Mr. Dutt.—Was Greenwich known to the Indian Astronomer in 1770—I mean is that the proper translation of the writings ?

The President.—I do not know, but I think the translations refer to Greenwich, Italy and Japan.

Dr. Harrison.—Has any one taken any observations by these instruments ?

The President.—Yes ; Babu Bhola Nath has tested them and sells an interesting book on them. He has tested some of them but not all ; some are still in course of restoration.

Mr. Simmons.—In returning a hearty vote of thanks to our President for his most interesting paper, which carries us back to the very earliest times when observations were made, I would remark that perhaps a visit to the Old Delhi Observatory would not only be an interesting but a very instructive undertaking to all interested in Astronomy.

The President next exhibited some very interesting photographs on the screen of nebula taken by Dr. Richie of America.

Mr. Meares.—Do you happen to know what exposure these were taken with ?

The President.—Three or four hours I believe.

In adjourning the Meeting the President remarked that the Astronomical Society of Barcelona intended holding an Exhibition next May and June and that this Society hoped to be in a position to forward a few exhibits. He invited help from Members. The Meeting was then adjourned to Tuesday, the 30th January 1912.

Inorganic Evolution.

BY DR. E. P. HARRISON.

Inorganic evolution deals with the changes which have gone on, and the causes that have been at work in building up from much simpler forms, the 70 or 80 so-called chemical elements as we now know them.

Some years ago a most remarkable theory which is nowadays generally accepted, and which has revolutionised modern thought in many directions, was put forward by Charles Darwin. It is known as the theory of organic evolution and it suggests that each species of plant and animal is not the result of special creation ; but has been modified by its surroundings and has become gradually changed by the action of natural causes from a more simple to a more complex type. On this theory all plants and animals at present existing are descendants of a very few ancient and much more simple types of life. The extreme difficulty of Darwin's problem is obvious, if it is realized how very little is known of the meaning of the word Life, and with what exceedingly delicate, complex and variable material the organic evolutionist has to deal, when he attempts to trace the ancestry of a species of plant or animal.

The problem of Inorganic Evolution which I am going to state this afternoon is one which logically should precede the Darwinian problem. For in attempting to trace the ancestry of the substance iron, for example, we are attacking what is clearly a simpler problem than when we try to determine the form of living being which preceded and devolped into (say) the modern living cat or the human being. Dead cat would not be so hard to deal with, as it can be analysed, and the chemist could tell us with great nicety of what it is composed. In fact we should have eliminated the great unknown factor, Life, from the inquiry.

However, the question of the origin of living species was actually propounded and had been partially answered before the idea of the evolution of the chemical elements seriously arose.

In all old books on chemistry it is stated as an article of faith that matter exists, when it has been simplified as far as possible, in the form of about 70 *elements*. Examples of such elementary substances are iron, oxygen gas, carbon or tin. An element cannot by any means at the disposal of the chemist (so we are told) be split up in anything simpler.

Now within the last few years our faith in the integrity of the elements has been breaking down in several directions: First, recent work in physics has shown conclusively that simpler forms of matter than any of the elements actually do exist, and that in certain cases there is a high probability that some of the elements are slowly and spontaneously changing into others. The old Alchemist's dream is being realised. Secondly, great changes of temperature, whatever the old text-books may say, do seem to have the effect of breaking up the elements into more primitive forms. It is about this last effect that I am going to speak to-day.

Nearly all the evidence concerning this temperature effect on the elements is obtained from Astronomical observations, simply because we do not possess on the Earth any sources of heat which in any way approach some of the hotter stars.

Here on the Earth we have several different gradations of temperature with which to experiment on the elements :—

(i) There is the bunsen burner flame.

(ii) There is the blow pipe flame in which a current of air is blown through the gas, and raises the temperature of the flame considerably.

(iii) There is the electric arc flame, which is much hotter than the blow pipe flame.

(iv) There is the electric spark. It is the hottest source known on the Earth and can volatalise or make gaseous a great many of the elements, so that they become luminous.

The spark is produced by means of an instrument known as an induction coil, and the temperature of the spark depends to a large extent on the size of the coil.

So much for the various means which we have, on the Earth, for producing very high temperatures.

The question now arises, how are we going to detect whether any particular element, exposed to these high temperatures, is split up in to something simpler, or not ?

In order to explain this, it is necessary to digress a little and to describe an instrument known as the spectroscope.

The light which is emitted by any of the flames above mentioned, consists of a series of vibrations or waves, which travel outwards in all directions, and give us the sensation of light. If we put into the flame a small portion of an element which is easily vapourised by the high temperature of the flame, the flame becomes coloured, as can be seen with the eye. The colouring of the flame means that the glowing metallic vapour sends out a *special* kind of wave of its own of a perfectly definite length. If now we let some of this light fall on the spectroscope, the instrument is so constructed that light waves of one particular length always pass to a fixed position in the instrument so that bright narrow bands or lines of light are seen, which always occupy a fixed position in the instrument. This is because in the case of light from any element only definite types of wave are given out.

It is more usual for several different kinds of waves to be emitted by a glowing element. Barium, for example, gives us 8 or 10 well-marked bands, in fixed positions. Iron gives us some hundreds. Such a series of lines is called the spectrum of the element. It is very important to realise that the positions of these lines are always fixed relatively to one another ; thus if we have once seen and measured the positions of the lines produced by any particular element we can always identify that element again.

The simplest method of identification is to photograph the spectrum ; the positions of the lines can then be determined on the plate at leisure, and one spectrum can be compared with another spectrum. The spectra of different elements are entirely different from one another.

It is now possible to describe how the evidence for the actual splitting up of the elements has been obtained. Suppose we observe the spectrum of barium heated in the bunsen burner ; it is perfectly definite and can be mapped or photographed. If we expose barium to the higher temperature of the electric arc, we get a similar spectrum, so far as *position* of the lines goes, but some of the lines will be found to be rather *brighter* than the corresponding lines in the flame spectrum. Such brightened lines are called *enhanced lines.*

If now barium is placed under the influence of the much higher temperature of the *spark*—the enhanced lines become fewer in number, and much more clearly marked, while some new lines may make their appearance.

A map, or photograph of the enhanced lines, is called the *Enhanced Spectrum.* Enhanced spectra have been obtained for a great many elements, even using such temperatures as are available on this earth—and by laying one enhanced spectrum on the top of another, we can get a combined enhanced spectrum for two elements or for three or for more. Such a combination of enhanced spectra has been called a *test spectrum* by Sir Norman Lockyer.

The production of enhanced lines in the spectrum of an element, as the temperature is raised from that of the flame to that of the spark, indicates that some change is going on in the molecules or atoms of the heated element, and we may well suppose that at higher temperatures than we can obtain here, nothing but enhanced lines would remain. Such is actually the case—for on making a photograph of the spectrum of the hottest part of the Sun, *viz.*, the Chromosphere—that spectrum is found to *coincide* almost line for line with the *test spectrum* obtained on the Earth in the way I have described.

The deduction is that in the Chromosphere of the Sun there exists all those elements which were used in compiling the test spectrum, at a temperature not less than that of the hottest electric spark yet produced.

Now there is every reason to believe that the Sun is by no means a very hot star compared with some.

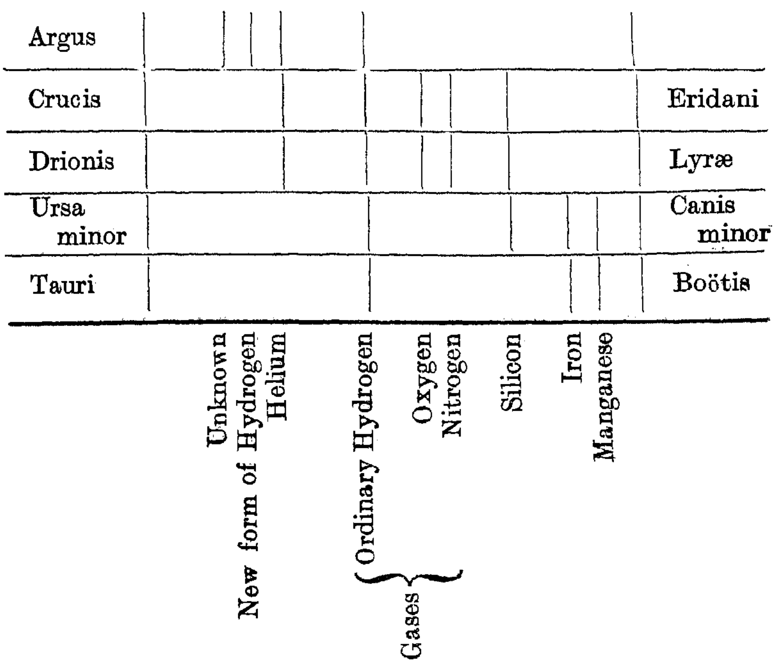
In most of the stars, it is found that there is a general decrease in the number of ordinary lines, and an increasing importance of enhanced lines, particularly the enhanced lines of iron and Hydrogen—and of the gas Helium, and also in some other stars which there is other reason to believe are the hottest, of all a certain number of the new, or *unknown*, lines which do not represent any known substance appear.

It is thus possible to classify the stars in some such way as this :—

Highest temperature stars ...	Strong Helium lines and faint enhanced metallic lines.
Medium ...	Faint Helium lines, Hydrogen lines and strong enhanced lines.
Lowest temperature ...	Faint arc lines.

Some of these stars will be rising in temperature, others will be cooling, and so we are able to construct a map on the following plan :—

Temperature increasing. Cooling stars.



The general tendency is evidently to simplify all elements in the very hottest stars, into Helium and modified Hydrogen, and unknown lines, and those gases would therefore appear to be almost the simplest forms of matter existing, and to be the parents of the many elements that we see on the Earth.

As the stars cool, we apparently have aggregations going on among these gaseous atoms, producing finally the ordinary metals and other elements.

And now a word or two as to how we may regard the general march of events in the universe.

First we have the nebula stage. Further back than that it is hard to go. The nebulæ are probably Meteoric Swarms, gravitating together. The more the mutual attraction of the meteoric particles condenses the swarm, the higher rises the temperature, until the whole finally glows. The spectrum of such a well formed meteoric swarm consists of faint metallic lines and the ordinary Hydrogen and Helium spectra. Evidently this Helium and Hydrogen were driven out of the meteors by the heat, and so far no *changes* of the elements themselves have taken place.

As condensation increases, the temperature steadily rises, until we reach the stage in which the nebula has condensed and has become a *star*. Then goes on the gradual simplification of the *metallic* forms into those forms which give enhanced spectra, and finally when the star has reached its highest temperature all elements originally present in the swarm of meteorites have been reduced to Helium, and to some unknown forms which possibly possess still simpler atoms than Helium itself. Any Helium that was *originally* present in the meteors would remain as such and would, at the highest temperatures, be indistinguishable from the Heliums produced by dissociation of the other elements by heat. From the hottest to the coldest stars 10 groups have been found, each group at a different temperature and which contain 10 different genera of chemical forms varying from unknown forms through Helium, Hydrogen, enhanced Iron and Calcium, to ordinary forms of iron or other elements.

The irresistible conclusion is that the elementary forms are by no means constant, and that great changes of temperature break them up into much simpler atoms.

I must finish by alluding to another branch of work which has been converging on this subject, and which supports the ideas just explained, in a most remarkable way.

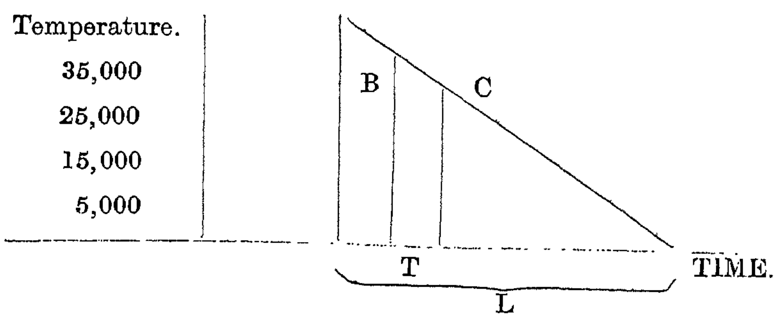
Certain new substances which have recently been discovered on the Earth, namely, Radium and Actmim, are themselves known to be breaking up spontaneously into simpler forms, quite independently of any changes in temperature, and one of these simpler forms is undoubtedly Helium gas itself. Here then is additional evidence of the changeableness of the elements under proper conditions. We are led to speculate that the primeval form of matter may have been a gaseous substance like Helium, or possibly simpler, and that all other forms are derivatives of this simple atom, produced by association.

On this view we might regard radium as "reverting to type" or going back to its ancient primitive form.

Having arrived in the course of ages at a cool planet like the Earth, it is natural to enquire into the causes at work which determined the appearance of Life on the surface. The stages which you will have now be prepared to follow are somewhat like this.

Helium—Other gases—Metals and other elements as we know them—Complicated organic compounds always containing carbon (*e.g.*, Sugar, or protoplasm)—The same plus life.

Sir Norman Lockyer has constructed a very suggestive diagram to illustrate the comparatively short time, compared with the process of evolution among the elements, which has been occupied in the production of the living species we now see.



As time has proceeded from the 1st cooling of the hottest star groups, we find that the time T. occupied in cooling, say from 35,000° to 25,000°, is represented by the length of the line B. C.

But all organic evolution on this planet has almost certainly taken place within limits of temperature equal to not more than say 10° or 20° and the time occupied in the process, has been variously estimated by geologists and biologists and something of the order of 1,000,000 years.

Now looking at the diagram, the time interval which corresponds to temperature interval of 10° or 20° is so small as to be imperceptible on the diagram—yet the total time for the hottest star groups to cool down to a temperature suitable for organic evolution to begin is represented on the *same* scale by the length L; thus the total time taken by the hot star groups in cooling down to 50° C. might well be 10, or 100, thousand million years, and even then we have only started measuring time from the instant the groups were *hottest*.

We have left out of account the incalculable ages which must have been occupied in building up from the nebulæ into the hot stars—and so as is usual when one begins to speculate in the broader paths of science, one reaches a hopeless inevitable barrier which the human mind cannot hope to penetrate.

Meteors.

By P. C. Bose.

The infinite dark space in which the Sun and the stars shine like so many brilliantly illuminated chandeliers, to human eyes seems ever to be wrapped in profound silence and mystery. Yet violent commotions are continually taking place. The interstellar and interplanatory spaces are filled with inconceivable myriads of meteors, too small and too distant to be visible by our telescopes. The new stars or novi, as they are called, and which are seen suddenly to appear from time to time, are nothing but the results of collisions against each other of these meteoric systems.

Wandering about aimlessly they happen to come within the sphere of attraction of the Sun, their paths are changed and thenceforward they go on revolving round and round the Sun—a member of its system.

Moving in long ellipses, their orbits sometimes cut the orbits of planets. It is clear that a time comes when these meteors occupy the same position as the planets do; then the meteors being smaller bodies—weighing from a few tons to a few grains—are attracted by the planets, they rush towards them and enter their atmosphere with tremendous velocities and are consumed by the friction thus induced. Then grand