received from the Society for the last five years during which investigations on Electric Radiation have been in progress at the Presidency College. I may say that the difficulties have been very numerous and disheartening, and that without this encouragement the work which it has been my good fortune to carry out would in all probability have remained unaccomplished. The Government of Bengal has also been pleased to evince a generous interest in these investigations. My assistant, Mr. Jagadindu Ray, and my pupils, Messrs. P. K. Sen, B.A., and B. C. Sen, B.A., have rendered me active assistance.]

"Contributions to the Comparative Anatomy of the Mammalian Eye, chiefly based on Ophthalmoscopic Examination." By GEORGE LINDSAY JOHNSON, M.D., F.R.C.S. Communicated by HANS GADOW, F.R.S. Received May 7,—Read May 17, 1900.

(Abstract.)

Observations were made on the eye of the living animal, 181 different species being examined, and frequently several individuals of the same species. The species comprise representatives of all the Mammalian orders except the Cetacea and Sirenia.

The conclusions arrived at can be summed up as follows :—

The *colour of the Fundus oculi* in animals devoid of a Tapetum is mainly determined by reflection from the choroidal pigment; in those with a Tapetum cellulosum (Carnivores) by the colour of the retinal pigment; in those with a Tapetum fibrosum (Ungulates) by the structural colour of the Tapetum modified by the colour of the retinal pigment. All the animals examined may be classed under three types —red, yellow, and green.

The *vascularisation of the retina* can be summarised as follows :—

1. Indirect supply by means of osmosis from the vessels of neighbouring parts. A. Hyaloid supply. (*a*) The corpus vitreum is nourished by a processus falciformis, the hyaloid vessels lying well inside the corpus vitreum (Elasmobranchs). (*b*) The hyaloid vessels spread over the surface of the corpus vitreum, being in consequence in the immediate vicinity of the retina (*e.g.*, holosteus and many teleosteous fishes). Hereto belong also the Amphibia and most of the Reptiles devoid of a pecten. B. Choroidal supply. This is probably the chief supply of the retina in those animals which possess a well-developed pecten (most Sauropsida), but are devoid of superficial hyaloid vessels. This choroidal supply by osmosis is also with certainty demonstrated in the Mammalia for at least part of the thickness of the retina.

2. Direct supply. A. From the superficial hyaloid vessels. This is

known to be the case when the hyaloid vessels are directly continued into the retina, where they produce two vascular layers. B. From special retinal vessels cumulating in the art. centralis. This mode is restricted to the Mammalia and some of the Snakes.

The vessels of the falciform process of the fishes and the central hyaline artery, wherever this occurs, are essentially the same. The falciform process and the pecten are analogous, but not homologous, structures. In Reptiles and Birds the hyaloid artery is superseded by a new development, viz., the Pectinal system. In some of the lower Mammalia both systems actually occur side by side, but both are rendered unnecessary by the development of a third system of supply, viz., special retinal vessels, which ultimately culminate in the possession of an art. and vena centralis retinæ.

Some of the normal conditions observable in certain animals closely resemble those which we find in Man as congenital defects or vestigial relics. 1. Membrana nictitans. A fully developed nictitating membrane active enough to sweep the whole cornea, exists only in the Ungulata, and not even throughout this order. In the Carnivora and Marsupials it is much less developed, whilst throughout the Primates, Rodents, Edentata, and Echidna it is still more reduced, and, with rare exceptions, entirely without movement. The primary use of this third lid, viz., that of cleaning the corneal surface, is lost within the class of the Mammalia, and seems to serve chiefly to protect the eye in the animals which graze and poke their heads down into the long and sharp grass. 2. The retractor muscle of the eyeball is of frequent occurrence, chiefly in Marsupials, Edentates, Rodents, and Ungulates, *i.e.*, in the lower orders of Mammals. 3. Opaque nerve fibres. All stages of opacity occur congenitally in Man, and are to be found normally throughout the Mammalia. Opaque nerve fibres are most marked in some of the Rodents and Marsupials. 4. Physiological cup and congenital discoloration of the disc frequently occur in Man. An appearance similar to the physiological cup occurs in all the Felidæ, and in a considerable number of the other Carnivora; also in the Flying Squirrels and some of the other Rodents. White and grey discs occur normally in a number of animals widely separated in classification, such as the Skunk, Rhinoceros, Porcupine, Armadillo, and Echidna. 5. Structures protruding from the disc into the corpus vitreum. A. Persistent hyaline artery. This congenital defect in Man is found as a normal condition in nearly all the Ruminants and in a large number of Rodents. B. Vestiges of a pecten. In some of the Rodents, more especially in all the Agoutis, a button-shaped vascular pigmented rudimentary pecten protrudes from the disc into the vitreous. It is remarkable to find in the Mammalia a relic of this Sauropsidan organ. In a number of Marsupials vascular protuberances from the disc into the vitreous occur in different forms. 6. Colobomata. The papillary

coloboma (Fuchs' Coloboma) has its analogy in a white or coloured scleral ring, which is normally met with in a large number of animals. 7. Retinitis pigmentosa. In the Galagos and Lorides a spreading of pigment occurs circumferentially in the retina, which greatly resembles Retinitis pigmentosa. If these nocturnal animals are exposed for prolonged periods to daylight the pigment advances concentrically, similar to the manner in which it progresses in Man, so that the animals gradually go blind. 8. Visible choroidal vessels and stippled fundus. Visible choroidal vessels occur in most of the Simiæ below Hylobates, and in a number of the other orders. They are most marked in the Macropodidæ, and some of the other Marsupials, which present the appearance observable in the extreme cases of the analogous congenital defect in Man. Stippled fundi are found in the feline Douroucouli and in the Lemurs, an appearance occasionally met with in Man. 9. Ectropion of the Uvea. In a number of the Ungulates, which have large oval pupils, pigmented excrescences of the iris are met with, and these evidently serve to screen the eye against glare, since their pupils only contract moderately to light. In the Hyracoidæ we meet with a distinct specialised organ, which can be projected from the iris towards the cornea, like a small screen, and this I propose to call the "Umbraculum."

The *divergence of the optic axes* follows the classification to a marked degree. The higher the order the nearer the axes approach parallel vision. Parallel vision with the power of convergence only occurs in those animals which possess a true macula, viz., Man and all the Simiæ. In other words, convergence appears to be the necessary outcome of a macula. This macula, which is bounded by a reflex ring, exists in all the Simiæ without exception, and in no other Mammals, so that it ceases with the last of the Simiæ.

If we eliminate the domestic animals in which the *refraction* varies over considerable limits in all directions, we find throughout the Mammalia, with a few notable exceptions, vision is hypermetropic. The eyes of amphibious and marine Mammals are adapted for vision in two ways. Those which live in fresh water have immensely developed ciliary muscles and proportionally increased accommodative power, enabling them to compensate for the loss of the refractive power of the cornea when the eye is submerged. In the marine Mammals, *i.e.*, Pinnipedia and Cetacea, not only is this ciliary muscle greatly developed, but there is always a large area of the cornea which is flattened in the horizontal meridian, producing an extraordinary degree of astigmatism.

Binocular Vision.—It seems that if Mammals below the Simiæ have binocular vision, they do not rely entirely on it. With the exception of Man and the Simiæ, Mammals very rarely move their eyes for the purposes of vision, but move their heads instead.

In all the Mammals below the Simiæ which have no macula we find a larger *sensitive area.* Sensitive areas of restricted dimensions, omitting those cases in which the area is limited to a macula, exist in the Carnivora, in which order the divergence is not great. In the Ungulates, Rodents, Edentates, and Marsupials, where we find great divergence of the axes, large corneæ, and nearly spherical lenses, the sensitive areas are larger, and probably the degree of difference in perception over such areas, compared with the more peripheral parts, is but little.

The great transparency of the retina and the extreme brilliancy of the reflecting surface of the choroid in the vast majority of Mammals, and an extraordinary prevalence of colours of every hue, lead one irresistibly to the conclusion that the rays of light do not form an image on the retina as usually taught, but that the image is formed behind the retina on the brilliant surface of the Tapetum or fusca pigment layer of the choroid, and is then reflected back on to the terminals of the bacillary layer. This arrangement for vision certainly bears a close resemblance to Lippmann's method of obtaining coloured negatives. He obtained negatives in natural colours by placing a reflecting mercury surface in direct contact with the sensitive film, thus reflecting the light which had traversed the film on to the particles of sensitised silver. In the eye the light passes through the nearly transparent retina (which is analogous to the photographic film) to be reflected from the Tapetum, or choroidal pigment, on to the terminals of the retinal elements (which may be compared to the particles of silver haloid). In Lippmann's device the colours are produced by interference. If we venture to carry our analogy still further, we may presume the same occurs in the eye. One difference between the two methods is that in nature the reflecting surface is always coloured, and only reflects a portion of the incident light. The colour of the fundus, however, is remarkable for the absence of blues and violets and the great prominence of red, yellow, and green colours. Yellow and orange are the prevailing colours in nocturnal animals. The peripheral area, which is characteristic of animals possessing a Tapetum, is usually dark brown, and reflects but feebly. It is probably nearly insensible to light, as it never occurs in animals having great divergence of the optic axes.

The eye is no exception to the rule that domestication greatly increases *variability.* The colour of the Fundus oculi of domesticated races differs not only from that of the wild species from which the races are supposed to be derived, but the colour varies also individually, an occurrence almost unknown in wild species. The influence of domestication is also indicated by the frequent occurrence of myopia and astigmatism. Myopia is almost unknown in wild animals, but it may occur in wild specimens which have long been kept in captivity.

Although no sound *classification* can be based on one single organ, a striking concordance exists between an attempted arrangement of the Mammalia according to the Fundus oculi and the most modern classification. The cases of disagreement are wonderfully few. These are restricted to the following:—

Chrysothrix leans towards the Arctopitheci. I find it necessary to separate the Galagos from the rest of the Lemurs—at least, as a subfamily. In the smaller Carnivores it is advisable to establish a separate family, the *Cynictidæ*, to include the otherwise viverrine genera, Cynictis and Galictis, together with Mephitis, hitherto placed with the Mustelidæ. The Sciuromorpha should be divided into Sciuridæ and Pteromyidæ, and Castor should decidedly be removed into the Hystricomorpha group, perhaps into the vicinity of the Octodontidæ. The Bats rank very low so far as the eye is concerned, possibly on account of their nocturnal habits. Among the Marsupials the Diprotodontia are decidedly lower than the Polyprotodontia chiefly on account of the high degree of development of the eyes of the Didelphidæ and Dasyuridæ. Since we meet with genera of the lowest type along with others of the highest type of retinal vascularisation, and again some without and others with the additional relic or specialisation of a Tapetum, it follows that the details of the vascularisation and of the Tapetum have been developed independently in the various main branches of the Mammalia.

In fine, the whole Fundus oculi affords a striking illustration of the working of progressive evolution, an example all the more valuable, since it illustrates the direct modifying effect of external factors upon a highly specialised organ—in the present case the continued influence of light upon the eye.

"The Influence of Increased Atmospheric Pressure on the Circulation of the Blood. (Preliminary Note.)" By LEONARD HILL, M.B. Communicated by Dr. MOTT, F.R.S. Received March 22,—Read May 17, 1900.

Paul Bert* recorded the arterial pressure in two dogs which he introduced, together with the kymograph, into a chamber, and submitted to a + pressure of 53 cm. Hg. The atmospheric pressure was raised to this height in the course of three-quarters of an hour. The mean arterial pressure rose in one dog 16 mm. Hg., in the other 46 mm. Hg.; the pulse frequency fell in the first from 216 to 200, and the respiration from 41 to 29 per minute. The respiratory oscillations of blood-pressure became increased. Bert ascribes the results

* 'Pression Barométrique,' Paris, 1878, p. 838.