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Observations on the Ophthalmoseopic Appearances of the
Eyes of the Order Primates. By G. LINDSAY JOHNSON,
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(Plates II.-VI.)

Adopting the classification given in Sir W. Flower's classical work on the Mammals, I include in the order Primates: Man, Monkeys, Marmosets, and the suborder Lemuroidea. I have found that a comparison of the ophthalmoscopic appearances of the fundus oculi of the various members of this most important order enables us to arrive at certain definite conclusions, which I believe to be of interest to zoologists.

All the animals, including Man, were examined by me in a darkened room with the same amount and the same kind of illumination, and also with the same degree of magnification.

Only animals in perfect health were selected, and, so far as possible, several animals of the same species were examined in order to preclude the possibility of abnormal fundi. Moreover, in all cases both eyes were examined and ascertained to be similar in all respects before a drawing was made. As a further precaution, each detail of the drawing as it was being painted by my artist, Mr. Head, was confirmed by myself in the living eye, and altered (if necessary) until it represented the original in all respects.

As regards keeping the animals quiet, I found considerable difficulty at first, but as my experience increased the difficulties vanished. In no case was any drug or anæsthetic used, but in the case of a few of the wilder Monkeys a net was thrown over them. In all the other cases the animal was held gently by the keeper in his lap. The animal rarely struggled, and usually became

quite reconciled and contented. I found that extreme gentleness, together with petting the animals, overcame their fears, so that no force was needed; nor, indeed, would I have suffered it to be employed under any circumstances. A few of the Monkeys and Lemurs were observed in the Belle Vue Gardens, Manchester, some in Mr. Jamrach's and Mr. Hamlin's collections, and in various travelling menageries, since they were not to be found in the Society's Gardens. In all examples of 38 distinct species of Monkeys and Lemurs were examined, including forms of every genus which could be found in the Society's and other menageries.

All the observations were made by what is termed the direct method with the ophthalmoscope, the instrument being used within an inch of the animal's eye without an interposed magnifying lens, thus presenting to the observer an upright picture of 10 diameters' magnification. This method is preferable to the indirect in which a lens is used, as the image then obtained is inverted, and only of 3 to 4 diameters' magnification, which is also less distinct than the larger upright image. In most cases cocaine and homatropine were dropped into the eye to obtain a larger pupil and consequently more light.

The fundus of the fair European human eye appears, when viewed with the ophthalmoscope, of an orange-red colour, pretty uniformly distributed over the entire fundus; only when we get towards the confines of the visible field does the background become more intermixed with streaks of pigment. A little to the inner or nasal side of the centre of the field we observe the disc of the optic nerve, of a pinkish colour and slightly oval shape, with the major axis vertical. From the centre of this disc the scarlet arteries and lake-red veins of the retina proceed, passing in every direction, dividing into numerous branches. In the dark-coloured races the appearances are similar, save that the orange-red background is replaced by a reddish brown, owing to the great increase of dark pigment (see Plate II.).

Only one part of the fundus is wholly free from vessels, and that is at and around the macula lutea or yellow spot. The macula is a small pit or depression situated in the axis of vision, about $2\frac{1}{2}$ disc breadths from the disc to the outer or temporal side. It appears different in colour in the eyes of different individuals. Generally it appears as a dark-reddish circular patch, with a bright spot in the centre, and in some cases surrounded by a circular glistening halo or ring, well defined on its internal margin, but fading away into the general background towards its external border (marked *d*, Plate II.). Occasionally a second or even a third ring may be seen inside this large one, all having the fovea as a common centre.

The macula being in ourselves the seat of most acute vision, considerable attention has been given to this highly differentiated area, which has an actual diameter of about 1.5 mm. It is only in this region, the size of a pin's head, that we see perfectly, our acuteness of vision decreasing rapidly outside this region. In

most books which treat on the subject we find it stated that among mammals Man and the Anthropoid Apes (the Simiidae) alone possess a macula; but I find, as I will presently explain, that the existence of the macula is not restricted to these only.

In addition to the scarlet and lake-red branches of the retinal vessels which proceed from the disc, a large number of interrupted orange-yellow and red vessels, uniformly coloured and much broader than the artery and the veins, can be observed, anastomosing so as to form a network (see *cc*, Plate V.). These vessels belong to the choroid, a vascular structure underlying the retina. As that portion of the retina which lies in contact with the choroid is pigmented, these choroidal vessels can only be distinctly observed in fair people and in albinos. I am, of course, speaking of the normal eye of the adult, and not taking into consideration defective senile or pathological conditions.

It is not only with regard to the degree of distinctness with which the choroidal vessels can be observed that the ophthalmoscopic appearance differs in fair and dark people. The colour of the fundus likewise varies in proportion to the pigmentation of the individual. In very fair people the colour is a bright vermilion, which gradually tends towards a reddish brown in people with very dark hair and skin, until we find it of a chocolate colour in the negro. Except in colour, the appearance of the fundus oculi does not differ in the various races of Man. I need hardly say that of course the colour of the macula varies with the general colour of the fundus, being always distinguishable as a darker patch than the rest, although occasionally, in very dark Europeans, I have seen it of a decidedly redder hue than the rest of the fundus.

The chocolate-coloured field, with a darker chocolate-coloured circular patch indicative of the macula region bordered by a bright scintillating ring, characteristic of the negro, is likewise what we find when we examine the eye of the Simiidae, but we find the fundus varies greatly in colour once we descend below this group. Even in the Gibbons, the lowest of the Simiidae, we already find a commencement of this departure.

Throughout the Anthropoidae the arrangement of the retinal vessels is the same as in Man, the first indication of variation being found as soon as we reach the Lemuroidae.

The disc is oval, with the long axis vertical, at times more or less circular, or practically the same as in Man. Here again we only find a difference in the Lemuroidae, which all have a circular disc.

The Lemuroidae have no macula, the existence of which ceases with the last of the true Monkeys. In other words, we find a striking resemblance between the appearance of the eye of Man and the entire order Anthropoidae, although in many details we can trace as we descend the scale a tendency towards that lower form which reveals itself to us when we examine the Lemuroidae; and here again we find a gradual departure from the higher type

as we wend our way from the Lemurs through the Galagos down to the Aye-Aye.

The eyes of all the Primates below Man are smaller than our own, but this is not so in proportion to the size of the body. I have found, for instance, that the transverse diameter of the globe of the eye of the half-grown Gorilla which lately died in the Society's Gardens measured 20·7 mm., which is the size of the eye of a child between the age of 9 and 11. Of course the eye of a small Marmoset is very much smaller, being in proportion to the size of the animal.

There are other distinctive differences between Man, the Monkeys, and Marmosets, in other words between the Anthropoidæ on the one hand and the Lemuroidæ on the other.

The pupil of Man and the Anthropoidæ is always circular, whilst we find a vertically oval pupil in all the Lemuroidæ. In addition to this I find from repeated observations that all the Anthropoidæ or true Monkeys are able to accommodate their eyes for near objects by converging both eyes on to a single point, and in so doing the pupil contracts as in Man, though to a less degree. The Lemuroidæ have not this power of convergence; and although I have noticed the power of convergence in all the Monkeys, I find it is only a transition stage—that is to say, they employ it with hesitation and difficulty, much in the same way as an infant uses its legs when learning to walk, since they cannot converge for more than one or two seconds at most. If you hold a small bright-coloured object near the nose of a Monkey, you will observe the eyes converge immediately in a horizontal plane, and the pupils contract slightly, but the next moment the eyes return to parallel vision, though not necessarily in a horizontal plane, being often accompanied by a slight elevation upwards.

We thus find that we must draw a broad distinction between Man and Monkeys as a group and the Lemuroidæ. Man and all the Monkeys and Marmosets without exception possess a macula, a circular pupil, and converge when accommodating for near objects. These characteristics are necessary for binocular vision. The Lemuroidæ have not got binocular vision and therefore we find all these peculiarities absent.

Going more into detail we find that every family has some characteristic peculiarity. Thus the eyes of the Gorilla, Chimpanzee, and the Orang closely resemble that of the negro, except that around the disc the whitish fine streaks are more marked. Were they as strongly marked in Man they would be attributed to a congenital defect known as opaque nerve-fibres, although the defective human eye shows these opaque nerve-fibres wholly opaque, whilst in these Apes they are more or less translucent. These translucent nerve-fibres radiating from the disc become somewhat more marked as we descend the scale. In the Gibbon we find an extreme prominence of the choroidal vessels.

In the next family, the Cercopithecidæ, we notice in some genera an approximation to the Simiidæ, notably in the Black Ape,

the Macaques, and the Baboons, and a retrogression of type in the pronounced semi-opacity of the optic nerve-fibres in the Mangabeys.

In the family Cebidæ we notice at once a striking difference between the almost Simian type of the Cebinæ (which includes the genera *Cebus*, *Lagothrix*, and *Ateles*) from the obviously lower type of eye in the Nyctipithecina (Dourocoulis and Squirrel Monkeys). The extraordinary development and prominence of the choroidal vessels and the peculiar pigmented background so characteristic of the Lemurs distinguish the latter at once. Only in the Howlers do we get an approximation to a *Cercopithecus*. But if we examine a Howler we notice at once how much more like a *Cercopithecus* it looks than any of the other genera above mentioned.

In the *Chrysothrix* we find a most peculiar change at the macula. This is surrounded by a remarkable rainbow-coloured ring (see Plate IV.). Now this rainbow ring is the characteristic of the Hapalidæ, occurring in every one of that family that I have examined, only differing from that seen in the *Chrysothrix* in being a smooth ring instead of a ring made up of extremely short and thick radiating streaks. This ring is the first indication of the gorgeous colours seen in the background of the eyes of the Galagos, the Loris, and the Aye-Aye.

When we then come to the Lemurs we do not find a single animal which possesses even a trace of a macula or ring, and the discs are all round. Instead of being pink they are quite white, as if atrophied, and the fundus is of a peculiar brown or greyish-brown colour stippled at regular intervals with large dots (see Plate V.). The moment we descend below the true Lemurs the entire fundus changes: instead of being brown it assumes an intensely dazzling golden yellow.

The Galagos, Lorises, and Aye-Aye are all nocturnal animals, and that is perhaps one reason why the fundus is of such a brilliant golden-yellow colour.

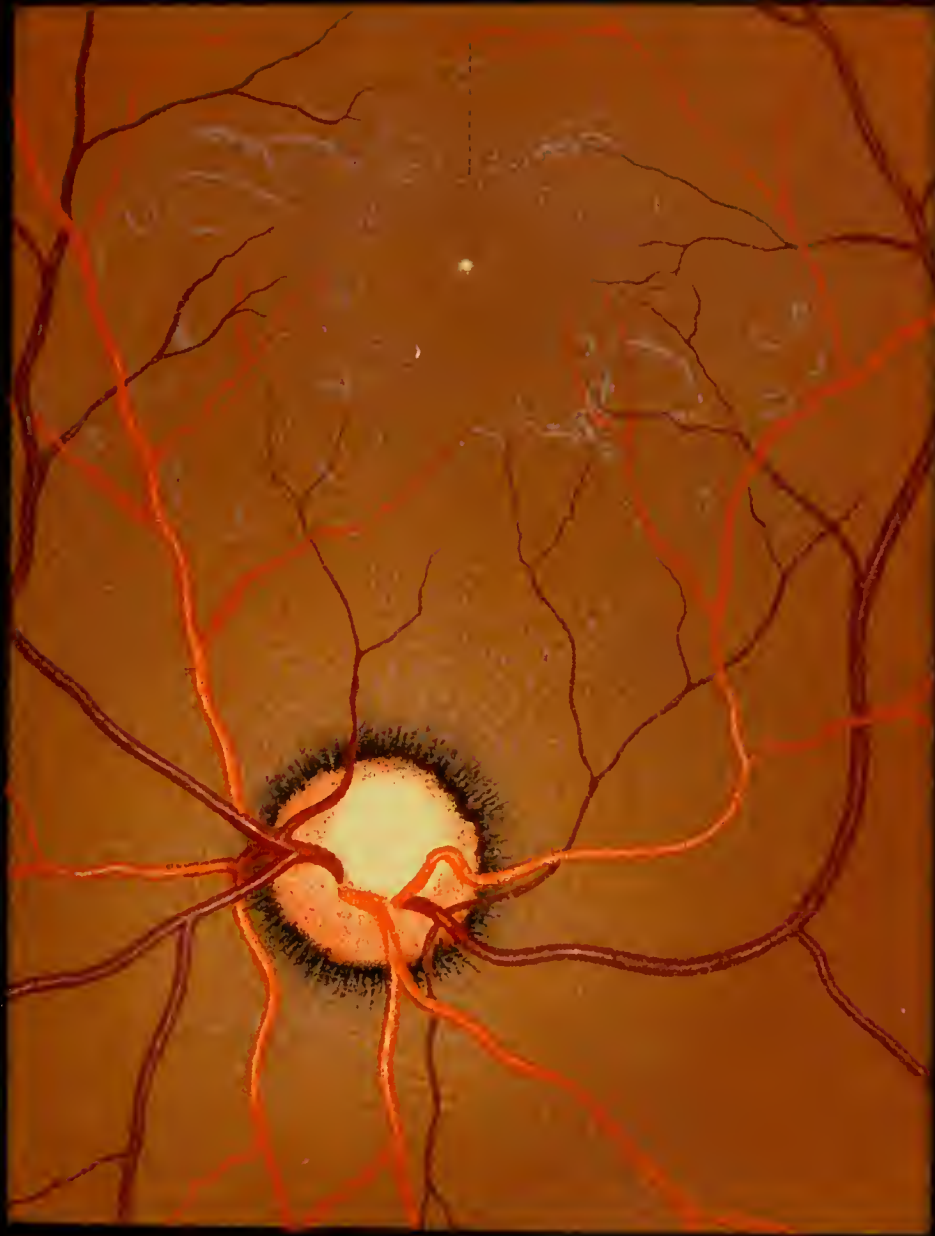
In the Galagos the disc is nearly black; the fundus is a rich golden yellow with a tinge of green and covered everywhere with minute black or brown stellate dots. These stellate dots are peculiar to the Galagos. If we examine the eyes of the Galagos we find they are nearly alike; and when we examine the Lemurs we likewise see a family likeness, but fundamentally different in type from the former. Among the latter, however, there is one exception, its fundus is identical with that of the Galagos and yet it is known as Coquerel's Lemur (see Plate VI.). Now I have examined this animal most carefully, and I am convinced it is a Galago and not a Lemur, notwithstanding the disproportionate size of the tarsus, which, however, is not much larger than those of the Lemurs. The difference of its eye is too striking to be overlooked, and in my opinion quite overweighs the other differences of structure and habitat. For the former differences, especially the shape of the ears and face, are very slight compared with the other members of the family; and as regards the habitat, it is at

least conceivable that it may in some way have been transported from Madagascar to the mainland. In any case I think that, having regard to the fact that the fundus oculi is distinctly that of a Galago, it would be well to consider whether the other points show sufficiently prominent characteristics to warrant the classification of that animal as a Lemur.

In concluding the few observations on the eyes of the Primates which I have laid before you I venture to express the belief that the study of both the interior and the outside of the eyes of animals may be conducive to an increase of our knowledge of zoological classification and comparative physiology, and may possibly throw some light on the habits and pursuits of animals. After all, the eye is the chief connecting-link between the outer world and the consciousness of the animal, and it requires vision to find its way, obtain food, and avoid danger.

EXPLANATION OF THE PLATES.

- PLATE II. Fundus oculi of a native youth from Nubia.
 " III. Fundus oculi of Ourang-Outang.
 " IV. Fundus oculi of *Hapale penicillata*.
 " V. Fundus oculi of *Lemur brunneus*.
 " VI. Fundus oculi of *Lemur coquereli*.



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Life erect image

Hanhart Chromo, Lith

Arthur W Head, F.R.S

FUNDUS OCULI OF A NUBIAN YOUTH



LE. erect image

Hanharb Chromo Lith

Arthur W. Head F.Z.S.

FUNDUS OCULI OF OURANG-OUTANG, (*Simia satyrus*.)



LE erect image

Hanharó Chromo, lith.

FUNDUS OCULI OF A MARMOSET, (*Haemate penicillata*.)

Arthur W Head, F.Z.S.

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RE. A. Brown Lemur,
PE. erect image

Hanhart Chromo, lith

FUNDUS OCULI OF A LEMUR, (*Lemur brunneus*)

Arthur W. Head, F.Z.S.



L. E. erect image

Hanhart Chromo, Lith

Arthur W. Head, F.R.S

FUNDUS OCULI OF *A. LEMUR*, (*Lemur coquereli*.)

