THE GENESIS OF LIMBS

WHY are our limbs so much alike and yet so different? What do our limbs stand for as compared with the bodies of other animals? Whence have limbs such as ours arisen? What *is* a limb?

The word *limb* is the Anglo-Saxon word *lim*, most probably connected with the Latin *limbus*—the border, outer edge, or extremity of anything, and thence applied to any attached, projecting, or out-lying portion.

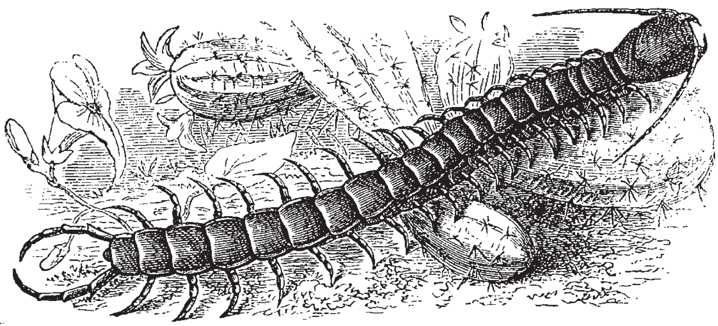

FIG. 1.—A Centipede.

But there are projecting portions of animal bodies essentially like our own body which are not called limbs, *e.g.*, the dorsal and anal fins of fishes, while yet that name is freely bestowed upon structures which have no relation to our limbs save a relation of analogy from similarity of use, as, *e.g.*, the legs of insects or the arms of star-fishes. Insects and their allies present certain resemblances and differences carried to a higher degree than in us, and which may be here adverted to. The difference in shape between the limbs of the right and left sides in us is minute and accidental. Our *bilateral* symmetry is complete, but in many crustaceans the shapes of the right and left great claws differ to a large extent. The resemblance between the thoracic and pelvic limbs in us is great, but the resemblance between the successive legs of many arthropods is much greater, especially in the class of centipedes, where the successive segments of the body, with their appendages, exhibit *serial* symmetry carried to the highest degree. The amount of likeness, as regards *serial symmetry*, which exists between our pairs of limbs is less than exists in many back-boned creatures, while at the same time there are a great many others in which it is not carried nearly so far as it is in ourselves. These varying degrees of serial symmetry are such that upon the theory of evolution we must suppose that if this serial symmetry originally existed, it must have been lost and reacquired perhaps several times to produce what we see before us in the existing creation.

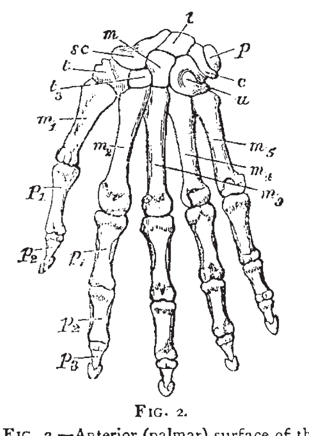

FIG. 2.

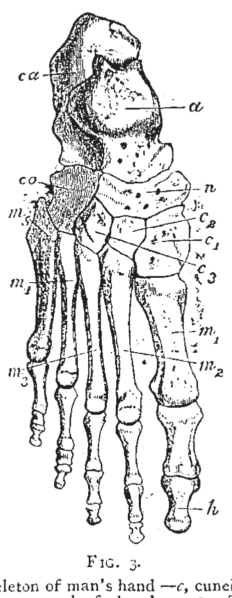

FIG. 3.

FIG. 2.—Anterior (palmar) surface of the skeleton of man's hand —*c*, cuneiforme: *l*, lunare; *m*, magnum; m^1, metacarpal of thumb; m^2–m^5, metacarpals of the four fingers; *p*, pisiforme; P^1, first phalanx of the thumb and four fingers—*i.e.* of the five "digits;" P^2, second phalanx of the five digits; P^3, third, or ungual phalanx; *sc*, scaphoides; *t*, trapezium; *tz*, trapezoides; *u*, unciforme.

FIG. 3.—Dorsum, or upper surface, of skeleton of right foot.—*a*, astragalus; c^1, ento-cuneiforme; c^2, meso-cuneiforme; c^3, ecto-cuneiforme; *ca*, calcaneum; *co*, cuboides; *h*, distal phalanx of hallux; m^1, metatarsal of hallux; m^2–m^5, metatarsals of the four outer toes; *n*, naviculare.

Thus if we compare with the structure of the human hand and foot the same parts in apes, we find that in them the toes (or digits of the foot), instead of being short like ours, are long and mobile like our fingers, while the great toe (or hallux) is set out at an angle from the others, to which it is powerfully opposable. At the same time the main points of structure of the ape's foot remain like our own, and thus while it is morphologically a foot, it is functionally more or less of a hand. Here, therefore, serial symmetry is already more complete than in us.

If we descend to hoofed beasts, *e.g.*, the hog, the giraffe, or the horse, we find the number of digits equally and simultaneously reduced in both the fore and the hind limb, and while in the two former creatures the third and fourth digits of each extremity are increased in size at the expense of the others, in the horse there is but one digit so increased—the animal walking upon but four digits, which answer respectively to our two middle fingers and our two middle toes.

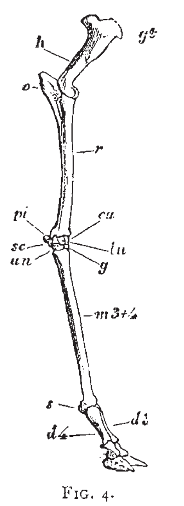

FIG. 4.

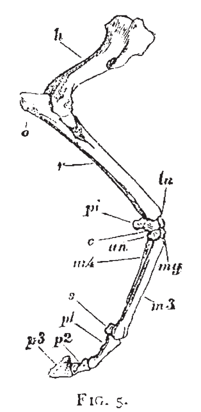

FIG. 5.

FIG. 4.—Right pectoral limb of a Giraffe.—*cu*, scaphoides; *d*3, proximal phalanx of third digit; d^4, proximal phalanx of fourth digit; *g*, magnum; *gt*, great tuberosity of the humerus; *h*, shaft of the humerus; *lu*, lunare; m^{3+4}, united metatarsals of third and fourth digits; *o*, olecranon; *pi*, pisiforme; *r*, radius; *sc*, cuneiforme; *un*, unciforme.

FIG. 5.—Right pectoral limb of Horse.—*c*, cuneiforme; *h*, humerus; *lu*, lunare; m^3, metacarpal of the third digit—the only one fully developed; m^4, rudimentary fourth metacarpal; *mg*, magnum; *pi*, pisiforme; p^1, proximal phalanx; p^2, middle phalanx; p^3, third or ungual phalanx; *s*, sesamoid; *un*, unciforme.

It is, then, quite a mistake to regard the ox's hoof as answering, morphologically, to the horse's hoof "cloven;" each single hoof of the horse answers only to the inner division of each double hoof of the ox or giraffe. Now in all these creatures we find a still further increase in serial symmetry as compared with the apes and man.

If, however, we turn to such an animal as the mole we find a much decreased degree of such symmetry, the fore-limb being of enormous strength, with its bones shortened and broadened out, while the hind-limb is slender and deli-

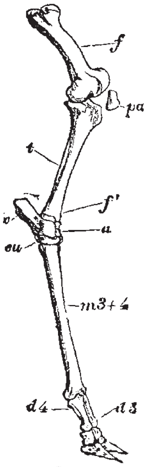

FIG. 6.

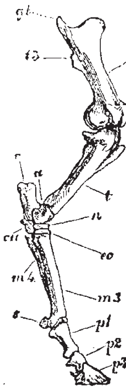

FIG. 7.

FIG. 6.—Right pelvic limb of Giraffe.—*a*, astragalus; *c*, calcaneum; *cu*, cuboides; *d* 3, proximal phalanx of third digit; *d* 4, proximal phalanx of fourth digit; *f*, femur; *f'*, rudiments of fibula (the line is not continued far enough—the rudimentary fibula is a small ossicle reposing on the upper surface of the calcaneum, as shown in the figure); m^{3+4}, metatarsals of digits 3 and 4 united into one "cannon-bone"; *pa*, patella; *t*, tibia.

FIG. 7.—Skeleton of right pelvic limb of Horse.—*a*, astragalus; *c*, calcaneum; *cu*, cuboides; *ec*, ecto-cuneiforme; *f*, femur; *gt*, great trochanter; *m*3, metatarsal of third digit; *m*4, rudimentary fourth metatarsal; *n*, naviculare; *pa*, patella; p^1, p^2, and p^3, first, second, and third phalanges of the third and only digit; *s*, sesamoid; *t*, tibia; *t*3, third trochanter.

cate. The mole works underground with such exceeding rapidity that it has been said to fly beneath the soil, but in the beast which really does fly—the bat—serial symmetry is still less developed. The framework of the bat's wing consists of the very same bones which exist in the human arm and hand, only exceedingly elongated and slender. The four fingers—wonderfully drawn out—are connected together (and to the body and legs) by a delicate web of skin. The foot is a striking contrast to the enormously enlarged hand, being small in size with short toes. And yet, though serial symmetry is thus disguised in the bat, it nevertheless shows itself in other ways more or less noteworthy. The outer bone of the fore-arm—the *ulna*, is incompletely developed, and the corresponding bone of the leg—the fibula, is also incompletely developed. But much more than this, in some bats we find outside the elbow-joint a distinct and separate little bone which quite answers to the knee-pan (or *patella*) of the leg—a most exceptional case of serial homology.

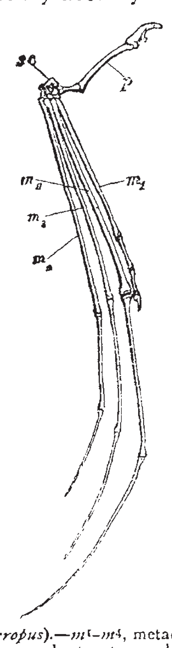

FIG. 8.—Hand of Bat (*Pteropus*).—m^1-m^4, metacarpals of the four fingers; *p*, pollex, with a very short metacarpal; *sc*, scaphoides.

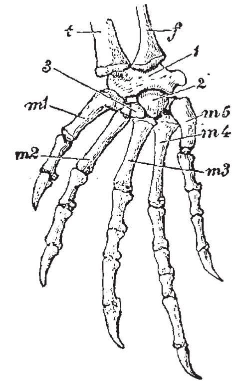

FIG. 9.—Left foot of a Monitor Lizard (*Varanus*).—*f*, fibula; m^1-m^5, the five metatarsals, m^1 being that of the hallux; *t*, tibia; 1, astragalo-calcaneum; 2, cuboides; 3, ecto-cuneiforme.

The creatures just referred to are all mammals, but birds and reptiles present us with some instructive examples both of serial homology and discrepancy. In ourselves and in all beasts, the motion of the foot upon the leg takes place between the long bones of the latter (tibia and fibula) and the tarsus. In the crocodile, or monitor, it is not so, but the upper part of the ankle, or tarsus (answering to our astragalus and os calcis), is firmly and immovably fixed to the leg bones, while the lower part of the tarsus is firmly fixed to the metatarsals. Thus in the crocodile, or monitor, motion does not take place between the whole ankle and the leg, but in the middle of the ankle (or tarsus) itself.

FIG. 11.—Right foot of Emeu.—*a*, astragalus; d_2-d_4, second, third, and fourth digits; *m*, metatarsals anchylosed together except at their distal ends; *t*, tibia; t_2, distal tarsal element.

In the leg of a bird there at first sight seems to be no tarsus at all, nor any bones which we can with certainty call "metatarsal." We have only one single long bone, at the lower end of which are three or four articular sur-

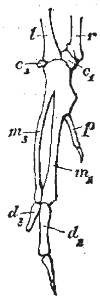

FIG. 10.—Right hand of Ostrich.—c^1, radial carpal ossicle; c^2, ulnar carpal ossicle; d^2, proximal phalanx of the index digit which has three phalanges; $d3$, phalanx of third digit; l, ulna; m^2 and $m3$, metacarpals of second and third digits anchylosed together and with that of the pollex; p, proximal phalanx of pollex; r, radius.

faces for the three or four toes. The study of the very young bird, however, has shown us that though no tarsus can be distinguished in the adult, yet such a part does exist for a certain brief period of the bird's life and then disappears.

In its fate we have an interesting resemblance to the condition which we have already found existing in the crocodile, and which condition the bird exaggerates. The upper part of the tarsus becomes not merely firmly fixed to, but indistinguishably united with, the leg-bone, or tibia, while the lower part of the tarsus becomes as indistinguishably united with the coalesced metatarsals, and thus it comes about that no tarsus whatever is distinguishable in the adult. The apparent leg-bone (tibia) is leg-bone with part of the tarsus also; the apparent metatarsal bone is made up of metatarsal bones with the other part of the tarsus also. The movement of the foot on the leg takes place in the bird (as in the crocodile), not between the leg and ankle, but in the middle of the ankle itself.

In the skeleton of the bird's fore-limb, or wing, the hand is strangely different in aspect from the foot. There is hardly any carpus (or wrist) visible. The metacarpus is represented by a single complex bone formed of three metacarpals anchylosed together, and there are only three fingers, which are all more or less rudimentary.

Here serial symmetry is more disguised than ever in the bat, the difference between a bird's wing and a bird's

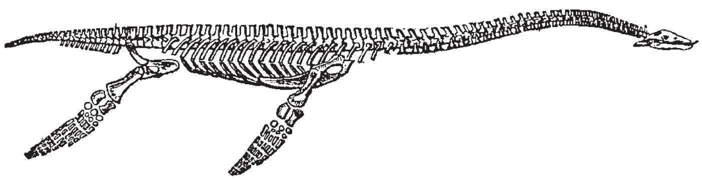

FIG. 13.—Skeleton of a Plesiosaurus.

leg being so great. And yet even here we meet with a curious example of the tendency to vary similarly which exists in serially homologous parts; for in the bird's carpus there is a similar arrangement, though less thoroughly carried out, to that which exists in the bird's tarsus. The distal part of the carpus coalesces altogether with the metacarpus (as the distal part of the tarsus does with the metacarpus), but the proximal part remains distinct in the form of two separate carpal bones.

(*To be continued*)

ST. GEORGE MIVART

THE OBSERVATORY OF PARIS

ARRANGEMENTS for the future management of the Observatory at Paris are now complete. Contre-Amiral (until recently Captain) Mouchez is appointed director, with M. Maurice Lœwy as sub-director—these appointments taking effect for five years.

M. Mouchez was born at Madrid in 1821, but is the son of French parents. He joined the Naval School at Brest in 1837, and in 1839 commenced his nautical career in the *Fortune*, which was taking part in the blockade of Buenos Ayres. In 1840 he was appointed to the *Favorite*, which proceeded on a circumnavigating expedition extending over five years. Having shown an early aptitude for astronomical observations, he was intrusted with them. On this voyage he became aware of the imperfect determination of the latitudes and longitudes of some of the sea-ports visited, and his attention was directed to the construction of portable instruments for improving them. In 1850 he embarked on board the *Capricieuse*, also destined for a scientific voyage round the world, which, like that of the *Favorite*, occupied five years. He was charged by the Dépôt de la Marine with the survey of the Rio de la Plata and the Brazils, a survey which extended over about 3,000 miles.

In 1860 M. Mouchez was commissioned by the French Government to visit England, for the purpose of reporting upon the system of weather predictions organised by the late Admiral Fitzroy, Leverrier at the time contemplating the establishment in France of his own system of storm-warnings. M. Mouchez, who was enthusiastic in favour of the Fitzroy arrangements, suggested that the *Dépêche anglaise* should be posted in the French ports, and recommended a special meteorological organisation independent of the Observatory at Paris. The proposition, which was carried into effect, is said to have created differences between Leverrier and the Minister of Marine. M. Mouchez greatly interested himself from an early period in his naval career in promoting astronomical and physical studies amongst the officers of the Government marine, and observations while at sea. His views are noticed by Arago in his introductory work for scientific travellers.

In 1867 he commenced the survey of the coast of Algeria, a work which, in consequence of repeated interruptions from his employment on other urgent missions, was not completed until 1877. Thus in 1870, Contre-Amiral Mouchez was sent with the French fleet to the Baltic for the blockade of the Prussian coasts, but the attempted blockade proving a failure, he was recalled and charged with the defence of Havre, which place he succeeded in preserving from a threatened hostile occupation.

In 1874 he was sent to the Island of St. Paul for the observation of the transit of Venus, and next to that of M. Janssen his mission may be considered the most successful. At his suggestion the French Government established, in 1875, an observatory at Montsouris, where naval officers are practised in making astronomical observations, as also intending travellers, on the recommendation of the Société de Geographie. He is a member of the Academy of Sciences in the section of Astronomy,