general effect combined with considerable differences of detail, and by the process of "projection" these differences of detail may be exaggerated while the general similarity is obscured.

While accepting Fritz Müller's explanation of the mimicry of protected species by each other, and as also affording the only intelligible reason for there being only two types of colour-pattern in the whole 400 species of the Danaoid *Heliconidæ*, he says that "unfortunately no *direct* experiments have been made on the feeding habits of young South American birds." But in view of the careful experiments of Prof. Lloyd Morgan on a variety of young birds this is hardly necessary, as it is proved that they have in no case any instinctive knowledge of what is edible or distasteful, while they acquire the knowledge by experience with extreme rapidity. Like many other writers on the subject who have recently criticised and rejected the theory of warning colours as indicating inedibility, Mr. Mayer does not distinguish between the *habitual* and the only *occasional* enemies of protected insects. Thus he refers to the experiments of Beddard, showing that toads will eat any insects whatever; but it is quite certain that toads are not very dangerous enemies to either butterflies or their larvæ, nor probably are marmosets which are also general feeders. There is quite sufficient evidence to show that insects with warning colours *are* rejected by most insectivorous birds and lizards, which are certainly the most general and most dangerous devourers of insects both in the larva and winged state, and these facts, taken in conjunction with the experiments of Prof. Lloyd Morgan, afford a firm foundation for the whole theory of warning colours and mimicry.

A. R. W.

THE PRIMATE BRAIN.¹

THE comparative study of the convolutions of the brain surface in man, apes and monkeys, may be said to have been founded by Gratiolet, who mapped out the fissures in the lower monkeys, traced the patterns upwards through the apes to man, and invented a system of names for the convolutions. In recent years this study has received impulse from two distinct causes: on the one hand, the greater opportunity of examining the brains of the higher apes; and, on the other, the attempt to locate in the convolutions definite functions has led to experiments being conducted, by physiologists and psychologists, upon the brains of monkeys. A great variation in the convolutions of species of monkeys and of apes has been thereby shown to exist, and more accurate data have been rendered available for a true morphological comparison with those of man; and although the subject has, to a very great extent, been attacked from a physiological standpoint, yet the morphology of the convolutions has received increased attention during the past few years, notably at the hands of Dr. Cunningham, whose careful and extended work on this subject covers a good deal of the ground opened up in the present memoir, which deserves a place alongside that of the Dublin anatomist.

The publication of Dr. Parker's work, which was communicated verbally, to the Academy of Philadelphia, as long ago as 1890, has been delayed till last year, owing to a variety of circumstances—amongst others, the death of the author in 1892. After an introduction dealing with the scope and aim of the memoir, there follows an interesting historical survey of the observations and opinions of the chief writers on the subject. The author then tabulates the names of the fissures and convolutions applied to the human brain, with their synonyms as employed by each author. This table will be of considerable value to students of the subject, as will be the historical survey.

How are these convolutions and furrows on the surface of the brain brought about? What is the cause of the gyrencephalous condition? This is still a matter of controversy. To this question two chief, but opposing answers have been suggested, each supported by equally competent authorities. The one school looks on these convolutions as due to the effect of pressure of the slowly growing skull on the more rapidly growing brain. The opposite school believe the cause to be innate—that is to say, the convolutions owe their origin to differential growth in certain definite regions of the brain surface itself. Dr. Parker combines these two opposing views: believing that certain "fundamental

fissures" are produced by mechanical causes, whilst others owe their origin to morphological processes of growth in the brain substance; the fissures, of course, representing lines of retarded growth. During early development, it is the brain which modifies the shape and structure of the skull, rather than the reverse; ultimately, as the skull grows more rigid, its influence is shown in the increasing tortuosities of the folds.

The development of the human brain is traced out, so far as is necessary to explain the author's views, and the various stages are compared with the adult brain of monkeys. At the age of three months the foetal human brain consists of three lobes, which he terms the "occipito-frontal," "occipito-temporal," and "occipital." It does not immediately appear evident why the author employs compound names for the two former lobes, unless it be to insist as strongly as possible upon the fact that there is no such thing as "parietal lobe," at any rate as a morphological equivalent of the others. The "island of Reil" is not homologous with a "lobe," but is developed at the bottom of a depressed area, the *fossa sylvii*. Each of the three lobes contains a portion of the lateral ventricle; each will exhibit a similar, and symmetrical series of furrows. He points out here, as elsewhere, that the "occipital" lobe, developed as it is round the posterior cornu of the lateral ventricle, is peculiar to the Primates.

During the third month a certain number of "temporary furrows" make their appearance on the surface of the hemispheres; they radiate from the region of the sylvian fossa, and when viewed from the mesial surface, lines drawn through all but those in the occipital lobe meet at a centre which lies in the cerebral peduncle: and the angle included between any two neighbouring lines is constantly 60°, or thereabouts. This fact he makes use of in considering the causes concerned with the production of these fissures, which he attributes to pressure between brain and skull.

But, as is well known, these temporary fissures disappear, and the brain again becomes smooth for a short time at about the fifth month; and he lays great stress on this smooth brain, with its three lobes, a sylvian fissure, a calcarine fissure, and "mesial arched fissure." The author regards this stage as the fundamental plan of the Primate brain; indeed, this is essentially the marmoset's brain enlarged. Later on, new fissures appear, and he recognises, in addition to the (1) fundamental or primary fissures, just mentioned, the (2) secondary fissures, (3) sulci of Pansch, mere vegetative repetitions of (2); (4) sulculi, which are inconstant, and (5) rami, which are the branches of (2) or (3). The mesial arched fissure gives rise to the callosal and the hippocampal fissures; each of which, with the calcarine, is similarly related to one of the three primary lobes.

The occipital lobe next becomes definitely marked off from the rest by two fissures, a dorsal and a ventral, constituting the "primary occipital arch." The dorsal one is the "parieto-occipital" or "perpendicular fissure" of monkeys. The mesial ends of these are symmetrical with regard to the calcarine. These fissures, again, are regarded as being due to pressure.

This stage represents the characteristic Simian brain (including that of man).

Parker disagrees with the usual view, that the *fissure of Rolando* is a primary fissure; nevertheless, it is certainly characteristic of the primate brain, for it occurs in no other order. He explains the fissure in an ingenious manner, by reference to a lemur's brain, in which there are two longitudinal fissures extending along the fronto-occipital lobe; a part of the upper one is supposed to become vertical. But no ontogenetic evidence is forthcoming for this view, which would lead us back readily to the condition of a carnivore's brain.

It is impossible to give briefly his many interesting suggestions as to the homologues of the frontal and parietal convolutions; but special interest will be taken in his account of the occipital convolutions, for these have always troubled anatomists, who have until recently regarded them as being more or less irregularly arranged, and consequently have neglected them. Parker endeavours to show that they can be reduced to order, especially if the development of the "plis de passage" or "annectant gyri" be taken into account. These rise up, as I have shown in discussing the brain of the chimpanzee "Sally," and as others have also shown, from the bottom of fissures; so that in one brain they may be hidden, in another they come to the surface and divide single fissures into two. Parker says: "The typical fissures represent the lines of least resistance to the differential action of the pressure forces.

¹ "Morphology of the Cerebral Convolution, with special reference to the Order of Primates." By Andrew J. Parker, M.D. *Journ. Acad. Nat. Sci. Philadelphia*, 2nd series, vol. x, 1896, pp. 247 to 362; with fifteen plates and several figures in the text.

... As development proceeds, and the skull begins to assume a more fixed and rigid shape, new conditions and relations of the growth forces take place, as a result of which those portions of the cerebral surface lying in the depths of some of the fissures, originally produced by depression, are placed under new dynamical conditions; instead of being situated as formerly along the lines of resolution of greatest pressure and least resistance, they become centres of relatively greatest growth force as compared with the resolution of pressure forces." Hence they rise up as annectant gyri. To these interesting, and at one time puzzling, features he devotes some pages.

He gives a very brief, and second-hand, account of the convolutions in Carnivora and Ungulata, rightly insisting that it is impossible to homologise these fissures, one by one, with those of Primates' brains; for, even between ungulate and carnivore, it is only possible to compare groups of fissures. This fact is gradually becoming more and more fully recognised; and in mounting a series of brains for the Oxford Museum, I have purposely indicated the fissures in the ungulate, for example, and the Primate brain, by means of entirely different sets of colours. There is a type of convolution for each order, these types being derived, not one from another, but independently for a smooth-brained condition; a view which accords with palæontological evidence. Nevertheless, there is more community between the Ungulata and the Carnivora, in this matter, than between other groups.

Finally, the author discusses the "Mechanics of the formation of cerebral fissures," and brings to bear on the subject (a) the theory of the formation of films in soap-bubbles, propounded by Plateau; and (b) the facts of surface tension as put forward by Maxwell. This part of the paper is illustrated by numerous formulæ and diagrams; but I imagine most anatomists will pass these by. If for surface tension of films we substitute the pressure forces produced by cerebral swellings aggregating round certain centres, then the peripheries, meeting each other within a confined space, produce the lines of fissuration.

The memoir, interesting as it is, would have been rendered more valuable by the addition of a bibliography; references are, indeed, given here and there in footnotes, but they are scarcely worthy of the work.

The figures, again, copied as many of them are from various sources, are variously lettered; there is practically no "explanation" of plates, and some of the figures, which are mere outline drawings without shading, represent the brain in oblique directions, which it is very difficult to follow, as no indication of these directions is given in the list of figures.

W. B. BENHAM.

LECTURE-ROOM DEMONSTRATION OF ORBITS OF BODIES UNDER THE ACTION OF A CENTRAL ATTRACTION.¹

NOT remembering to have seen any attempt to show experimentally in the lecture-room the motion of bodies acted on by a central attractive force varying inversely as the square of the distance in elliptic, parabolic and hyperbolic orbits, I have made a few experiments with a view of determining how well these curves could be imitated by the motion of a small steel ball around a magnetic pole. The results were so good that I feel warranted in making them known, and believe that the experiment may be found useful in making more cheerful that portion of the course usually rather destitute of pyrotechnics.

The apparatus used was very simple, consisting of a circular glass plate about 40 cm. in diameter, with a small hole in the centre, through which projected the somewhat conical pole-piece of a large electro-magnet (Fig. 1). The surface of the plate was smoked, and it was made level as nearly as possible, the axis of the magnet being of course vertical.

A small, highly-polished ball of steel about 5 mm. in diameter (from a bicycle bearing), when projected across the plate, traced its path in the soot, and left a permanent record of its motion.

Under these conditions gravity exerts no direct influence on the motion, and we have only the initial velocity and the central attractive force to deal with, together with the loss of velocity due to friction. There are several other circumstances which make the conditions unlike those existing in the case of two

gravitating bodies in space, and, taking everything into consideration, it is quite surprising what good results were obtained.

The ball was blown out of a short piece of glass tubing held in the plane of the plate with varying initial velocities, and curved orbits obtained, which were, at least, good imitations of the ellipse parabola and hyperbola.

Fig. 2 is a photograph of a plate showing all three forms, the white spot in the centre being the hole occupied by the magnet pole; the arrows indicate the direction of the motion.

No. 1 was produced with low initial velocity, and is a very fair representation of an ellipse, with the attractive force in

FIG. 1.

one focus. The loss of velocity due to friction caused the ball to "fall into the sun" after completing one revolution, a one year's existence of the system.

On another trial an ellipse (*spiral*, strictly speaking) was obtained that was almost re-entering, the miss being not more than a couple of millimetres, while in the one figured it was nearly a centimetre.

The right-hand branch of No. 2 resembles a parabola, and was produced by a somewhat higher initial velocity. It will be noticed that the ball moved to its perihelion position in a path rather like a hyperbola, and on rounding the pole, its velocity having been diminished somewhat, moved off in a

FIG. 2.

parabola. It would be more exact, probably, if we called this curve an ellipse of great eccentricity, since the conditions governing the formation of a parabolic orbit would be difficult even to approximate.

No. 3 and 4 are hyperbolæ, produced by still higher initial velocities.

None of the orbits shown in the figure are as perfect as some that have been obtained by accident on other plates. It is very difficult to make a plate showing all three forms with only four or five trials, as the velocity has to be nicely adjusted; consequently, the curves shown in the figure must not be taken as samples of the best that can be produced by a large number of trials.

¹ Reprinted from the *Physical Review*, with supplementary note by the author.