nating current electromotors were still comparatively untried.

Tests of a secondary generator were next undertaken in 1885 by Prof. Galileo Ferraris, of Turin, who found the efficiency at full load to be no less than 97 per cent.,—a value even higher than that previously published. This investigation is the more memorable, in that it led Prof. Ferraris to take up the mathematical and experimental investigation of alternating currents, resulting in the discovery and construction of the self-starting alternate current motor in 1885, and to extensions of considerable practical importance in our knowledge of the action of secondary generators, now called *transformers*. And so one of the chief lions this year at the Frankfort Exhibition was Prof. Ferraris. W. E. A.

(*To be continued.*)

THE GIRAFFE AND ITS ALLIES.

ALTHOUGH coming within that well-defined group of ruminants known as the Pecora, the Giraffe (the sole existing representative of the genus *Giraffa*) stands markedly alone among the mammals of the present epoch; although, on the whole, its nearest living relations appear to be the deer (*Cervidæ*). Moreover, not only is the giraffe now isolated from all other ruminants in respect of its structure, but it is also exclusively confined to that part of the African continent which constitutes the Ethiopian region of distributionists. When, however, we turn to the records of past epochs of the earth's history, we find that both the structural and distributional isolation of the giraffe are but features of the present condition of things. Thus, in regard to its distribution, we find that in the Pliocene epoch giraffes were abundant in Greece, Persia, India, and China; and we may therefore fairly assume that they were once spread over the greater part of the Palæarctic and Oriental regions. Then, again, with regard to their allies, the researches of palæontologists have been gradually bringing to light remains of several large extinct ruminants from various regions, which are more or less nearly related to the giraffe, but whose affinities appear to be so complex and so difficult to decipher, that not only do they remove the stigma of isolation from that animal, but even render it well-nigh impossible to give a definition of the group of more or less giraffe-like animals, by which it may be distinguished on the one hand from the deer (*Cervidæ*), and on the other from the antelopes (*Bovidæ*). Since an interesting account of a new extinct Giraffoid from the Pliocene deposits of Maragha in Persia has been recently given by Messrs. Rodler and Weithofer in the *Denkschriften* of the Vienna Academy, the present time is a suitable one to offer a brief *résumé* of the present state of our knowledge of this group of animals, and the different views which have been entertained as to the affinities of some of its members.

Among the chief structural peculiarities of the giraffe, the most noticeable is its great height, which is mainly produced by the excessive length of the neck and limbs. The fore-limbs are, moreover, longer than the hind ones, as is well shown by the circumstance that the radius, or main bone of the fore-leg, is longer than the tibia in the hind-leg; whereas, in other living ruminants the reverse condition obtains. The skull is more like that of the deer than of any other existing ruminants, this being shown by its general contour, and also by the presence of the large unossified space below the eye, which completely separates the lachrymal from the nasal bone; a condition but very rarely met with in the *Bovidæ*, although found in the skull of the water-buck. Then, again, the skull resembles that of the deer in the great elongation of the portion situated behind the eyes, *i.e.* the parietal region. The bony processes arising from the skull between the occiput and the eyes, and clothed in the living animal with skin, are not strictly comparable either with the antlers of the deer or the horn cores of the antelopes; in the young condition they are separate from the bones of the skull, with which, however, they unite as age advances. The whole of the frontal and nasal region is much swollen and inflated by the development of air-cells between the inner and outer layers of bone; and at the junction of the frontal and nasal bones there is a large oval hillock-like protuberance in the middle line, which is sometimes termed a third horn. This excessive inflation of the region of the face makes the appearance of this part of the skull very different from that of the deer, in which it is much flattened. The grinding or molar teeth of the giraffe are remarkable for the peculiar roughness of their external coating of enamel, and also for their broad and low crowns, which in the upper jaw lack the internal additional column occuring in those of most deer and many antelopes. These teeth are, however, more like those of the deer than those of other ruminants, although they can be distinguished at a glance from all others except the larger ones of the under-mentioned fossil forms.

Since a good deal depends on the similarity between the structure of the molar teeth of the giraffe and those of the extinct ruminants in question, it may be well to observe that the characters of the molar teeth among all the ruminants are of great importance in classification. Thus, these teeth in all the deer, although varying to a certain extent in the relative height of their crowns, present the same general structure, those of the upper jaw being comparatively short and broad, with a large internal additional column. Then, again, in the *Bovidæ* we may notice that each of the several groups into which the antelopes are divided, as well as the goats and sheep and the oxen, are severally distinguished by the characters of their molar teeth, and that, although the teeth of one group may approximate more or less closely to that of another, we do not find any instances where one member of a group possesses teeth of a totally different type from those of the other representatives of the same group. These facts strongly indicate that, when we meet with fossil ruminants having molar teeth of the very peculiar type met with in the giraffe, we shall be justified in considering that there must be a certain amount of relationship between the owners of such teeth.

Another marked peculiarity of the giraffe is that the humerus has a double groove for the biceps muscle, instead of the single one found in ordinary ruminants. In regard to its soft parts, the giraffe resembles the deer in the usual absence of the gall-bladder, although its reproductive organs are constructed more on the Bovine type.

With these preliminary remarks on some of the structural peculiarities of the giraffe, we may proceed to the consideration of its fossil allies. The genus which probably comes nearest to the giraffe is the imperfectly known *Vishnutherium*, founded upon part of a lower jaw from the Pliocene of Burma, but to which have been referred some upper molars and bones from the corresponding beds of the Punjab. This animal must have been considerably larger than the giraffe, and the upper molars are remarkable for the great flatness of the outer surfaces of their external columns, in which respect they come nearer to the corresponding teeth of the elk than do those of any other members of the group. The posterior cannon-bone, or metatarsus, assigned to this genus, although relatively much shorter than that of the giraffe, is more elongated and giraffe-like than the corresponding bone of any other fossil genus in which this part of the skeleton has been described. The cervical vertebræ are also more elongated and giraffe-like than those of any of the under-mentioned genera. It will of course be immaterial if these bones prove to belong to a genus distinct from *Vishnutherium*; their interest lying in the circumstance that they indicate the existence of an animal to a great extent intermediate between the giraffe and the following genus.

The genus *Helladotherium* was established upon the remains of a large giraffe-like ruminant from the Pikermi beds of Greece, to which a skull from the Indian Siwaliks, which had been previously regarded as referable to the female of *Sivatherium*, proved to belong. The Helladothere, of which the entire skeleton is known, was a hornless animal, of larger size than the giraffe, but with much shorter and stouter neck and limbs. The skull approximates in many respects to that of the giraffe, having the same long parietal region, but with a minor development of cells in the frontals, and the important difference that there is no unossified space below the eye. The limbs agree with those of the giraffe in the great relative length of the anterior pair, as is shown by the radius being considerably longer than the tibia. That the Helladothere was not the female of the Sivathere seems to be evident from the absence in the Pikermi beds of the antler-like cranial appendages of the latter, which are comparatively common in the Indian Siwaliks. The intimate affinity existing between the Helladothere and the giraffe has been admitted by all who have written on the subject.

The animal recently described by Messrs. Rodler and Weithofer from the Persian Pliocene, for which the hybrid name *Alcicephalus* has been proposed, tends to connect the Helladothere with the deer, and more especially the elk. Thus, in the first place, the front and hind limbs are approximately equal, the length of the radius and ulna being nearly the same. Then, again, from the total absence of air-cells in the frontal region of the skull, the middle of the face is nearly flat, and the orbits have their frontal borders in the plane of the face, instead of considerably below it, as in the Helladothere, and still more so in the giraffe. There is, however, no unossified space in front of the eye; although the whole contour of the skull is strikingly elk-like.

The conclusion to be drawn from these hornless forms appears to be that they serve to connect the giraffe with less aberrant ruminants, and more especially the *Cervidæ*, and also that the unossified vacuity in the skull of the giraffe is probably an acquired feature, since it is absent both in the extinct giraffoid genera, and in the earliest deer, like the Miocene *Amphitragulus*. Both giraffes and deer may, therefore, probably have had a common ancestor more or less closely allied to the lower Miocene genus *Gelocus*.

Leaving now these hornless forms, as to the affinities of which there has been no dispute, we have to turn our attention to another group provided with cranial appendages of very curious and still imperfectly understood structure, in regard to whose relationship exceedingly different views have been entertained. This group, so far as we know at present, seems to be confined to the Pliocene of India and Persia, being represented in the former area by the gigantic *Sivatherium*, *Bramatherium*, and *Hydaspitherium*, and in the latter by the much smaller *Urmiatherium*. In all these animals the skull is characterized by the extreme shortness of the parietal region, and the position of the horns or antlers immediately over the occiput; the elevated facial profile thus produced being in very striking contrast to the straight one of the deer. In *Bramatherium* and *Hydaspitherium* the cranial appendages rise from a massive common base, and the latter genus is distinguished from all the others by the presence of an unossified space below the eye, corresponding to that of the giraffe. Their molar teeth are very similar to those of the Helladothere. In the Sivathere, on the other hand, there is one pair of large branching and palmated cranial appendages rising from separate bases immediately above the occiput; and in addition to these a pair of much smaller conical ones placed immediately over the orbits. In general appearance the large palmated appendages are more like the antlers of the elk than those of any other existing ruminants; but the absence of a "burr" at their base indicates that they were not deciduous, while the deep arterial grooves on their surface suggest that they were clothed either with skin or with a horny substance. The molar teeth conform to those of the giraffe—and to a less degree the deer—having the same rugose enamel; but the ridges on the outer surfaces of those of the upper jaw are more developed than in the other extinct genera. A peculiarly giraffe-like and cervine feature in these upper teeth is the extension of the anterior extremity of the anterior crescent far towards the outer side of the crown. Lastly, the humerus of the Sivathere resembles that of the giraffe in the presence of a double groove for the biceps muscle; while the form of the terminal bones of the feet is almost identical in the two animals. In the small Persian *Urmiatherium*, which is known only by the hinder portion of the skull, it appears that the cranial appendages consisted of a pair of unbranched, somewhat compressed, and upright processes rising immediately above the occiput.

With regard to the affinities of this group, it has been argued that the shortness of the parietal region of the skull, and the position of the cranial appendages immediately above the occiput, indicate affinity with certain African antelopes, such as the Sassabi and its kindred (*Alcelaphus*). In that group of antelopes it is, however, perfectly clear that the features in question are acquired ones; the allied Blessbok scarcely possessing them in any degree. Again, the straightness of the cranial axis in the skull of Waller's gazelle (*Gazella walleri*) shows that the arching of this axis, which is so characteristic of most antelopes, is likewise a feature specially acquired among that group of animals. Moreover, apart from this evidence, no one who thinks for a moment on the subject can believe that the Sassabi, with its narrow sheep-like molars and true horns, and the Sivathere, with its broad giraffe-like molars and cranial appendages, which are neither true horns nor true antlers, can be anything approaching to first cousins; and yet if they are not so, it is perfectly evident that the similarity in the structure of their skulls must have been independently acquired. It is therefore abundantly clear that no arguments based on these resemblances will hold water; the true explanation probably being that the superficial similarity of their skulls is solely connected with the support of cranial appendages having a similar position in both groups.

It follows from this that, if a type of skull with a short parietal region, a curved basal axis, and horns placed immediately over the occiput, has been independently developed among the antelopes from a type of skull with a long parietal region, a straight basal axis, and horns placed over the orbits, there is no conceivable reason why a similar line of development should not have taken place among giraffe-like animals. Taking, therefore, into consideration that the Sivathere and its allies have molar teeth like those of the giraffe, that their cranial appendages could be derived from those of the latter by special modification and development better than from those of any other group, that their humerus has a double bicipital groove, that the terminal phalangeals of their feet are giraffe-like, and that the proportions of their limbs are only a step beyond those obtaining in the admittedly giraffoid Helladothere, the evidence in favour of regarding these animals as greatly modified Giraffoids is so strong as to be almost a certainty. Indeed, it appears most probable that we ought to regard the Sivathere and its allies as holding a somewhat analogous position among the Giraffoids to that occupied among the antelopes by the Sassabi and its cousins.

The writer has purposely refrained from making any reference to the large unossified suborbital vacuity in the skull of the Hydaspithere, as reasons have already been given for regarding that feature as an acquired one. If, however, that view be incorrect, the presence of this vacuity at once stultifies the statement that the Sivathere can have no kinship with the giraffe and the deer, on account of the absence of a similar vacuity; and its presence, so far as it goes, is also another argument against the Sassabi theory.

The last representative of the Giraffoid animals that we have to mention is the recently discovered *Samotherium*, from the Pliocene of Samos, a figure of the skull of which appeared in NATURE, illustrating an article on the extinct mammals of those deposits. In this animal, the elongated form and straight profile characteristic of the skull of the Giraffe are retained; and the teeth are almost indistinguishable from those of the latter. There is, however, no development of air-cells in the bones of the frontal region, so that the upper border of the orbit is approximated to the plane of the face; and the cranial appendages take the form of upright compressed processes rising immediately over the orbits. These appendages, which appear to have been inseparable from the bones of the forehead, are, indeed, very similar, both in form and position, to the horn-cores of certain extinct antelopes, but we are, of course, unacquainted with the nature of their covering. If, however, as seems to be undoubtedly the case, the Samothere is a Giraffoid, it would seem that we must here again regard this superficial resemblance to the antelopes as one independently acquired.

Finally, if the views expressed above are anywhere near the truth, it would appear that, in the Pliocene epoch, Giraffoid animals played a very important *rôle* among the ruminants, and that they have undergone modifications and developments fully as marked as those which we observe among the antelopes at the present day. Whether the circumstance that none of them, except the giraffe (which is obviously an animal incapable of further modification), appears to have obtained an entrance into Africa has been the chief reason why only a single representative of the group has survived to our own times may be a fair subject of conjecture, since after the Pliocene epoch both India and Europe seem to have been unsuited to the maintenance of many forms of large Artiodactyle Ungulates, as is proved by the disappearance from those regions of the hippopotamus, the giraffe, and a number of antelopes of African type. R. L.

PHOTOGRAPHIC MAGNITUDES OF STARS.

THE character of the image of a star photographed on a sensitized film; the relation between the intensity of the light photographed and the blackened disk produced; the influence of the time of exposure on the image—are questions now receiving much attention. For this reason, Dr. Scheiner's contribution to the subject, embracing, as it does, the latest results of the Potsdam Observatory, is especially welcome; but these results will not be accepted without great reserve, contravening, as they do, a theory, or at least an assertion, that has been very generally accepted, viz. that increasing the intensity of light is exactly equivalent to increasing the time of photographic exposure. A consequence of such a law would be that an additional magnitude would be impressed on the film by increasing the time of exposure two and a half times the length.

Such a law cannot be rigorously exact, and its stoutest supporters have been careful to confine its application "within limits." But Dr. Scheiner's contention is that, owing to the complex character of the disk produced on the film, such a principle is a very unsafe guide, either as a rule for the determination of the feeblest magnitude impressed on the negative, or as offering a satisfactory explanation of the growth of the diameter or area.

In the first place, there is evidence of want of uniformity of actinic action throughout the whole extent of the stellar disk. A mean intensity (i) may be assumed at a certain distance (r) from the centre of the image, where the intensity is I. This centre will not be a geometrical point, but, owing to atmospheric and other disturbances, will occupy a small area of radius (ρ). The intensity (i) at distance (r) will depend materially on the increase of the area (ρ), which may be represented by $\psi(\rho)$. Consequently, the simplest expression for $i = I\psi(\rho)e^{ar}$, where a is the coefficient of absorption of the sensitive film. On comparing two stellar disks, formed on the same emulsion, and treated by the same developer, this expression becomes

$$\frac{t_0}{t_1} = \frac{I_1\,\psi(\rho_1)}{I_0\,\psi(\rho_0)}e^{a(r_1-r_0)},$$

and, if the disks be on the same plate, $\rho_1 = \rho_0$ and $t_1 = t_0$, so that the formula can be simplified to

$$a(r_0 - r_1) = \log\frac{I_1}{I_0} = \frac{0 \cdot 4}{\text{mod.}}(m_1 - m_0)$$

In order to derive the relation between diameters and exposure, put $I_0 = I_1$, and then

$$\log\frac{t_0}{t_1} = a(r_1 - r_0).$$

It is not likely that such an expression has any other value than to serve as a convenient formula for interpolation. The variable character of a under different conditions, but always depending on the time of exposure, is shown by the following table:—

Exposure. m. s.		Instrument.	*a*.		Instrument.	*a*.
1 0	...	Reflector	4·99	...	5-in. refractor	4·12
2 0	...	,,	4·57	...	,,	5·09
4 0	...	,,	4·67	...	,,	5·47
8 0	...	,,	4·89	...	,,	5·89
16 0	...	,,	5·39	...	,,	7·51
0 24	...	13-in. refractor	3·18	...	13-in. refractor	2·67
1 0	...	,,	3·16	...	,,	2·20
2 30	...	,,	3·33	...	,,	2·48
6 15	...	,,	3·33	..	,,	3·00
15 38	...	,,	4·48	...	,,	—

Another well-known formula in which magnitude is made to depend on diameter is $m = a - b \log D$, and in this case b is shown, notwithstanding Dr. Charlier's results to the contrary, to be a function of the time of exposure. The results are as follows:—

Time of exposure. h. m.		*b* Charlier.		Time of exposure. m. s.		*b* Scheiner.
0 13	...	6·719	...	0 24	...	5·17
1 30	...	6·779	...	1 0	...	6·35
2 0	...	6·683	...	2 30	...	7·06
3 0	...	6·814	...	6 15	...	8·08

The disagreement is conspicuous, but the explanation offered by Dr. Scheiner is scarcely satisfactory. He would ascribe the constancy in the value of b, found by Dr. Charlier, to the fact that in his experiments there is always a large absolute value of the time coefficient. It will, however, be observed that the ratio between Dr. Charlier's extreme exposures is not greatly different from that which obtains in Dr. Scheiner's experiments.

If it be admitted that the product of intensity by the time is *not* a constant quantity, it becomes a matter of great practical importance to determine what is gained on a photographic plate by prolonged exposure. This question forms the real investigation of Dr. Scheiner's two papers, and though some of his results may be questioned, yet the general issue is so grave and disquieting that it may not be utterly ignored. Passing over the details of his method of examination, and the precautions taken to insure accurate results, for which the reputation