

ART. X.—On the higher subdivisions in the Classification of Mammals; by JAMES D. DANA.

THE precise position of Man in the system of Mammals has long been, and still remains, a subject of discussion. There are those who regard him as too remote from all other species of the class to be subject to ordinary principles of classification. But zoologists, generally, place him either in an independent order, (or subclass, if the highest divisions be subclasses,) or else at the head of the order containing the *Quadrumana*. Science, in searching out the system in nature, leaves psychical or intellectual qualities out of view; and this is right. It is also safe: for these immaterial characteristics have, in all cases, a material or structural expression; and when this expression is apprehended, and its true importance fully admitted, classification will not fail of its duty in recognizing the distinctions they indicate.

Cuvier, in distinguishing Man as of the order *Bimana*, and the Monkeys of the order *Quadrumana*, did not bring out to view any profound difference between the groups. The relations of the two are so close, that Man, on this ground alone, would be far from certain of his separate place. No reason can be derived from the study of other departments of the Mammals, or of the animal kingdom, for considering the having of two hands a mark of superior rank to the having of four.

Prof. Owen, in his recent classification of Mammals,<sup>1</sup> makes the characteristics of the brain the basis of the several grand divisions. But, as he admits, the distinctions fail in many cases of corresponding to the groups laid down: and although the brain of Man (his group *Archencephala*) differs in some striking points from that of the *Quadrumana*, yet no study of the brain alone would suggest the real distinction between the groups, or prove that Man was not coördinal with the Monkeys. In fact, the nervous system is a very unsafe basis of classification below the highest grade of subdivisions—that into subkingdoms. The same subkingdom may contain species with, and without, a distinct nervous system, and a class or order may present very wide diversities as to its form and development,—for the reason, that the system or plan of structure in species is far more authoritative in classification than the condition of the nervous system.

The fitness of the parts of the body of Man for intellectual uses and his erect position have been considered zoological characteristics of eminent importance, separating him from other Mammals. But even these qualities, although admitted to be of

<sup>1</sup> This Journal, vol. xxv, pp. 7, 177, 1858—cited from the Journal of the Proceedings of the Linnæan Soc. of London, for Feb. 17 and Ap. 21, 1857.



real weight, are not, to many zoologists, unquestionable or authoritative evidence on this point.

But, while the structural distinctions mentioned may fail to establish Man's independent ordinal rank, there is a characteristic that appears to be decisive,—one, which has that deep foundation in zoological science required to give it prominence and authority.

The criterion referred to is this:—that while all other Mammals have both the anterior and posterior limbs organs of locomotion, in Man the anterior are transferred from the *locomotive* to the *cephalic* series. They serve the purposes of the *head*, and are not for locomotion. The *cephalization* of the body,—that is, the subordination of its members and structure to head-uses—so variously exemplified in the animal kingdom, here reaches its extreme limit. Man, in this, stands *alone* among Mammals.

The author has shown elsewhere<sup>2</sup> that this cephalization is a fundamental principle, as respects grade, in zoological life. He has not only illustrated the fact, that *concentration of the anterior extremity of the body and abbreviation of its posterior portion* is a mark of elevation; but further than this, that *the transfer of the anterior members of the thorax to the cephalic series* is the foundation of rank among the orders of Crustaceans. In the highest order of this class—that of the *Decapods*, (containing crabs, lobsters, shrimps, etc.), *nine* pairs of organs, out of the *fourteen* pertaining to the head and thorax, belong to the head—that is, to the senses and the mouth. In the second order, that of the *Tetradecapods*, there are only *seven* pairs of organs, out of the fourteen, thus devoted to the head,—two of the pairs which are mouth-organs in the Decapods being true legs in the Tetradecapods. In the third or lowest order, that of the *Entomostracans*, there are only *six, five, or four* pairs of cephalic organs; and besides, these, in most species, are partly pediform, even the mandibles having often a long foot-like branch or extremity, and the antennæ being sometimes, also, organs of prehension or locomotion.

Two of the laws bearing on grade, under this system of cephalization or decephalization, have been stated; its connection with (1) a concentration of the anterior extremity and abbreviation of the posterior extremity, and the reverse; and with (2) a transfer of thoracic members to the cephalic series, and the reverse. There is a third law which should be mentioned to explain the relations of the Entomostracans to the other orders; namely, (3) that a decline in grade, after the laxness and elongation of the anterior and posterior extremities have reached their limit, is further exhibited by a *degradation* of the body and especially of its extremities.

<sup>2</sup> See his Report on Crustacea, the Chapter on Classification, page 1395; also this Journal, vol. xxii, p. 14, 1856; where the principles explained in this paper are illustrated by many examples, and with direct reference to the general subject of classification.



In the step down from the Decapods to the Tetradecapods, there is an illustration of this principle in the eyes of the latter being imbedded in the head instead of being pedicellate. In the Entomostracans, (1) the elongated abdomen is destitute of all but one or two of the normal pairs of members—not through a system of abbreviation, as exhibited in crabs, but a system of *degradation*; and in some species, all the normal members are wanting, and even the abdomen itself is nearly obsolete. Again (2) the two posterior pairs of thoracic legs are wanting in the species, and sometimes more than two pairs. Again, (3) at the anterior extremity, one pair of antennæ is often obsolete, and sometimes the second pair nearly or even quite so. The *Limulus*, though so large an animal, has the abdomen reduced to a straight spine, and the antennæ to a small pair of pincer-legs, while all the mouth organs are true legs—the whole structure indicating an extreme of degradation.

In the order of Decapods, having nine as the normal number of pairs of cephalic organs, the species of the highest group have these organs compacted within the least space consistent with the structure of the type; in those a grade lower, the posterior pair is a little more remote from the others and begins to be somewhat pediform; a grade lower, this pair is really pediform or nearly like the other feet; and still lower, two or three pairs are pediform. Still lower in the series of Decapods (the Schizopods), there are examples under the principle of *degradation* above explained; (1) in the absence of two or three pairs of the posterior thoracic appendages; (2) in the absence or obsolescence of the abdominal appendages; (3) in the Schizopod character of the feet. These Decapods, thus degraded, approximate to the Entomostracans, although true Decapods in type of structure. Thus the principle is exemplified within the limits of a single order, as well as in the range of orders.

This connection of cephalization with rise of rank is also illustrated abundantly in embryonic development. It is one of the fundamental principles in living nature.<sup>3</sup>

When then, in a group like that of Mammals, in which *two* is the prevailing number of pairs of locomotive organs, there is a transfer of the anterior of these two from the locomotive to the cephalic series, there is evidence, in this exalted cephalization

<sup>3</sup> In his Manual of Geology, just published, the writer, speaking of the ancient Ganoids, has preferred to use the term *vertebrated* tails rather than *heterocercal*, because this characteristic of a prolonged vertebral column is a mark of inferiority of grade on the principle explained; and the disappearance of it, in the Mesozoic era, was an instance of that abbreviation of the posterior extremity connected with a rise in grade. It is well exemplified, also, as Agassiz has made known, in the development of the modern Ganoid, the young having a vertebrated upper lobe of the tail, which is lost before reaching the adult size. Another reason for using the term *vertebrated*, is, that in some of the ancient Ganoids with vertebrated tails the vertebral prolongation is central in the tail, and the form is therefore not at all heterocercal.



of the system, of a distinction of the very highest significance. Moreover, it is of the more eminent value that it occurs in a class in which the number of locomotive members is so nearly a constant number. It places Man apart from the whole series of Mammals; and does it, on the basis of a character which is fundamentally a criterion of grade. This extreme cephalization of the system is, in fact, that material or structural expression of the dominance of mind in the being, which meets the desire both of the natural and intellectual philosopher.

This cephalization of the human system has been recognized by Carus; but not in its connection with a deep-rooted structural law pervading the animal kingdom. It is the comprehensiveness of the law which gives the special fact its great weight. Aristotle, in his three groups of Mammals, the *Dipoda* or two-footed, the *Tetrapoda* or four-footed, and the *Apoda* or footless species, expresses distinctions according with this law. The term *Dipoda*, as applied to Man, is far better and more philosophical than *Bimana*.

The erect form of the structure in Man, although less authoritative in classification, is a concomitant expression of this cephalization. For the body is thus placed directly beneath the brain or the subordinating power, and no part of the structure is either anterior or posterior to it. Two feet for locomotion is the smallest possible number in an animal. Cephalic concentration and posterior abbreviation are at their maximum. The characters of the brain distinguishing the Archencephala (Man) in Prof. Owen's system, so far as based on its general form or the relative position of its parts, flow from the erect form.

Man's title to a position by himself, separate from the other Mammals in classification, appears hence to be fixed on structural as well as psychical grounds.

The other Mammals are either true *viviparous* species, or *semi-oviparous*.

The latter, including the *Marsupials* and *Monotremes*, constitute a natural group, as usually so regarded, the most fundamental characteristic of which—the immaturity of the young at birth, by which they are related to oviparous Vertebrates—suggests the name OÖTICOIDS.

The viviparous species are variously arranged by different zoologists.<sup>4</sup> Prof. Owen, basing his subdivisions largely, as has been stated, on the characters of the brain, makes the two groups *Gyrencephala* and *Lissancephala*,—the former so named from having, in general, the surface of the brain *convoluted*, and the latter from its being, with some exceptions, *smooth*.<sup>5</sup>

<sup>4</sup> See Professor Owen's memoir already referred to for an account of different earlier systems of the Classification of Mammals.

<sup>5</sup> See this Journal, vol. xxv, pp. 178, 179, for the precise characters of these groups.



The GYRENCEPHALA include, in Prof. Owen's system, three groups—I, the *Unguiculata* (consisting, as presented by him, of the orders 1, Quadrumana, 2, Carnivora); II, the *Ungulata* (1, Artiodactyla, or Ruminantia, 2, Perissodactyla or Solidungulata and Multungulata, 3, Proboscidea, 4, Toxodontia); III, the *Mutilata* (1, Sirenia, 2, Cetacea). The LISSENCEPHALA comprise four orders, arranged by him as follows: (1) Bruta or Edentata (Sloth, etc.), (2) Cheiroptera or Bats, (3) Insectivora (Mole, Hedgehog, etc.), (4) Rodentia.

Although the characteristics of the brain do not set forth satisfactorily the distinctions between the Gyrencephala and Lissencephala, the groups themselves (first laid down with the limits here assigned, as Prof. Owen states, by Jourdan) appear to be founded in nature. In the arrangement of the groups under these two divisions, however, the system proposed below widely differs from the above.

The Crustaceans have here also afforded the writer the principles of classification on which he rests his conclusions.<sup>6</sup>

The orders among Crustaceans are based not only on a difference of structure and cephalization, but also on a difference in the normal magnitude of the life-system. The Decapods are built on a life-system of large size as to plan as compared with that of the Tetradecapods. Deducing the relative size from the mean dimensions of the active species under the two types, the ratio is lineally as 4:1. (See the papers of the author already referred to.) Moreover, while thus distinct, the subdivisions of the two orders form parallel series—the Brachyurans, Anomourens and Macrourans running a close parallel with the Isopods, Anisopods and Amphipods; for the Isopods are literally *Brachyural* Tetradecapods and the Amphipods, *Macroural*.<sup>7</sup>

The life-system in the Entomostracans is on a still smaller plan.

Among the viviparous Mammals (exclusive of Man) the *first* group differs from the *second* on this same principle—the fact of a larger and more powerful type of structure or life-system. This fact stands out boldly to view on comparing active species

<sup>6</sup> Principles are none the less important because indicated among these lower Articulata. The turns of a closed spiral are easily mistaken for circles, as was long the case with those of flowers in plants; but if the spire be drawn out long, it then exhibits its true characters and may display details that are otherwise undiscoverable. The class of Crustaceans is an example of a type of structure thus *drawn out*—its species ranging from the microscopic memberless Rotifer to the highest crabs, and the genera are distributed, so to speak, at distant intervals along the course of the series, since they are comparatively few in number. Fundamental principles in zoological science are therefore exhibited in this class on a magnified scale, easily perceived and understood.

<sup>7</sup> The parallelism is complete: for the Amphipods differ from the Isopods just as the Macrourans from the Brachyurans, in having a larger and less compacted head, looser and larger mouth-organs, longer segments to the body, and an elongated foot-bearing abdomen; all, points of inferior concentration and cephalization.



of each—the orang-outang with the largest bat; the tiger with any Insectivore; the horse or elk with any Rodent; a Cetacean with any Edentate. The species of the second division, are relatively small and feeble animals; and if they are sometimes of great bulk, as with some ancient sloths, it is an example—though natural to the species—of vegetative overgrowth; for the bodies of the sloths; great and small, are, in fact, too bulky to be wielded well by the small life-system within.

Adopting this view as presenting the true basis for the subdivision of the viviparous Mammals, the two groups are significantly designated (1) MEGASTHENES (from *μεγας*, *great*, and *σθενος*, *strength*), and (2) MICROSTHENES (from *μικρος* *small* and *σθενος*). Judging of the mean size of the life-system in the two divisions from their more active as well as powerful species, the lineal ratio is not far from 4:1, as between the Decapods and Tetradecapods.

The orders in these two groups, the *Microsthenes* and *Megasthenes*, have throughout a precise parallelism. The *Bats* or *Chiropters* in the latter represent the *Monkeys* or *Quadrumanes* in the former, these orders having so close relations that they are made to follow one another in Cuvier's system; the *Insectivores* represent the *Carnivores*; the *Rodents* represent the *Herbivores*; and the *Brutes* or *Edentates*, the *Mutilates*.

The classification indicated is then as follows:

I. ARCHONTIA (vel DIPODA)—MAN (alone).

II. MEGASTHENA.

1. Quadrumana.
2. Carnivora.
3. Herbivora.
4. Mutilata.

III. MICROSTHENA.

1. Cheiroptera.
2. Insectivora.
3. Rodentia.
4. Bruta (Edentata.)

IV. OÖTICOIDEA.

1. Marsupialia.
2. Monotremata.

It is interesting to observe, also, that the four orders of Megasthenes rise in grade, from the 4th to the 1st, on the principles of cephalization stated; and this affords other evidence, *superadded* to that of higher importance based on difference in type of structure, as to the naturalness of these subdivisions. The species of the 4th—the Mutilates—are characterized by a degradation and partial obsolescence of the limbs; by the body being massively prolonged behind; by a large part of the elongated vertebral column being used for locomotion; by the form and the low grade of structure of the head; and by the teeth, always of extreme simplicity of form, in most species of one set only, in some excessively multiplied in number, in others all wanting;—peculiarities indicating a very low degree of cephaliz-



ation, and even a *degradation* of the anterior as well as posterior extremity. Those of the 3d—the Herbivores—by a more abbreviated body; by the two pairs of limbs being complete, but serving only for locomotion; by an elongated head. Those of the 2d—the Carnivores—by the limbs being still more perfect and serving, the anterior especially, for grasping; by the head being shorter and more compacted, and, in general, more complete in the series of teeth. Those of the 1st—the Quadrumanes—by the anterior limbs serving still more perfectly as hands; by the cephalic extremity further shortened; also by the mammæ being pectoral as in man. There is, in the series of orders, an advance by stages towards that acme of cephalization, Man.

Among the Microsthenes, the rise in rank on this principle is no less apparent. It is well seen between the lowest—the Brutes—and the others. These have posteriorly a remarkably lax vertebral column, but two or three of the vertebræ being soldered together to form the sacrum. The cephalic extremity exhibits, not only a low grade of cephalic concentration, as shown in the larger number of cervical vertebræ in some species—the excessive number of teeth in some species—the characters of the skull; but also a marked example of cephalic *degradation*, in the jaws,—in the very few teeth in most species and their total absence in some—in the inferior character of the teeth, and the growth of but one set; in all of which characteristics, as well as their bulky bodies, there is a close parallelism with the Mutilates, the lowest of the Megasthenes.

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ART. XI.—*Astronomical Observations with the Spectroscope*; by  
LEWIS M. RUTHERFURD, (in a letter to the Editors).

*Gentlemen*.:—In the course of a conversation, last December, with Dr. Gibbs, upon the remarkable revelations of the spectroscope, he suggested the continuation of Fraunhofer's observations upon the spectra of the heavenly bodies. At that time I had not seen Fraunhofer's paper on this subject, I immediately began a series of experiments with the view of determining the best form of instrument for the purpose; they resulted in adopting Bunsen and Kirchhoff's simple form of spectroscope, consisting of a condensing telescope with adjustable slit, a scale telescope with photographed scale of equal parts showing bright lines upon a dark ground, a flint-glass prism of 60° and an observing telescope with Hygenian eye-piece, magnifying about five times, the whole firmly but lightly mounted on seasoned wood and provided with an adapting tube in front of the slit by means of which the spectroscope is attached to the eye-tube of the