,

[1] "Peripatus, Myriapods, Insects." By A. Sedgwick, F. G. Sinclair, and D. Sharp. Pp. xii + 584. (London: Macmillan and Co., 1895.)