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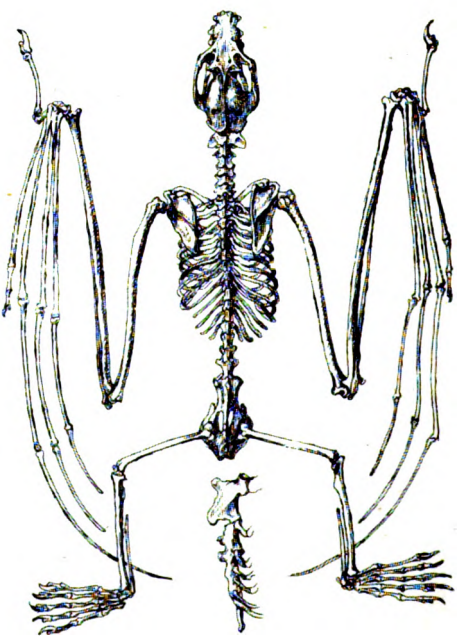

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1. Flying Fox, _ Pteropus Whitmeei.
2. Skeleton of Flying Fox._3. Side view of Sternum.

WHAT ARE BATS?

By St. GEORGE MIVART, Ph.D., F.R.S.

[PLATE CXXXVI.]

THE group of animals called "Bats" is one full of interest to those specially occupied with the study of animal structure—the anatomist, the physiologist, and the philosophical zoologist. At the same time it must be confessed that bats are far from exciting that general interest which in fact they merit. This disregard, however, is very natural. The small size of the bats inhabiting this and other parts of the temperate regions of the globe conspires with their nocturnal habits to remove them from general observation, while the great similarity one to another of their different species is an obstacle to their popularity even amongst zoologists—since it makes their discrimination and classification a matter of difficulty.

Yet bats are, as I hope we shall see, really *very* interesting animals. The bat exhibits to us the body of a beast, specially modified to live the life of a bird, and at the same time serves to give us a fair conception of certain ancient reptilian forms, the remains of which are found deeply buried in deposits made untold ages ago—in the secondary rocks.

But what is a bat? Probably not one of my readers would be likely, if called upon to answer, to fall into the old error of considering it a kind of bird!

All who have ever examined a bat closely, and observed its fur, ears, and teeth, must, I think, have recognised it as a kind of beast. Its real affinities, however, serve excellently well to demonstrate how little mere external aspect can be trusted as a guide to fundamental relationship. The *bat* is essentially an animal of the air—all its structure is modified for flight, and it rarely *descends* to the surface of the ground. The *mole*, on the contrary, is essentially an animal of the earth—all its structure is modified for burrowing, and it rarely *ascends* to the surface of the ground. The contrast could hardly be more complete, and yet the bat and the mole are cousins—the mole, the hedge-

hog, and the shrew mouse belonging to a group of beasts with which the bats show no inconsiderable affinity.

I have spoken of the opinion that the bat is a kind of bird. This view seems to have been entertained by the Jews, and the "bird of darkness" is placed in Deut. xiv., v. 18 amongst the unclean ones forbidden as food:—

"And the stork and the heron after her kind, and the lapwing and the bat."

Aristotle, though he placed the bats amongst flying animals, and therefore amongst birds, distinctly recognised the differences in their organisation, and the same thing may be affirmed of Pliny. But in spite of this, and although Albertus Magnus, in the Middle Ages, was fully acquainted with the true nature of bats, as beasts, as well as with their winter torpidity, we find later on a retrogression of opinion.

Thus Belon, in 1557, in his *Histoire de la Nature des Oyseaux*, includes bats with his birds. At the same time, he was not unacquainted with the mode of their reproduction, as the following verse proves:—

La souris chauve est un oiseau de nuict
Qui point no pond; ains ses petits enfante,
Lesquels du laict de ses tetins sustante,
En petit corps grande vertu reluit.

Yet later—by nearly a century—in 1645, Aldrovandus decided that bats were rather birds than beasts, and this in spite of his careful study of them, as proved by his beginning to distinguish their different kinds one from another.

Some twenty-five years later, Ray gave them their true position amongst quadrupeds—a position which they have ever since retained.

The Teutonic mind seems early to have appreciated the true nature of bats, as we may judge from the German name, *Fledermaus*, and the old English term, *flittermouse*.

Let us look a little closely at our subject of to-day—the bat.

In the first place, there is a little rounded body, covered with soft fur, which is indeed, what Shakspeare calls it, "wool," when giving the ingredients of the cauldron of Macbeth's witches.

There is a small head, little eyes, large ears, a tail, and two pairs of limbs of very unequal size. The hind pair (the legs) are of moderate length and singularly disposed, so that the knees are turned almost backwards, like our elbows.

Each leg terminates in a foot, furnished with five toes, each with a long, curved claw, all of about the same length. These toes are not webbed, like those of a duck, but are free.

The other pair of limbs (the arms and hands) are of exceeding length. Both the arm and forearm are long—especially the latter—but it is the fingers which are so wonderfully drawn out, and they *are* webbed, like the toes of a water-fowl. Moreover, the web not only connects these long fingers together, but also connects them with the sides of the body and with the legs (as far as the ankle); and does not stop even here, but continues on to the tail, thus connecting it with the two legs.

This large web or membranous expansion has two names. The part belonging to the hand and joining the sides of the body (which is supported by the fingers as an umbrella by its rods) is termed the *alar membrane*. The part connecting the legs with the tail is called the *interfemoral membrane*.

Looking more closely, however, we find that though the four fingers of each hand are thus bound together, the thumb is free, standing out at a wide angle, and furnished with a very long and strong, hooked claw. Of the four fingers, it is only the first which is clawed.

The uses made by the bat of its singularly-formed limbs are, of course, in exact correspondence with their structure. The fore-limbs are true organs of flight; the hind-limbs and tail have a rudder-like action. Besides flight (their predominant mode of motion), bats can crawl upon the surface of the earth with an awkward, shuffling gait. When so crawling, the wings are closed (the long fingers then lying side by side) and the animal rests on its wrists and hind-feet, the body being dragged forward by the help of the strong, hooked thumb nails, which also help it to climb with ease up any rough surface, even though perpendicular.

When at rest, bats usually hang suspended, head downwards, by the claws of their feet, though occasionally they turn round and hang from the claws of their thumbs.

Most nocturnal beasts have large eyes, but most bats have very small ones.

This is perhaps due to the fact that bats in their flight are guided by an extraordinarily delicate sense of touch—so delicate as to seem almost like a sixth sense.

HEAD OF LARGE-EARED BAT.
t, Tragus.

The external ear of most bats appears at first to be double—a very small one seeming to stand up inside the larger one. This appearance, however, is due merely to the very large development of a little piece which in ourselves projects backwards as a small rounded process guarding externally the opening of our ear, and called the *tragus*.

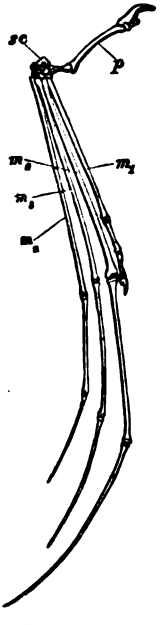
The food of our English bats consists of insects, and their teeth bristle with sharp points, well suited to pierce the chitinous cases by which the bodies of insects are protected.

The stomach (like that of most beasts which live upon a purely animal diet) is a simple, short and rounded bag.

The female is provided with a pair of milk glands, situated on the breast—as in the apes and in man.

The skeleton of the bat, when compared with those of some other animals, affords an excellent example of how fundamental uniformity of structure may underlie forms which are strikingly different—in accordance with diverging habits of life.

I have already called attention to the divergent aspects of the aerial bat and the subterranean mole. Yet the bones of the flying organ of the bat closely resemble that of the burrowing organ of the mole, save as regards the relative shapes and dimensions of the component bones. But while in the bat these bones are drawn out into excessive length and tenuity, in the mole they exhibit the maximum of concentration and robustness. Now both these conditions are but diverging manifestations of the human structure, and the same indeed may be said of such extreme modifications as the fore-leg of the horse or the paddle of the whale.



sc, wrist-bones; *p*, bones of thumb; $m_{1\text{-}4}$, bones of middle part of hands.

But the bat and the mole present us with a special point of similarity in their skeleton not found in the other animals named, including ourselves.

It is that the breast-bone in both the bat and mole develops a median ridge or keel. This keel serves to afford additional surface for the attachment of powerful muscles which pass thence to the arms, and which, in the bat, by their contraction, strike the wings downwards in flight.

Everyone present must have observed, when carving a fowl, that there is a ridge or keel to the breast-bone, and that a voluminous mass of muscle—the breast of the fowl—is situated on each side of such keel. Now, our bat has not got such a mass of muscle on each side of the keel of its breast-bone as has the bird, and for a very good reason. In the bat, as in ourselves, the muscles which antagonise those just noticed (and which draw the arms away from the breast) are situated in the back; but in the

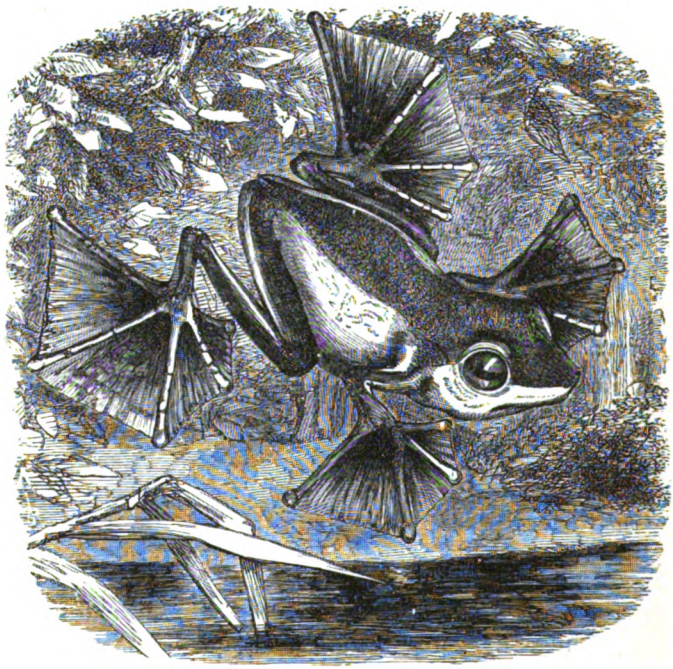
bird, both the muscles which strike the wings downwards, and those which raise them upwards, are both together placed upon the breast, and hence its much deeper and more conspicuous keel. Still, though the muscular structure of the breast of a bat is not so perfectly arranged for flight as is that of a bird, it is an approximation to bird structure, and one we can well understand from the similarity of action. But it may puzzle some of my hearers at first to think why the mole, of all creatures in the world, should have a breast-bone at all like that of a bird. But a moment's reflection will make it obvious that the mole also requires most powerful breast muscles, in order that it may dig its way through the soil with the wonderful speed with which it does dig through it. Similar causes produce similar effects, and thus it is that the mole, like the bat and the bird, comes to have a keeled breast-bone.

The membrane of the bat's wing is a structure of extreme and peculiar delicacy as regards the sense of touch, and the perfection of this sense is doubtless contributed to by a special condition of its blood-vessels. Although the sense of touch depends, of course, directly on the nerves, the functional activity of the nerves depends upon the quantity and the sufficiently rapid renewal of the blood sent to them. This is shown by the familiar examples of numbness brought about by checking the supply of blood to any part with a ligature, as also by the increased sensibility occasioned by inflammation; that is, through a more copious supply of blood. Now, in most animals, as in ourselves, the heart pulsates with rhythmical contractility: but the blood-vessels which distribute the blood over the body are not themselves contractile, however highly elastic they may be. In the bat's wing, however, the vessels which convey blood towards the heart (*i.e.* the veins) have been found by Dr. Wharton Jones to be themselves positively contractile, and so fitted in a most exceptional manner to help on the blood supply, thus indirectly augmenting the power of touch.

This exceptional condition of the vascular system may then have something to do with that exceptional perfection of the power of sensation before referred to, and which was experimentally demonstrated by Spallanzani. He found, not having the fear of anti-vivisectionists before his eyes, that bats deprived of sight, and as far as possible also of smell and hearing, were still able not only to avoid ordinary obstacles to their flight in strange localities, but even to pass between threads purposely extended in various directions across the room in which the experiments were made. This skill it is believed is due to an excessively delicate power of sensation possessed by the flying membrane—a power enabling the creatures by atmospheric pressure and vibration to feel, before contact, the nearness of

adjacent objects. Dr. Dobson, who has paid more attention to bats perhaps than any other living naturalist, is disposed to think, and very reasonably so, that tactile power may be thus greatly increased by such increase of the surface on which tactile sensations may be received as is found in the bat's wing, and that this is the explanation of the mysterious power revealed to us by Spallanzani.

The flight of the bat compared with that of most birds is excessively fluttering; but it is a true and perfect flight, and therefore very different from the analogous action of other beasts called "flying," such as the flying squirrels, the flying opossums, and the flying lemur. In these animals the skin of



A Flying Frog.

the flanks can indeed be extended outwards to the arm and the leg, and when so stretched (as when these animals take long jumps) seems as a sort of parchment to sustain them somewhat in the air, and so far break their fall as to enable them to flit from one bough to another; but they cannot truly fly. The flying lemur is the best furnished in this respect, as it has not only a very extensive "alar membrane," but a short expansion of skin connects together not only the fingers but the toes also

(which is not the case in bats), and has a true interfemoral membrane extending from the hind-legs to the tail.

There is no other such instance in beasts, or in any existing reptiles; but web-footedness is carried to such an extreme degree in a certain frog found in Borneo as to give rise to the conjecture that it was a flying animal.

Mr. Wallace, in his travels in the Malay Archipelago, encountered in Borneo a tree-frog (*Rhacophorus*) to which he considered that the term "flying" might be applied. He tells us:—

"One of the most curious and interesting creatures which I met with in Borneo was a large tree-frog, which was brought me by one of the Chinese workmen. He assured me that he had seen it come down in a slanting direction from a high tree as if it flew. On examining it I found the toes very long and fully webbed to their extremity, so that, when expanded, they offered a surface much larger than the body. The fore-legs were also bordered by a membrane, and the body was capable of considerable inflation. The back and limbs were of a very deep shining green colour, the under surface of the inner toes yellow, while the webs were black rayed with yellow. The body was about four inches long, while the webs of each hind-foot, when fully expanded, covered a surface of four square inches, and the webs of all the feet together about twelve square inches. As the extremities of the toes have dilated discs for adhesion, showing the creature to be a true tree-frog, it is difficult to imagine that this immense membrane of the toes can be for the purpose of swimming only, and the account of the Chinaman that it flew down from the tree becomes more credible."

Although no existing reptile is thus furnished, there is a small Asiatic lizard which is ordinarily spoken of as "flying," the *Draco volans*. And, in fact, though this creature cannot truly fly, but only flit, it has a membrane which can be extended from each side of the body, and which, like the bat's wing, is supported by a number of bony rods. These rods, however, are not, as in the bat, enormously elongated fingers, but are elongated ribs, which stand out freely from the body when jumping, but otherwise are folded back against the flanks.

Existing reptiles, then, present us with no close resemblance to bat-structure; but when we come to extinct reptiles—reptiles which flourished during and anterior to the deposition of our chalk cliffs—the secondary or mesozoic period—we there find reptiles to have existed which present the most striking analogies with existing bats in all that regards their modes of locomotion, and their structure as far as it is related to such modes of locomotion.

These reptiles flew, in the same way that bats do, by means of a vast membrane extending from each enormously elongated hand to the adjacent side of the body.

While, however, in the bat all the fingers of each hand are enormously elongated (to support the alar membrane)—the thumb alone remaining free—in these flying reptiles only a single finger of each hand was thus elongated, the others remaining short, and being provided with claws like the thumb.

With the approach of the winter season bats (like dormice) fall into a peculiar state of winter sleep called hibernation. For this purpose they generally assemble together in large numbers, in out-of-the-way places—caverns, hollow trees, or the roofs of buildings—hanging head downwards by the claws of their feet. During this condition the most important functions of life—breathing and the circulation of the blood—are performed only with exceedingly reduced activity, the temperature of the body becoming notably diminished.

Some of our English bats may be kept in confinement and partly domesticated for a time, small pieces of raw meat being given to them in lieu of their natural insect foot. Speaking of the long-eared bat, Mr. Bell tells us: "It is more readily tamed than any other, and may soon be brought to exhibit a considerable degree of familiarity with those who feed and caress it. I have frequently watched them when in confinement, and have observed them to be bold and familiar even from the first. They are very cleanly; not only cleaning themselves after feeding, and at other times, with great assiduity, but occasionally assisting each other in this office. They are very playful, too, and their gambols are not the less amusing from their awkwardness. They run over and against each other, pretending to bite, but never harming their companions of the same species; though I have seen them exhibit a sad spirit of persecution to an unfortunate Barbastelle which was placed in the same cage with them. They may be readily brought to eat from the hand, and my friend Mr. James Sowerby had one which, when at liberty in the parlour, would fly to the hand of any of the young people who held up a fly towards it, and, pitching on the hand, take the fly without hesitation. If the insect were held between the lips, the bat would then settle on its young patron's cheek, and take the fly with great gentleness from the mouth; and so far was this familiarity carried, that when either of my young friends made a humming noise with the mouth in imitation of an insect, the bat would search about the lips for the promised dainty."

One of the "young friends" here referred to is now the esteemed secretary at the Botanical Gardens, and he has assured me of the truth of the anecdote.

The cry of the bat is exceedingly shrill, so much so that some persons' ears are quite unable to detect it.

Homer compares the voices of the ghosts to the cries of bats. In the 24th book of the Odyssey, 6, he says: "As when bats in a corner of a great cave, when one of them has fallen from off the cluster—so they (the ghosts) went along screaming."

Or, as Pope gives it:—

> Trembling the spectres glide, and plaintive vent
> Their hollow screams along the deep descent,
> As in the cavern of some rifted den,
> Where flock nocturnal bats, and birds obscene:
> Clustered they hang, till at some sudden shock
> They move, and murmurs run through all the rock.
> So cowering fled the sable heap of ghosts.

Bats bring forth but one or two young ones at a birth—when they are received into the interfemoral membrane as into a cradle—the mother then hanging suspended not by her feet but by her thumbs.

The young are born naked and blind, and are suckled at the breast much as is the human infant.

There are many kinds of bats, though their number is uncertain.

There *are* some 14 species even in England, and at least 320, arranged in some 79 genera, in the world at large.

One of our English bats, already referred to as "the long-eared bat," does indeed merit its name, since it has relatively the largest ears found in the whole animal kingdom, being about equal to the length of its entire body. They are capable of being folded up, and generally are so folded, during sleep.

Another kind of bat found in England is called the leaf-nosed bat, because in it not the ear but the nose is the seat of extraordinary skin development—productions of skin curiously folded surrounding and surmounting the external nostrils.

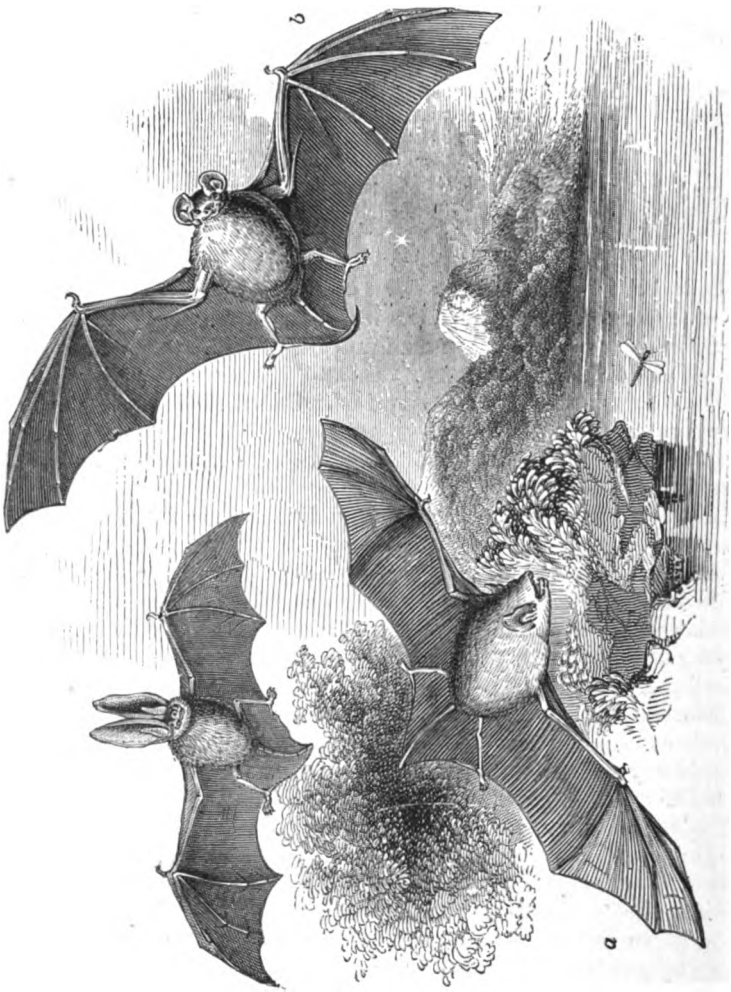
The use of this membrane, according to Dr. Dobson, is to serve as a tactile organ (like the wings); and this is the more probable, seeing that that family of leaf-nosed bats which is represented in England have the smallest eyes, and are devoid of a tragus or inner part of the seemingly double ear before spoken of.

NOSE-LEAF OF THE BAT
Megaderma.

Bats are divisible into two great groups. One of them includes all the insect-eating bats (with or without nose-leaves), more or less like the bats which inhabit this country. They have almost always teeth such as those already described, often a very large tragus to the ear, and a stomach

short and rounded, or at least not prolonged at its pyloric (or more specially digestive) extremity.

These bats are subdivided into various families, three of which alone immediately concern us. 1. The *Vespertilionidæ*, which



British Bats.

includes, amongst very many others, all the English bats without a nose-leaf. 2. The *Rhinolophidæ*, which includes, amongst very many others, the English leaf-nosed bats; and 3. the *Phyllostomidæ*, or leaf-nosed bats of America.

The other group of bats are made up of those, mostly of large

size, called *flying foxes*, of which we have specimens now living in the Zoological Gardens. They are confined to the tropical and subtropical regions of the Old World and the Pacific, but are not found even in the hottest regions of South America. They have grinding teeth, which are not drawn out into sharp points, but have their crowns marked simply with a longitudinal furrow, in accordance with their fruit-eating habits, and their stomach (also in accordance with this habit) is much prolonged at its pyloric, or more specially digestive, end.

Certain leaf-nosed bats of South America go by the formidable name of vampires, from their reputed blood-sucking habits.

Although such a habit could only have been attributed erroneously to the entire group, one certain kind of this group is very truly blood-sucking, and its organisation is peculiarly and very strikingly modified to efficiently subserve this function.

The bat in question is called *Desmodus*, and the truth as to its blood-sucking habit has been fully established by the testimony of Mr. Darwin.* He tells us: "The vampire bat is often the cause of much trouble, by biting the horses on their withers. The injury is generally not so much owing to the loss of blood, as to the inflammation which the pressure of the saddle afterwards produces. The whole circumstance having been lately doubted in England, I was therefore fortunate in being present when one (*Desmodus d'Orbignyi*) was actually caught on a horse's back. We were bivouacking late one evening near Coquimbo in Chile, when my servant, noticing that one of the horses was very restive, went to see what was the matter, and, fancying he could distinguish something, suddenly put his hand on the beast's withers, and secured the vampire. In the morning the spot where the bite had been inflicted was easily distinguished from being swollen and bloody. The third day afterwards we rode the horse, without any ill effects."

The special modifications of structure which harmonise with this special function are mainly two. First, the form of the teeth, and secondly that of the stomach.

TEETH OF THE VAMPIRE BAT. *Desmodus.*
i, cutting-teeth; *c*, eye-teeth.

As to the teeth, the grinding ones are reduced to a minimum both as to size and number; while the two middle or cutting teeth of the upper jaw are of great size, with a sharp cutting edge well fitted to inflict the small incision needful for the animal's nourishment.

As to the stomach, it presents us with a structure unique in the animal kingdom. Here it is not the pyloric end of the stomach, but the opposite or cardiac end,

* "Journal of Voyage of Beagle," vol. i. p. 22.

which is produced into an enormously long pouch, while the opposite or pyloric end is reduced to a mere rudiment—the highly nutritious food (blood) requiring very little digestion, but needing a capacious chamber for its speedy reception.

Although this is the only bat perfectly organised to live by blood-sucking exclusively, nevertheless it is probable that various other kinds practise blood-sucking as at least one part of their mode of nutrition.

The late distinguished zoologist belonging to the Zoological Society—Mr. Blyth—has observed this habit in a leaf-nosed bat of India, one belonging to quite another family from that to which the American vampire belongs. The bat in question is called *Megaderma Lyra*. Respecting its habits Mr. Blyth tells us* as follows:—

"Chancing one evening to see a rather large bat enter an outhouse from which there was no other egress than by the doorway, I was fortunate in being able to procure a light, and thus proceed to the capture of the animal. Upon finding itself pursued, it took three or four turns round the apartment, when down dropped what at the moment I supposed to be its young, and which I deposited in my handkerchief. After a somewhat tedious chase, I then secured the object of my pursuit, which proved to be a fine pregnant female of *Megaderma Lyra*.

"I then looked at the other bat which I had picked up, and, to my surprise, found it to be a small *Vespertilio*, nearly allied to the European *V. pipistrellus*, which is exceedingly abundant, not only here, but apparently throughout India, being the same also, to all appearance, as a small species which my friend Dr. Cantor procured in Chusan. The individual now referred to was feeble from loss of blood, which it was evident the *Megaderma* had been sucking from a large and still bleeding wound under and behind the ear; and the very obviously suctorial form of the mouth of the vampire was of itself sufficient to hint the strong probability of such being the case. During the very short time that elapsed before I entered the outhouse, it did not appear that the depredator had once alighted: but I am satisfied that it sucked the vital current from its victim as it flew, having probably seized it on the wing, and that it was seeking a quiet nook where it might devour the body at leisure. I kept both animals wrapped separately in my handkerchief till the next morning, when, procuring a convenient cage, I first put in the *Megaderma*, and, after observing it some time, I placed the other bat with it. No sooner was the latter perceived than the other fastened

* In the "Journal of the Asiatic Society of Calcutta," vol. xi. p. 225, quoted in P.Z.S. 1872, p. 713.

on it with the ferocity of a tiger, again seizing it behind the ear, and made several efforts to fly off with it; but, finding it must needs stay within the precincts of the cage, it soon hung by the hind-legs to one side of its prison, and, after sucking its victim till no more blood was left, commenced devouring it, and soon left nothing but the head and some portions of the limbs. The voidings observed very shortly afterwards in its cage resembled clotted blood, which will explain the statement of Stedman and others concerning masses of congealed blood being always observed near a patient who has been attacked by a South African vampire. Such, then, is the mode of subsistence of the *Megaderma*."

Bats are most widely diffused over the surface of the globe—as their powers of flight might lead us to expect. Even Australia—so very peculiar in the character of the other beasts which inhabit it—possesses bats belonging to both of the bat families which are found in our own island.

But although the whole group of bats, and also that family to which most English bats belong—the *Vespertilionidæ*—are thus widely distributed, the geographical limits of some families of bats are very sharply defined.

To appreciate these facts it is necessary to be acquainted with the geographical areas into which the surface of our globe may be divided, each considerable tract of the earth's surface having its more or less peculiar animal population, or *fauna*, as it has its indigenous plants; that is, its *flora*. The earth's surface is divisible into six zoological regions.

1. The *Palæarctic region*, or Europe, Asia north of the Himalaya, and Africa north of the Sahara.
2. The *Ethiopian region*, or Africa south of the Sahara, and including Madagascar and also Arabia, which geologically is part of Africa.
3. The *Oriental region*, or Asia south of the Himalaya, with Southern China and the Philippine Islands and Indian Archipelago as far as the island of Baly.
4. The *Australian region*, or Australia, New Zealand, the less remote Pacific Islands, and those of the Indian Archipelago from New Guinea up to Lumbock.
5. The *Neotropical region*, or South America, together with tropical North America and the West Indies.
6. The *Nearctic region*, or temperate North America and Greenland.

Now the whole group of flying foxes is strictly confined to the tropical regions of the Old World and Australia. In the same way the family of leaf-nosed bats like those of England—the *Rhinolophidæ*—is limited to the Old World, though reaching there much higher latitudes than do the flying foxes.

The groups to which the vampires belong—the *Phyllostomidæ*—is strictly confined to the Neotropical and Nearctic regions; and the Neotropical region is not only distinguished as the head-quarters of the *Phyllostomidæ*, but also by being altogether destitute of the flying foxes and *Rhinolophidæ*.

Such being the relation of bats to space—their geographical distribution—what are their relations to time—their geological distribution?

I assume that my readers are acquainted with the fundamental facts and laws of geology, and know that the successive layers, of which the superficial crust of the earth is in very various degrees composed, are classifiable into three sets: (1) The Primary or Palæozoic rocks, (2) the Secondary or Mesozoic rocks (from the Trias to the Chalk inclusively), and lastly (3) the Tertiary or Cainozoic rocks, extending upwards from the Chalk to the present day.

Remains of beasts more or less closely resembling some of those existing now in Australia are found low down in the secondary rocks, namely in the Triassic and Oolitic formations. Generally speaking, however, beasts such as those which now exist are not found deeper than the Tertiary strata, and this is the case with bats.

The oldest fossil bat yet known is represented by a few teeth found in Eocene deposits in Suffolk. The oldest perfect fossil bat is the *Vespertilio parisiensis* of the gypsum beds of Montmartre, near Paris.

Some forms of existing beasts, however, which are *now* distinct enough, such as the ox and the pig, or the tapir and the horse, were preceded in early Tertiary times by others which were more or less intermediate in structure. This is not the case as regards bats. Bats, as soon as they appear at all, appear as thoroughly and as perfectly organised bats as are those living amongst us now.

This leads us to speculate upon questions of origin; but, before so doing, let us see that we have a clear idea of what a bat is, and can give a good definition of it.

In order that we may have this clear idea, we must consider for a few moments zoological classification.

The whole group of animals is fancifully termed the animal kingdom, in contradistinction to the world of plants—the vegetable kingdom.

This vast mass of animals is subdivided into a number of very large groups, each of which is called a subkingdom. Thus we have the subkingdom to which we ourselves belong—the vertebrate subkingdom; the subkingdom of insects, &c.; that of snails, cuttle-fishes, &c., and so on.

Each of these various subkingdoms is again divided into

certain subordinate, but still very large, groups, each of which is called a class.

Thus the subkingdom Vertebrata is made up of the class of man and beasts, that of birds, that of reptiles, that of frogs, toads, and efts, and that of fishes.

Every class is again subdivided into certain subordinate groups, termed orders.

Each order is composed of families, each family of genera, and each genus of its component kinds or "species."

Now the bat, as already said, belongs to man's own class, possessing as it does all the characters which distinguish that class from the other classes of vertebrate animals.

Man's own class, Mammalia, is divisible into some dozen orders, and all the bats form one such order (*Cheiroptera*), into which no animal but a bat is admitted. The characters of this order are the possession of a truly flying membrane, sustained by very elongated fingers; and the bat is capable of being very shortly defined—namely, as *a truly flying mammal.*

Bats present no real resemblance whatever to birds, but are of course much more like ourselves (who are their class-fellows) than they are like any bird.

Similarly, in spite of this analogical relation of bats to those extinct reptiles, the pterodactyles, these creatures have no true affinity. Pterodactyles are aerial modifications of the Reptilian type, just as bats are aerial modifications of the Mammalian type. We may say, in a rough and general way, as pterodactyles are to reptiles, so are bats to mammals.

Before concluding, we may now glance at the question of the genesis or origin of bats. To those who accept the doctrine of Evolution—as I myself do—there can be no question but that bats did arise by natural generation from some anterior beasts which were not bats. But at what period, and from what progenitors? these are questions which it is quite impossible to answer at present. As has been said, there are certain cases in which we may imagine now existing more highly specialised and differentiated forms were developed from anterior less highly specialised and differentiated ones. We may do so, *e.g.*, as regards the horse and the ox. But we cannot do so as regards the bat, because up to the present time no fossil remains whatever have been found which connect bats with other creatures. Moreover, the development of the bat's wing, difficult as it is to conceive upon any view of evolution, seems to me to be especially difficult as the mere result of the survival of the fittest, when we consider the origin of the initial stages of the organ. The nearest existing relatives of the bat which are not bats are perhaps the little shrew mice belonging to the order Insectivora. Some of these are aquatic;

and it is conceivable, though there is no fragment of evidence in favour of it, that some ancestral aquatic form may have developed long fingers and webs like those of the flying frog. This speculation does not, however, commend itself to my mind as a satisfactory one; and though doubtless, could we see all the extinct forms of life which have existed during the secondary period, we should find some creatures developing by more or less rapid stages along a definite course in the direction of the type of structure selected for our consideration to-day, and though I am ready to make an act of scientific faith in the existence of such creatures, I confess my imagination fairly baffled in its attempts to depict them, or the road which this particular course of evolution followed. We must wait patiently for more light from palæontology. But we may wait very hopefully. We may do so because the wonderfully rich harvest of fossil remains now being gathered in North America supplies us with good and solid ground for hope.

Already forms have been discovered there so strange that they cannot be satisfactorily grouped in any existing order of mammals—forms such as imagination could hardly have anticipated. We may, then, not unreasonably expect that sooner or later—perhaps very soon—fossils deeply buried in the secondary rocks will come to light, clearly pointing out the line which has been followed in the evolution and development of the only truly flying mammal—the bat.

EXPLANATION OF PLATE CXXXVI.

FIG. 1. A Flying Fox from Samoa, *Pteropus Whitmeei*.

FIG. 2. Skeleton of a Flying Fox.

FIG. 3. Side view of breast-bone of ditto.