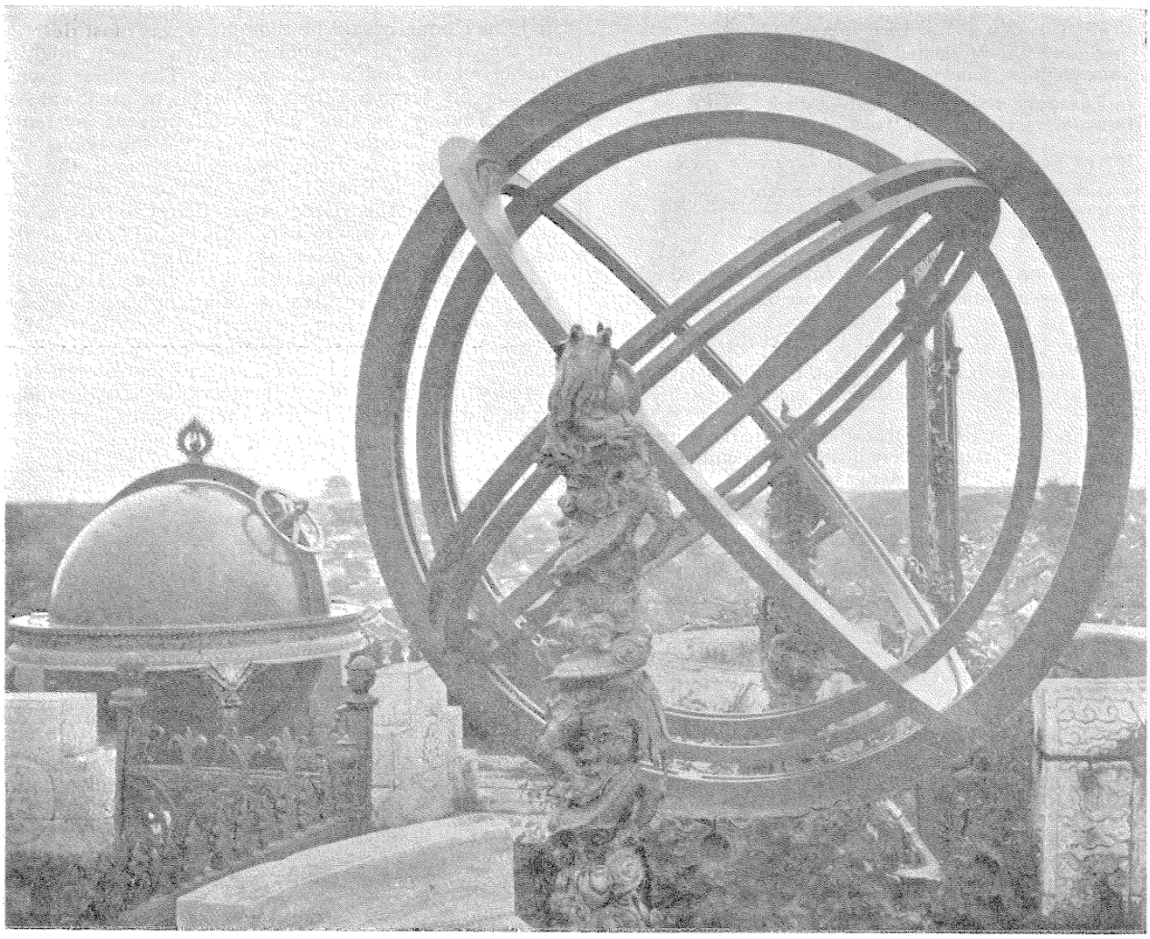
of Europe, the perusal of these chapters should prove useful; and so should the description of the various great centres of population on the coast, in the Yangtze valley and Pekin.

Not the least interesting of the photographs is that which, by the courtesy of the publishers, we are able to give here. The illustration shows two ancient astronomical instruments of purely Chinese construction, which stand on the walls of Pekin, with instruments dating from the thirteenth century, and others constructed for the Chinese Government by the Jesuit missionaries of the seventeenth century. The circles of the instruments of the thirteenth century are divided into $365\frac{1}{4}$ degrees to correspond to the days of the year, each degree being subdivided into hundredths, but the later instruments have their circles divided into 360 degrees.



Ancient Chinese Astronomical Instruments.

THE HEIGHTS OF METEORS.

IT is perhaps surprising that the heights of meteors, and especially of that class known as fireballs, were not determined with any accuracy until the near approach of the present century. It is true that a few individual attempts were made in this direction but, considering the large number of brilliant meteors which appear every year, it is curious that some systematic attempts were not made at a much earlier date in this direction. It must, however, be remembered that many years ago there were comparatively few astronomical observers, that means of communication were slow, and that the importance of recording these objects as precisely as possible had not been recognised.

The present is perhaps an appropriate period to refer to this subject, for it was in 1798, just a century ago, that the first systematic attempt was made (by Brandes at Leipzic, and Benzenberg at Dusseldorf) to determine the heights of meteors. Schröter had in 1795 seen a shooting-star (in his reflecting telescope of 20 feet focus), the height of which he estimated at more than four millions of miles! Brandes and Benzenberg, however, found from 22 meteors which they mutually observed in 1798, heights varying between 6 and 140 miles. Brandes instituted some further observations in 1823, and of 62 meteors available for calculation 55 were found to have heights between 30 and 70 miles. On August 10, 1838, M. Wartmann, at Geneva, followed up Brandes's inquiries, and derived the average height of the meteors seen on that occasion as 550 miles, and their velocity 240 miles a second. These values, compared with modern observations, were far less accurate than Brandes's earlier ones.

It is not proposed in this paper to deal fully with the average heights of meteors, for that has been discussed by several authorities. The values are about 76 and 51 miles respectively for the mean elevations at appearance and disappearance. In the case of fireballs, however, they penetrate much deeper into our atmosphere than

the ordinary shooting-stars, and their heights at extinction appear to be about 30 miles. For the present purpose it is intended to refer to the elevation of these objects at the beginning of their visible flights, for this elevation is so considerable in some cases, that, if atmospheric friction induces their combustion, the air extends to a much greater distance from the earth than is ordinarily supposed.

It is not at all a rarity to find meteors which, at the instant of their first appearance, were more than 100 miles in height. I have looked through various lists of the computed real paths of fireballs and shooting-stars, and find that, out of 577 cases, 116 exhibited a beginning height of 100 miles or more, the average being 130 miles. In fact, one meteor out of five displayed incandescence when 100 miles or more from the earth's surface. The materials from which I obtained these results were by Dr. E. Heis, Prof. A. S. Herschel, Prof. G. von Niessl, and myself. The most extreme heights[1] were :—

Date of meteor.	Height at beginning. Miles	Authority.
1868 September 5	483 ...	G. von Niessl.
1849 August 11	216 ...	E. Heis.
1861 July 16	195 ...	A. S. Herschel.
1862 February 2	190 ...	,,
1864 August 10	188 ...	E. Heis.
1883 June 3	188 ...	G. von Niessl.
1861 August 10	184 ...	E. Heis.
1864 July 28	184 ...	,,
1870 September 27	184 ...	G. von Niessl.
1877 March 21	184 ...	,,

The first of these is probably erroneous, for the observations, though numerous, were not accordant, and with such data it is possible for different computers to work out anomalous results. Thus, in the instance of the very long-pathed fireball seen in France and Germany in 1868, three paths have been computed, and they differ widely in their character. These differences are induced by the erroneous observations, and the difficulty of putting a consistent interpretation upon them. The radiant point, as adopted by the various computers, is dissimilar; and this in itself must occasion a great discordance in the heights, for one observer putting the radiant 5° above the horizon will obviously obtain a lower elevation for the beginning point than another who places it 15° above the horizon—the angle of the meteor's descent being much less. In regard to the fireball of September 5, 1868, the following results were obtained :—

Height at beginning. Miles	Height at ending. Miles	Length of path. Miles	Radiant.	Authority.
483 ...	115 ...	1770 ..	13— 3 ...	G. von Niessl.
69* ...	191 ...	1000 ...	22—12 ...	A. Tissot.
103 ...	65—70 ...	880 ...	18— 8 ...	A. S. Herschel.

Thus, while von Niessl made it descend from 483 to 115 miles, M. Tissot concluded that it really ascended from 69 to 191 miles! Prof. Herschel's results appear to be the best that can be derived from the materials available, for he obtains normal heights and a slight ascent of the meteor just before extinction. Its enormous length of path is quite beyond dispute.

In every instance where the observations are very inconsistent, it is clear that the results of investigations of this kind must depend largely upon the interpretation put upon them. And for strictly scientific purposes the real paths derived from such materials are of little use, for any critical deductions or trustworthy comparisons cannot be made from them. The instance above alluded to furnishes, however, a very exceptional case; but it has been selected in proof of the great uncertainty attaching to deductions based upon conflicting observations.

It appears that about 20 per cent. of meteors are at least 100 miles high at the instant of their first visible apparition. This conclusion rests upon a considerable number of results, including a large proportion of fireballs, and may be trusted within small limits of error. From the materials I have examined, I believe the actual height at first appearance of a meteor is *very rarely* as much as 150 miles, and that it seldom reaches beyond 130 miles.

It is singular that in 1897 I found unusual elevations for several meteors, in fact 9 out of 26 (*i.e.* more than one-third), whose real paths I computed, indicated a beginning-height of over 100 miles. These were :—

Date, 1897. h.	m.	Mag.	Height at beginning. Miles	Height at ending. Miles	Length of path. Miles	Radiant. °	°
Aug. 2, 11	5½ ...	2 ...	112 ...	90 ...	40 ...	40	+ 55
2, 11	24 ...	5—4 ...	139 ...	124 ...	28 ...	73	+ 66
8, 9	15 ...	> ♀ ...	133 ...	115 ...	63 ...	52	+ 47
9, 13	27 ...	3—1 ...	140 ...	77 ...	81 ...	46	+ 56
9, 13	52 ...	3 ...	131 ...	89 ...	56 ...	58	+ 60
9, 14	18 ...	3 × ♀ ...	137 ...	75 ...	75 ...	44	+ 45
Nov. 13, 15	28 ..	1 ...	125 ...	77 ...	75 ...	136	+ 9
13, 15	52 ...	1 ...	103 ...	59 ...	60 ...	152	+ 22
Dec. 12, 8	6 ...	> ♀ ...	112 ...	19 ...	151 ...	80	+ 23

It is possible that in several of these cases mistakes of identification may have occurred. It must sometimes happen, and especially during the occurrence of a rich shower, that two meteors are recorded at the same time at different places, which show parallax in the right direction, though they are entirely separate objects. Accidental coincidences of this kind would, however, not very often occur, and they would usually be detected by some features of mutual discordance.

There is another point in connection with the first appearance of meteors which merits attention—this is, that observers seldom secure an accurate view of it. The end point is more precisely determined as the eye steadily follows the object until its extinction. But it is rarely the case that even an habitual observer of meteoric phenomena happens to be looking directly to that point of the heavens where a meteor appears. He generally catches it after it has already traversed a section of its flight, and often estimates the extent of its backward trajectory, sometimes adding 5° or 10° to the observed starting-point. Now, a slight error in carrying the visible line of flight too far back may put 30 or 50 miles on the beginning-height of a meteor, especially if it is anywhere near its radiant. It would, therefore, be safer for observers to record the path actually witnessed, without assuming the extent of the portion which escaped them.

But apart from all the uncertainties (which have their outcome in the rough character of the observations) attaching to the subject, it is impossible to put aside the evidence that meteors are sometimes 130 miles and, in extremely rare instances, 150 miles high when they are first visible. There are grave doubts that any meteor has ever been visible at a height of 200 miles. And it is probable that many, if not all, of the instances where heights of about 170, 180 or 190 miles have been found, were due to the commencing points of the flights having been carried too far back by the observers, or that mistakes in the directions have led the computer to adopt erroneous radiants and deduce initial heights considerably in excess of the correct ones.

If photography could step in here, and dispel all the doubts arising from our hurried and often questionable

[1] Other instances of abnormal height might be quoted from the deductions of other authorities, but they are open to serious question. Thus, for the fireball of March 19, 1718, the height at first appearance has been given at 297½ miles; but Prof. Herschel finds, from a careful rediscussion of the observations, that the meteor began at an elevation of only 80 miles.

* This is the lowest elevation of the meteor as found by M. Tissot, and quoted in British Association Report for 1869, p. 272.

observations, it would be a matter for congratulation. When a meteor is observed by two or more practised observers, the results usually work out very well; but in the case of large fireballs witnessed by a great number of persons, the descriptions are often very conflicting and dubious, and the discussion of such materials is seldom either profitable or trustworthy. W. F. DENNING.

RUDOLF LEUCKART.

RUDOLF LEUCKART, whose death removes one of the most eminent figures in the zoological world, was the son of a bookseller, and was born on October 7, 1822, at Helstedt, which until 1809 had been the seat of one of the universities of the state of Brunswick. A taste for the study of natural history was probably hereditary in the family, for his uncle, Friedrich Sigismund Leuckart (1794–1843), was a zoologist of no mean reputation. The subject of our sketch began his career as an author at a comparatively early age, for whilst still a student at the University of Göttingen he completed the "Lehrbuch der Zootomie" of his teacher, Rudolf Wagner. After serving for a time as assistant in the Physiological Institute of his *alma mater*, he received in 1850 the appointment of extraordinary professor at Giessen, which the genius of Liebig had then raised to a position of great importance among the universities of Germany.

He had already shown what manner of man he was by the publication of two treatises, "Beiträge zur Kenntniss wirbelloser Thiere" (in conjunction with Heinrich Frey, 1847) and "Ueber die Morphologie und Verwandtschaftsverhältnisse der wirbellosen Thiere" (1848), in which the great division *Radiata* of Cuvier was broken up into *Cœlenterata* and *Echinodermata*. He further recognised Metazoa as divisible into six types—*Cœlenterata*, *Echinodermata*, *Vermes*, *Arthropoda*, *Mollusca* and *Vertebrata*—and thus initiated a system which, in its main features, is still maintained at the present day, and must be recognised as a stroke of genius in a young man of some twenty-five summers, working at such an early stage in the history of morphological science.

In 1855 he was made ordinary professor, and in 1870 removed to Leipzig. As a teacher he was clear and stimulating, and his remarkable success in this department of scientific work is attested by the volume issued in commemoration of his seventieth birthday, in which about 139 men of science, including many of the most eminent zoologists of the day, are proud to acknowledge themselves his pupils.

As an investigator he fully realised the promise of his early youth. His knowledge was as accurate as it was extensive, and that to a degree which only becomes comprehensible when we remember that unaided he contributed for nearly forty years a masterly summary of current researches into the natural history of the lower animals to the pages of the *Archiv für Naturgeschichte*. It is clearly impossible to give anything like a detailed account of such an active and many-sided career in a moderate space: let it suffice to recall his insistence on the division of labour in the animal kingdom, his researches on the reproduction of bees and of the Cephalopoda, his recognition of the ciliated organ of Heteropoda and Pteropoda as an osphradium, and his reference of *Neomenia* to the Mollusca.

Undoubtedly, however, his greatest energy was devoted to the study of parasitic life in general and to the life-history of the parasitic worms in particular. He at once recognised the importance of the methods of experimental helminthology introduced by Küchenmeister, and demonstrated the life-history of nearly all the bladder-worms then known by rearing them in suitable hosts. He was the author of epoch-making researches on *Trichina* and on the *Pentastomida*, and contemporaneously with the Englishman, A. P. Thomas, worked out the life-history of the Liverfluke. His work on the "Parasites of Man," the first volume of which has been translated into English, is a perfect cyclopædia of information derived from the writings of others and from his own observations. He has passed away full of years and full of honours, leaving a name which will ever be venerated by zoologists of every tongue and nation.

NOTES.

THE first soirée of the Royal Society, to which gentlemen only are invited, is fixed for Wednesday, May 11.

ON Saturday last (April 2) the Council of University College, London, elected Prof. H. L. Callendar, F.R.S., to the Quain Professorship of Physics, about to become vacant by the resignation of Prof. G. Carey Foster, who in a few months will have held his Professorship in University College for thirty-three years. Prof. Callendar, who has been Professor of Physics in McGill College, Montreal, will enter upon his duties in London in October next.

SIR WILLIAM TURNER, F.R.S., professor of anatomy in the University of Edinburgh, has been elected a corresponding member of the Berlin Academy of Sciences. He has also been elected president of the General Medical Council, in succession to the late Sir Richard Quain.

PROF. H. C. BUMPUS has been appointed director of the laboratory of the United States Fish Commission Station at Wood's Holl.

SIR SAMUEL WILKS has been re-elected president of the Royal College of Physicians of London.

M. RICHET has been elected a member of the Paris Academy of Medicine.

A "JARDIN DE KEW" is to be established in the neighbourhood of Nantes by a rich citizen of that town. The new botanical garden will be planned on the same lines as the Royal Gardens at Kew, and special attention will be given to the cultivation of plants useful in French colonies. It is hoped that the garden will eventually do for French colonial possessions what Kew does for British colonies.

THE Paris correspondent of the *British Medical Journal* announces that a recent decree authorises the University of Paris to borrow 68,000*l.* for the purpose of building laboratories where physical science, chemistry, and natural history will be taught for the benefit of students who are preparing for the examination for Science Certificate. Part of the money is to be applied to the completion of the Laboratory of Vegetable Biology belonging to the University of Paris at Fontainebleau.

THE policy exemplified by the following appointment, announced in *Science*, might be adopted with advantage in this country:—Dr. Charles Wardell Stiles, of the United States Department of Agriculture, has been appointed *attaché* to the United States Embassy in Berlin. Dr. Stiles's duty will be to keep the Agricultural Department informed on important discoveries and other matters of interest to agricultural science, to defend American meats, fruits and other exports against unjust discrimination, and to advise the Secretary of Agriculture from time to time concerning the purity of the food products that are shipped from Germany to the United States. It is said that the appointment of Dr. Stiles will probably be followed by other similar appointments, and it consequently represents an important advance in the application of scientific principles to diplomatic and commercial affairs.