THE EYES OF ANIMALS.

BY PERCY COLLINS.

The late Sir William H. Flower, sometime director of the British Museum (Natural History), once expressed the opinion that it was impossible to overestimate the benefit that would eventually accrue to science from a thorough and systematized knowledge of eye-anatomy among the lower orders of animals. Such a knowledge, he added, would revolutionize the classification of the animal kingdom, and reinstate it upon a basis of unassailable fact. Year by year, this conviction has been gaining strength in the minds of certain advanced exponents of zoological science, on the continent of Europe and (more especially) in America. Moreover, in this connection it is pleasing to note that art and science have formed an alliance —the Old World supplying a skilled delineator in the person of Mr. Arthur W. Head, F. Z. S., of London, the New World the keen scientific element. In the United States, Mr. Head's studies and records have already aroused the greatest enthusiasm; and a movement, organized and headed by Dr. Casey A. Wood, president of the American Academy of Ophthalmology, is on foot with the object of securing capital which shall enable Mr. Head to make drawings of the eyes of all known birds—such drawings to be classified and published at the earliest possible date.

The object of the present article is to place before the readers of the SCIENTIFIC AMERICAN a brief account, couched in popular terms, of Mr. Head's labors, and of his achievements to the time of writing. For, be it noted, Mr. Head is no upstart naturalist with a novel theory formulated to tickle the fancy of the moment. He commenced to study and delineate the eyes of mammals, birds, reptiles, and fishes as long ago as 1892; and he has thus been engaged in the work, without intermission, for a period of nearly seventeen years. He has already made finished drawings, by the erect method, of some 250 mammals and reptiles, and these include at least one example of the normal eye of every order, *Cetacea* (i. e., the whale kind) alone excepted. In addition to this, Mr. Head has actually completed drawings of a large number of birds' eyes, these forming the foundation of the vast collection which, it is hoped, will ultimately be completed and supply the key to bird-classification on truly scientific lines. Apart from his expenditure of unremitting labor upon his self-imposed task, Mr. Head's drawings have cost him nearly $15,000 in cash to obtain. But Mr. Head is now working as an artist in collaboration with Dr. Casey A. Wood, the well-known eye-scientist of Chicago. Eventually, his completed series of drawings are to be published in colors, in the form of an atlas; and although Mr. Head resides and works in London, the United States will present the results of his labors to the world of science.

Most persons who lack ophthalmic knowledge find it a difficult matter to understand the exact part of the eye which is represented in a drawing by Mr. Head. It should be explained, therefore, that the paintings represent what is known as the "fundus oculi"—not the exposed part of the eye, visible under normal circumstances, but the interior or back of the eye-ground. In other words, if we regard the eyeball as a hollow sphere, the center of the inner wall most distant from the observer is the part which the pictures present. To obtain a view of the fundus oculi a special optical instrument, known as the ophthalmoscope, is necessary; and when the reader thinks of the constant movement of an animal's eye, he will be able to form some idea of the time and patience evoked in Mr. Head's work. Moreover, observations must be made under special conditions, a strong shaft of light being directed into the eye of the subject, which is confined in an otherwise dark chamber. Mr. Head tells us that he has spent several weeks in accustoming a caged animal to his presence, and to the brilliant shaft of light, before he could take the first peep through his ophthalmoscope.

We may now briefly describe the figures (photographs from Mr. Head's original drawings) which illustrate this article, mentioning the special points of interest in each.

Fig. 1.—The fundus oculi of the chimpanzee is chocolate brown in color, very similar to that of a negro. The disk is red, showing a strong gray reflex round the macula lutea, i. e., the wavy patch to the right of the picture, which is the area of vision, where mirages are sharply defined. The veins are indicated by the thicker streaks converging upon the disk, while the thinner streaks represent the arteries. It should be noted that the veins are highly reticulated and ramified—a condition in accord with Mr. Head's theory that the presence of numerous blood-vessels in the eye is concomitant with a high type of life. After a hasty glance at this picture, many medical men would probably conclude that it was intended to represent a human eye under conditions of disease. Indeed, the eye of the chimpanzee comes nearest to the eye of man; and, as Mr. Head has pointed out, those unscientific persons who may wonder what sort of use his labors can serve will find a striking answer to their inquiry if they compare this painting of an ape's eye with the representation of a negro's eye; or, better still, if they ask a scientific friend to let them glance through an ophthalmoscope at the fundus of a living human eye. Those who admit the Darwinian theory of evolution will find the extraordinary similarity which exists between the eye-grounds of ape and man of profound interest and significance.

Fig. 2.—In this picture Mr. Head has faithfully portrayed the eye-ground of the African elephant. It is pale straw-yellow color, covered with irregular brownish rod-like markings, the whole producing a pretty tessellated effect. The disk is pale gray. Few blood vessels are evident—the elephant possessing, in the opinion of Mr. Head, the comparatively simple eye of a prehistoric survival. Moreover, great atrophy of the optic nerve is present, a condition which, while normal in the elephant, would mean well-nigh total blindness in a man.

Fig. 3.—In the African lion we have a far more highly developed eye, with many blood vessels. The eye-ground is emerald green in color, mottled all over with bright golden-yellow blotches with tiny brown dots in their centers. The optic disk is pale red, and forms a cup, into which the retinal vessels dip on all sides.

Fig. 4.—This shows us the eye-ground of the Mississippi alligator. It is bright yellow, verging to orange toward the outer region, where are scattered a number of black, wavy markings such as are present in the diseased condition of the human eye described as retinitis pigmentosa. The whole eye-ground is stippled over with irregular patches of gray, while the disk is white, with a mass of black pigment in the center and round its edge. A number of opaque nerve fibers radiate from all sides.

Fig. 5.—This illustrates the eye of a reptile, viz., the tigrine frog. The fundus oculi is warm gray in

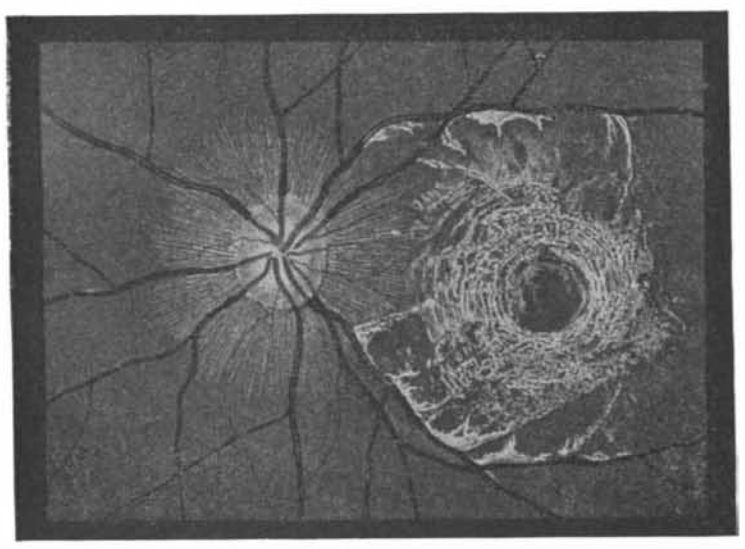

FIG. 1.—The fundus oculi of chimpanzee, very similar to that of the negro. The wavy patch to right is the area of vision.

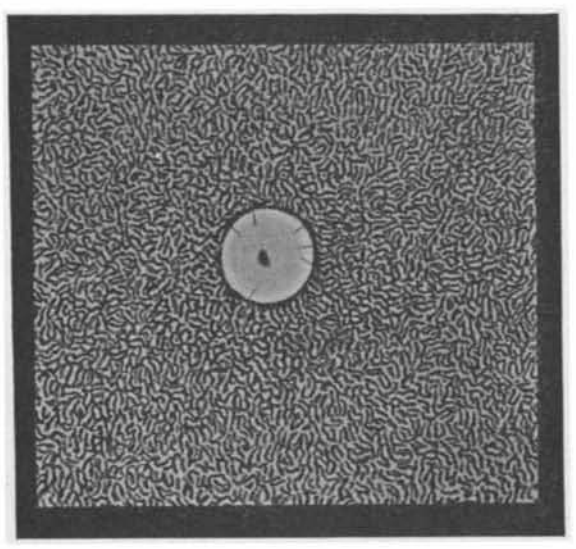

FIG. 2.—The eye-ground of the African elephant. The comparatively simple eye of prehistoric survival.

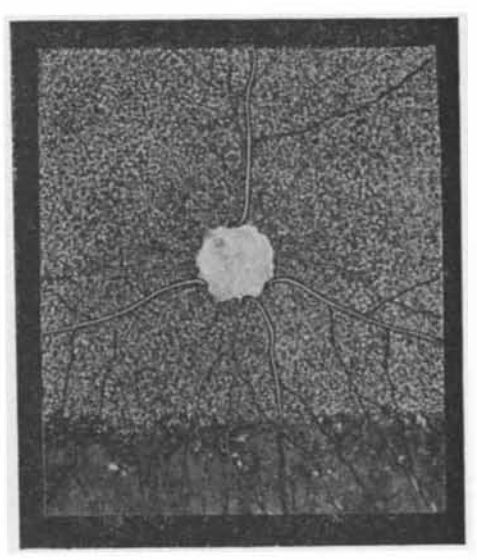

FIG. 3.—Showing the more highly developed eye of the African lion, with many blood vessels.

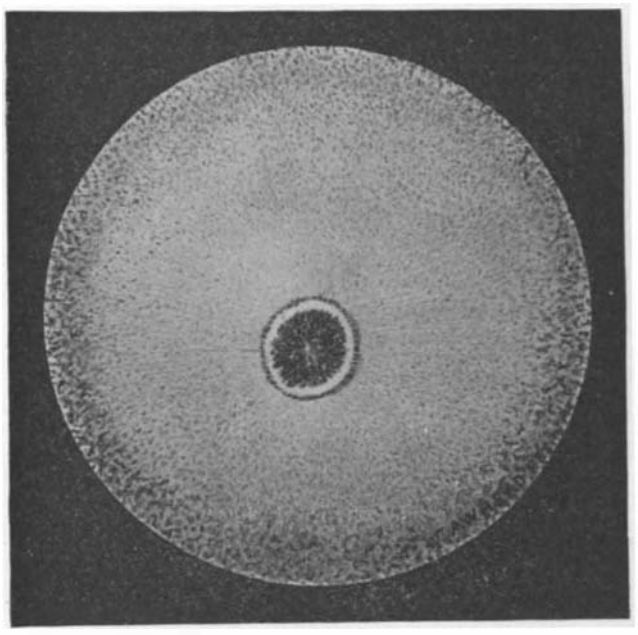

FIG. 4.—Right eye of the Mississippi alligator. Direct image. Opaque nerve fibers radiate from all sides.

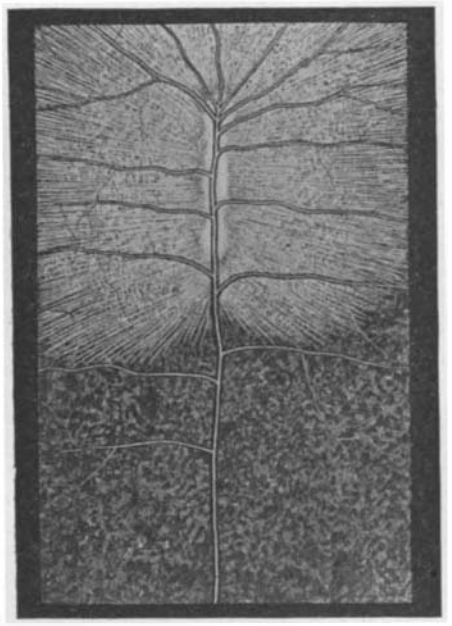

FIG. 5.—The eye of the tigrine frog. Ramifying blood vessels are evident.

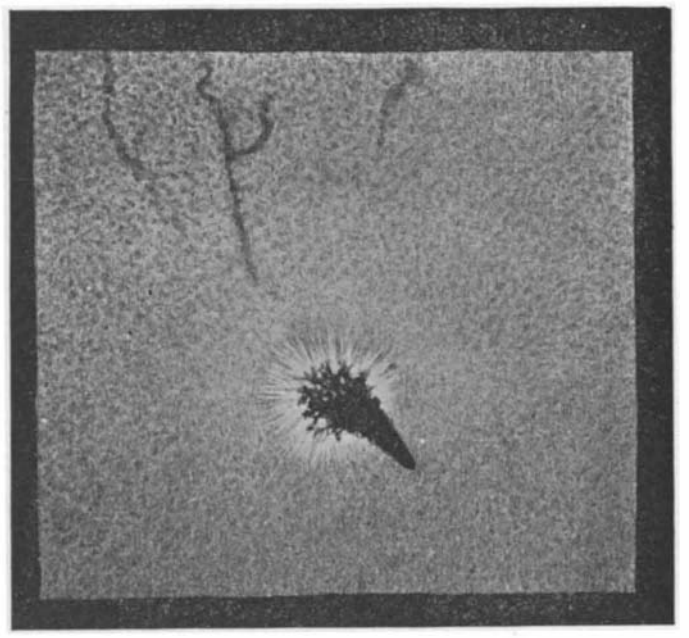

FIG. 6.—The eye-ground of the strange bird kiwi. White disk covered with rods of the pecten, a fold not developed in mammals.

color, blotched all over with bright orange-red patches. The oblong disk is white, surrounded on both its long sides with a mass of coarse, opaque nerve fibers. Ramifying blood vessels are evident.

Fig. 6.—In this picture we have the eye-ground of that strange Australian bird known as Mantell's apteryx, or the kiwi. The fundus oculi is brick red in color, stippled all over with a duller red. Toward the upper portion of the area several bright red choroidal vessels are evident. The white disk is covered with the rods of the pecten—a peculiar fold projecting inward from the choroid through the retina. The pecten is a structure which is not developed in mammals. It carries the nutrient vessels of the retina, and may be alternately filled with and emptied of blood at short notice. In a word, it is a special gland which nourishes the eye with blood—blood being as necessary to the eye for sight as it is to the brain for thinking.

Now although the pecten had been identified in the eyes of all other birds, it was supposed to be absent from the eye of the kiwi, until discovered by Mr. Head in the year 1900. The structure is very dark brown in color, cone-shaped, with coarse nerve fibers all round it. It comes nearly up to the lens; and as it originates low down in the eye it is apt to be mistaken for part of the iris, which it resembles exactly in color. This peculiarity, as we have said, led to the actual statement that the kiwi was the only bird without a pecten in its eye, until the error was corrected by Mr. Head.

In describing the above-mentioned pictures, it has already been shown that the normal condition of the fundus oculi in certain animals resembles a quality which, in the human eye, would indicate the presence of disease. Medical men will at once recognize this fact when looking at Figs. 1, 2 and 3, for example. Mr. Head's pictures should therefore prove to be of considerable assistance to oculists in enabling them to form correct diagnoses in several diseases of the human eye; they should also become of great importance to professors and students as a means of readily imparting and emphasizing instruction.

The whole subject of the eye and the power of visicn is fraught with fascinating interest. This statement applies especially to birds. In a preliminary paper on his studies, Dr. Wood tells, albeit in scientific language, an entrancing story of the miracle of a bird's eye, and whets the appetite of the reader for the revelations which will be made subsequently in the *magnum opus* for which Mr. Head's series of pictures is being prepared. Dr. Wood insists that bird vision is the very highest expression of eyesight. Beginning with the eyelids, he dilates upon the fact that in addition to the true upper and lower lids, birds possess a third eyelid, such as is found in reptiles, but only as a vestige in mankind. With this third eyelid a bird protects its eye when fighting or seeking food—swiftly drawing down the curtain, as it were. Simultaneously with the sweeping of the third eyelid across the eyeball, a special gland comes into play, shedding a copious supply of tears, which disinfect and cleanse the corneal surface, of foreign bodies.

The retina and the optic nerve are very highly developed in the bird's eye, and closely resemble man's. But some birds possess a double macula, or visual area, in the eye, so that they are able to see before and behind at the same time. This double macula, which furnishes stereoscopic vision, and all the advantages of binocular sight, doubtless explains the wonderful range and accuracy of the monocular eyesight of eagles, hawks, and vultures. Another notable feature of the bird's eye is the big muscle which encircles the globe, enabling its shape to be changed in accordance with the distance of objects which are being regarded. In a word, this muscle enables the eye to be converted instantly from a telescope into a microscope. Thus is it that a bird can see a tiny object at a distance of a mile, and can still pick up from the ground seeds so minute that the human eye could only distinguish them from dust with the aid of a magnifying lens.

The brightness of a bird's eye must have often attracted the attention of the reader. This characteristic is accounted for by the fact that practically every bird has a cornea (or horny, transparent membrane through which the light passes) much more conical than man's. Besides accounting for the brightness of the eye, the conical cornea explains in large measure the wonderful power and range of the vision. All these and many other points of entrancing interest relating to birds' eyes and birds' vision are discussed by Dr. Wood in his preliminary paper.

In conclusion, a word must be added as to the adventurous side of Mr. Head's experiences as a delineator of animal's eyes. To examine at close quarters, and for lengthy periods, the eye of a lion or an alligator calls for courage of no common order on the part of the student. These with elephants, hyenas, bears, and snakes are a few of the beasts whose eyes have been studied and portrayed by this dauntless artist. A lion being held only by a chain, Mr. Head tells how his cheeks were wet, and his mustache dripping, with the moisture of the animal's breath. In spite of the lion's resentment, Mr. Head calmly continued his investigations and drawing until suddenly the great beast broke away with a roar and romped round the building, greatly to the discomfort of the artist and the two keepers within, and to the alarm of the crowd without. The darkness of the shed was in favor of its human occupants. The lion was at length cornered; and Mr. Head escaped with nothing more serious than a long scratch upon the back of his hand.

Mr. Head ran a grave risk in order to secure his drawing of the eye-ground of the Mississippi alligator in the London Zoological Gardens. Although the reptile had been in captivity for a considerable period, it remained quite intractable, and was in every respect a most undesirable subject for close study. However, the tank in which it lay was drained, a rope was passed around its huge jaws to prevent it from snapping at the investigator, and the creature was held in position by a number of keepers. Mr. Head then spread out his materials, lay down on a plank beside his gigantic subject, and so commenced his labors—alternately peering through the ophthalmoscope into the depth of the alligator's eye and transferring to paper what his investigations revealed.

Some of Mr. Head's drawings of animals' eyes were exhibited in the science section of the Franco-British Exhibition. The artist was awarded both a gold and a silver medal. Mr. Arthur W. Head has would-be correspondents in many parts of the world, and he desires it to be known that his address is 26, Dornton Road, Balham, London, England.

Aluminium Coins.

In 1907, the French government proposed to replace the bronze pieces of 5 and 10 centimes with coins of pure nickel, but the project was abandoned because of the expense which it involved. This objection does not apply to the present proposal to substitute aluminium for bronze.

Aluminium is a bluish white metal, which is very malleable when pure. In hardness and tenacity it is comparable with silver. Experiments in abrasion conducted at the French mint have proved that aluminium coins will be less rapidly worn by use than coins of gold, silver, or even bronze. Aluminium has a metallic ring and is unaffected by exposure to the air at any ordinary temperature. Its extreme lightness is another advantage. It is only 2.56 times heavier than water and is four times lighter than silver. Hence aluminium coins could be carried in considerable quantities without inconvenience and they would be easily distinguished from silver coins by their lightness.

The total nominal value of the bronze 5 and 10 centime pieces in circulation is estimated to be about 56 million francs (about $10,800,000). According to Cosmos, it is proposed to replace some 50 million francs' worth of these coins with aluminium coins of the same denominations, to the nominal value of 63 million francs, this expansion being made to meet the normal increase of demand during the ten years allowed to accomplish the substitution. The aluminium coins are to have the same diameters as the bronze coins, about 1 inch and 1¼ inch, but they will weigh only 2 and 3 grammes (about 31 and 46 grains), while the bronze pieces weigh 5 and 10 grammes (77 and 154 grains). About 2,000 tons of aluminium, worth 44 cents a pound in blanks ready for stamping, will be required. This represents an outlay of nearly 11 million francs, which the cost of minting will increase to 12 million francs, but this will be more than covered by the profit derived by the government from the expansion of the currency, without counting the revenue derived from the sale of the 5,000 tons of bronze obtained by melting the old coins.

Wine Making in the Province of Shantung, China.

Near Tsingtau, in the Province of Shantung, China, chiefly on the southern slopes of the Laushan Mountains, large quantities of grapes are grown, a variety much resembling the Tokay grape of California being the commonest. A kind of sweet water grape and one named "Markobrunner" are also grown, but blue and black grapes are unknown in the region. The grapes are sent to Shanghai and other places for table use, but no attempt to turn them into wine is made.

In the Chefoo district of northeastern Shantung, the hills surrounding the city of Chefoo have been terraced and a large winery has been in operation for several years. It is said that white and red wines, as well as champagnes, have been made, but none has yet been offered for sale. As the making of wine bas been going on for ten years, there is a large quantity on hand, and it is said that the wine is to be put on the market this year. The wine is to be sold in China only, and, considering the amount of money that has been expended, the price will probably be pretty high. The hill-land near Chefoo was bought by a rich Chinaman and grapes from the principal wine-producing countries of Europe were planted under the supervision of a European expert, who still has charge of the vineyards and winery. More land is being bought and planted, but, other Chinamen having embarked in the business, the price of suitable land has gone up considerably. It is reported that some of the vines have been attacked by phylloxera, but most of them seem immune to the pest. The winery is in the environs of Chefoo and the wine is stored in large casks, made in sections in Austria and put together in Chefoo. Each barrel is marked with the kind of wine contained in it and the year of production. The cellars in which the wine is stored are below the level of the sea and at first were flooded, frequently. Now they are lined with concrete. Two years were expended in their construction.

The Current Supplement.

The general principles involved in the design of a vessel are excellently set forth by the famous shipbuilder Leslie Denny in the current Supplement, No. 1737. The recent flights of the Zeppelin airship are discussed. The best-known type of friction brake for imposing an artificial load on engines in order to measure their horse-power is the widely-used and much-abused Prony brake. G. Everett Quick writes instructively on the subject of using the Prony brake in practical testing. Underground temperature and radium is the subject of a paper by the distinguished geologist Prof. John Joly. This year, as the subject of his course of lectures at the Royal Institution, Prof. Sir Joseph J. Thomson selected the properties of matter. His first lecture is summarized in the current Supplement. How narrow-gage rolling stock may be handled on broad-gage railroads is told by the English correspondent of the Scientfic American. Caligula's galleys in Lake Nemi is the subject of a scholarly article in which the secret of the waters of Nemi is explained. Prof. Jacob Reighard begins an exhaustive treatise on the photographing of aquatic animals in their natural environment.

Testing Gasoline for Automobile Engines.

BY RANDOLPH BOLLING.

Every consumer of gasoline for automobile engine use should know how to test gasoline. As everyone knows, gasoline is a petroleum distillate; it is among the numerous oils that come over when crude petroleum is subjected to distillation. In the trade gasoline is known as 64-degree, 72-degree, and 86-degree. This standard is based on the Baumé hydrometer scale, which in turn is based on the specific gravity of water, which is 1.000 at 60 deg. F. Baumé for convenience sake made salt solutions of 10 per cent, 20 per cent, and so on, and got out an empirical scale on this basis. The only practical way, therefore, to see if gasoline is up to the test you desire to use, is to take its specific gravity. This can be done in three ways—first, by the pycnometer or so-called specific-gravity bottle; second, by the hydrometer, which is standardized on the stem of the tube to read degrees Baumé; or, third, by the Westphal specific-gravity balance. Of these three methods the Westphal balance is by far the most accurate and convenient. With the pycnometer a high-grade analytical balance is required and some knowledge of the metric system and manipulation. With the hydrometer you cannot be sure that the graduations given by the manufacturers are correct. With the Westphal balance all these troubles vanish. You have a neat physical instrument, held in a small wood box and the most accurate system of measuring specific gravity known to science; besides, the instrument is sold at an exceedingly low price by chemical and physical supply houses. If the reader has on file the Scientific American Supplement of March 21st, 1891, he will find an exceedingly good cut of this apparatus in use with special cooling or heating device, that is ordinarily not required, as all that is necessary is to chill the gasoline to 60 deg. F. and take the reading.. On using the Westphal balance, the instrument is adjusted so that the needle points match. Then the glass cylinder is filled with gasoline and the riders suspended on the arm until the needle points again match. The specific gravity can then be read off the arm directly. In order to convert specific gravity into degrees Baumé, at 60 deg. F.:

Specific Gravity.	Deg. Baumé.
0.7777	50
0.7734	51
0.7692	52
0.7650	53
0.7608	54
0.7567	55
0.7526	56
0.7486	57
0.7446	58
0.7407	59
0.7368	60
0.7000	70

This test of gasoline by taking the specific gravity is the only one that can be depended on.