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

meteoric displays occur. Such a display took place on our Earth last in 1866, and of which brilliant descriptions can be read in the books. We have never had an opportunity of viewing such a grand display. It is very probable that some of the meteoric systems have spent themselves. The Earth in its annual revolution round the Sun makes a good haul of thousands and thousands of them, but there may be thousands and thousands yet left.

While some are precipitated on the planets or are consumed, there are others which either escape and continue to move on in their orbits or are captivated by the planets and move round and round them. A good example of this is the ring system of the planet Saturn, and I believe that our own Moon has such an origin and that a good number of meteors may yet be moving about our planet.

Comets have been known to break up and appear to us as meteors. Biela's Comet is a typical example of this kind. It was a Comet of 6¼ years period and was discovered in 1826. In 1845 at the fourth appearance of the Comet it was seen to be broken up in two, and in 1852 the time of the next return of the Comet it was lost, and since then no one has seen it. Now see what happened. In the year 1872 on the night of the 27th November there occurred a copious meteoric shower and the same phenomenon was repeated about the same date in 1885. Hence the conclusion may be drawn that the Comet had undergone further disintegrations and will not appear as a Comet again. What the immediate causes of such disintegrations are cannot be said with any amount of certainty, but collisions with meteors might be one of the reasons. As a matter of fact, Morehouse's Comet in 1908 when near the Sun came into violent collision with a body of meteors and narrowly escaped utter destruction. I could name some more Comets that have shown similar phenomena of disintegrations, but I think that the one I have just mentioned will be quite sufficient for our purpose. We may, therefore, infer that all meteoric displays are the outcome of the collisions of the Earth with a Comet or with the dense meteoric swarms.

And mighty are some of these meteoric streams—the length and breadth of some of these are sometimes enormous. In the case of the Leonids there are reasons to believe that the breadth is more than 100,000 miles and the Earth on the night between the 13th and 14th of November 1866 entered its stream at the head and moving at the rate of 18 miles a second took 5 hours to cross it. But its length far surpasses its breadth. The Earth encountered this stream for three successive years, and since then in its passage across the meteor's orbit

the Earth has encountered a few stragglers every year. These meteors have a period of $33\frac{1}{4}$ years. There are other meteoric showers which the Earth in its annual revolution round the Sun experiences. In fact, there is a shower every month of the year so to say. These showers have been named after the constellations in which their radiants are situated. They are the Bielids or the Andromedes, the Perseids, the Geminids, etc., etc. Up to the present about a hundred such radiants have been discovered.

Besides these visible meteors there are others called the telescopic meteors and which could be seen by telescopes of low powers and large fields of view. These meteors are very slow and generally their paths are confined within the same field of view.

The days of idle sentiment and imagining had long passed away. Science required a thorough, rigid, prosaic scrutiny into these things. From chemical examinations of the samples of meteors that fell on the surface of the Earth, it became possible to know their exact composition, and from a consideration of their chemical and physical aspects it was found convenient to divide them into groups, and accordingly they were named—the meteors, bolides or shooting stars, the fireballs and the meteorites. Of these classes the meteorites are comparatively rare. They are divided into Aerotites or Meteoric stones, Aerosiderites or Meteoric irons and Aerosiderolites, which include the intervening variations. These last are again subdivided into two groups, *viz.*, (α) the carbonaceous and (β) the non-carbonaceous. The pieces of meteorites that have been presented to our Society by His Highness the Maharaja Bahadur of Jalawar are of the latter (β) type. The fireballs are brilliant and slow and noiseless, although a few have been known to be of detonating nature. They are generally pear-shaped.

Generally a meteor appears at a distance of less than 90 miles and disappears at more than 40 miles. From a large number of computations Mr. Winning got the average values for beginning height and end height to be 76·4 miles and 50·8 miles respectively. For fireballs the height of disappearance is 30 miles.

If the paths followed by meteors, on a particular date, are carefully marked on a chart and produced backwards, a point is found in which they intersect each other. This point is called the radiant point. The radiants do not actually reside in the constellations they are named after, but only seem so on projection. In all meteoric observations the aim of the astronomer should be the determination of these radiant points.

This can be done by a very simple method, which has been too lucidly explained by Mr. Rakshit in the November number of the Journal of this Society to require any repetition here. Some meteors, such as the Perseids and the Lyrids, have been found to shift their radiants from fixed positions, and it is just possible that there are others that might be classed with them. Observations must be taken at different nights and the results kept separate for future comparisons. They will then show whether the radiants are shifting or not, and if shifting, the rate and direction of displacement. In fixing the radiants at least 5 paths must be taken.

There are other things equally important to an observer. The direction of motion, the duration of flight, the observed paths in R. A. and Dec., whether the showers are continuous or intermittent, etc., etc., are to be carefully noted. The last Geminid shower, which I observed on the night of the 15th of December last, was interesting in many ways. Some of the meteors were long and bright not lasting more than 2 seconds, and others short swift and pale blue lasting less than a second. There were some small ones of the appearance of red-hot pieces of iron. The meteors were observed most towards the east and south, a very few towards the west, but none towards the north. Another interesting feature about this shower was its intermittent nature—there was a distinct pause of some 10 or 12 mts. after every shower.

The study of this branch of Astronomy is very interesting. Though much has been explained, much yet remains to be elucidated. Naked eye observations are bound to be imperfect and erroneous, but that cannot be helped. Our refined instruments are perfectly powerless to cope with these erratic, fugitive little bodies. So the eye must be trained to take such observations as are most near the truth.

The Old Observatory of Jai Singh at Delhi.

By H. G. Tomkins, C.I.E., F.R.A.S.

Visitors to Delhi will doubtless remember the quaint looking ruins which were until recently to be seen from the road leading from the Ajmere Gate of the City of Delhi to the Kutub Minar. They were the remains of an important observatory built by Maharaja Jai Singh in the year 1710 A.D. The