On the formation and arrangement of a dental museum : with a proposed dental classification of the placental Mammalia / by Robert T. Hulme.

On the Formation and Arrangement of a Dental Museum, with a proposed Dental Classification of the Placental Mammalia. By Robert T. Hulme, M.R.C.S.

In forming a Museum intended to illustrate any special branch of Natural History, it is necessary in the first place to determine the scope and limits of the subject. While this should be done in a wide and comprehensive spirit, so as to exhibit the relation in which the special department stands to the general science of which it is a portion, it ought, at the same time to be so far restricted as to retain the distinctive character of the collection.

The comparative anatomist classes the teeth with the skeleton, while the physiologist regards them as forming a portion of the digestive organs. The function of digestion consists of a mechanical and a chemical action; the first is accomplished in the higher animals by means of the teeth, the second by means of the stomach and various glands, some of which prepare the food for its entrance into the stomach, while others exert their influence upon it after it has emerged from the digestive cavity. To include the whole of

the digestive organs and their various modifications throughout the animal kingdom in the collection would be to convert it into a physiological museum, and would extend it beyond what can properly be termed a dental museum. The specimens should therefore be confined to illustrating the history and modifications of those organs that are concerned in performing the mechanical portion of the digestive function. Another point, of not less importance, is to consider the requirements of those who may desire to avail themselves of the information to be obtained from the contents of the museum.

A dental museum intended for the use of dental practitioners must necessarily contain such a series of preparations as shall fully illustrate the anatomy, physiology, and pathology of the human teeth, and also of the parts with which the teeth are so immediately connected that disease in the one may extend to or influence the other. To these must be added specimens of the instruments and mechanical appliances employed in dental practice.

It might be considered that here the museum should terminate, but since man, although placed at the head of the animal kingdom, represents only one form of animal life, the knowledge which could be acquired of the physiology of the teeth would be extremely limited unless the varieties of dental development presented by other

animals were also included in the collection. When to this is added the importance of the teeth in the study of zoology; the use which may be made of them for the purpose of classification often enabling the naturalist to determine not only the family but even the species to which the individual belonged; the light they throw upon the food, habits, and organization of an animal; the information they give as to the nature of those extinct forms of life which inhabited our globe in former ages, and of which they are frequently the only records that are left; the propriety of including the teeth of the lower animals in a dental museum can hardly be questioned.

Incapable of being properly illustrated by preparations of the human teeth alone and liable to be lost sight of amidst the details of their comparative anatomy, the physiology of the teeth, or the general laws which regulate their development, growth, and structure should be illustrated by a separate series of preparations. In a purely scientific point of view, this series should, in fact, be placed at the head of the collection, but considering the special object and character of the museum, it is better it should follow the department connected with practical dentistry and precede the comparative anatomy series.

The microscopic structure of the teeth and the changes their tissues undergo in disease must

necessarily be included in the natural history and pathology of the human teeth; the ultimate structure of the teeth of the lower animals should also be shown in the comparative anatomy series. Inasmuch, however, as these specimens are of a distinct kind and require to be prepared and preserved in a different manner to those which illustrate the formal or external anatomy of the teeth, it will be most convenient to bring them together into a distinct series of microscopic preparations.

Should circumstances permit, a department might be advantageously devoted to the teeth of the animals indigenous to Great Britain, showing the changes which take place from the eruption of the temporary to the completion of the permanent set. In the case of the Horse, the Ox, and the Sheep whose commercial value depends upon their age, the order in which the teeth are lost as old age advances should also be shown.

It must be borne in mind that the whole of the class Aves and the Chelonian division of the class Reptilia are edentulous and are provided with horny mandibles of various forms adapted to the nature of the food and mode of life of the individual. These modifications of the jaws are not less interesting and instructive illustrations of teleological adaptations than those which are exhibited by the teeth themselves. Although it may not be necessary that every modification of the

beak should be represented, yet it is desirable that type specimens and such special modifications as are directly connected with the habits of the animal or the nature of its food should find a place in the collection.

Thus far the museum would illustrate the teeth of the vertebrate animals. If it is desired to complete the subject and to give the entire history of the cibarial instruments throughout the animal kingdom and of all that relates to the mechanical portion of the digestive function, it will be necessary to add illustrations of the modifications which the mouth undergoes in those lower forms of life which are collectively spoken of as the Invertebrata. Carried out in this manner the museum would consist of the eight following departments :—

1. Anatomy, physiology, and pathology of the human teeth.
2. Surgical instruments.
3. Mechanical appliances.
4. Physiology of the teeth.
5. Comparative anatomy of the teeth.
6. Microscopic structure of the teeth.
7. Teeth of animals indigenous to Great Britain.
8. Instruments employed by the Invertebrata in procuring and comminuting the food.

Having determined the scope and limits of the museum, the next object must be to ascertain the

best method of arranging the specimens. The two last divisions being only suggested as additions to be made to the museum at some future time, they need not detain us on the present occasion, while the manner in which the specimens belonging to the four first divisions should be arranged, is so far evident that it is unnecessary to enter into details as to the precise order of their distribution. With regard to the microscopic specimens, these will follow in the same order as the comparative anatomy series, and it is therefore the arrangement of the specimens belonging to this important division of the museum that has to be considered. The question is whether the same order and arrangement must be followed as the naturalist has adopted from the study of the other organs, or whether the teeth can be taken as the basis of a classification, without violating the natural affinities of the different families and orders belonging to the vertebrate sub-kingdom, and more especially of those which constitute the class Mammalia.

In a general anatomical museum, each system of organs belonging to the animal economy finds its appropriate place, and is illustrated by a separate series of specimens. Each series is supplemental to the others, and all of them together form one continuous and harmonious whole. By studying the different series, we may obtain a complete history of the organization of each in-

dividual animal, are enabled to determine its true position in the animal kingdom, and to form a correct estimate of the relation in which it stands to other animals. This cannot be accomplished in an unexceptionable manner by means of any single organ, even where it is of such importance as the nervous system, still less can it be done when we have only a comparatively subordinate system, such as that of the teeth. At the same time the teeth are so important amongst the higher animals, and afford such valuable information as to the nature of the food and the habits of the individual, that it is necessary to examine the subject somewhat in detail, and ascertain what use the naturalist and classifier have made of these organs, in their attempts to define and group together the different families and genera of the vertebrate animals.

In an ascending survey of the animal kingdom true teeth * are first met with in the class of fishes. In the majority of these animals the teeth are numerous; the cone, or some modification of it, is their usual form; they may be triangular, with smooth or serrated edges, or broad, flat, and adapted for crushing. Hence Agassiz has divided the teeth of the fish into *prehensile*

---

* A tooth may be defined as a peculiar osseous body situated in the mouth or at the commencement of the alimentary canal, serving to procure and masticate the food.

teeth and into *molar* teeth. Whatever form they may assume, they generally resemble each other in the individual, presenting a good illustration of what has been termed "vegetative or irrelative repetition." As we ascend in the scale of organization, that subdivision and specialization of the organs take place by which the various functions are brought to their most perfect condition. Thus the pectoral and abdominal fins of the fish, with their multiplicity of rays, are, in reality, the prototypes of the anterior and posterior limbs of the higher animals; and so also the hundreds of teeth with which the mouth of the Sharks, the Rays, the Osteoglossum, and many other fishes is beset, are the forerunners of the dental system of the Primates.

In most fish, then, the teeth closely resemble each other, and exhibit little difference in either their form or their function, excepting that those at the anterior part of the mouth may be adapted to seizing and holding the prey, while those at the posterior part may serve to lacerate and crush it, as exemplified in the tesselated jaws of the Cestracion Philippi, or Port Jackson Shark. Any increase in the number of the teeth simply adds to the power the creature possesses of thus holding and destroying its prey, the uses to which these organs are restricted in the present class, where the food is rapidly swallowed without undergoing any elaborate process of mastication. So long as

this repetition of a part continues, however well the organ may be adapted to the requirements and habits of life of the animal, it can afford no sound basis of classification. Hence the only use which the naturalist has made of the teeth in the classification and arrangement of existing fishes has been to designate some two or three families from certain peculiarities in their teeth. Thus we have the family of the Gymnodonts,* or naked teeth, and these are subdivided into the Diodonts † and Tetradonts,‡ or those with two and those with four teeth. In the family of the Goniodonts § the teeth are long, slender, and bent at an angle, from whence the name is derived. In the Chætodonts ‖ the teeth in their length and tenuity resemble hairs, and are collected in several close-set rows like the bristles of a brush. But while these families have received their names from the characters presented by the teeth, they have been classified by means of peculiarities presented by other parts of their organization.

On the other hand, when defining the minor groups into which the primary divisions of the class are subdivided, the teeth even in the fish often afford useful and readily-ascertained cha-

---

* Gr. *gumnos*, naked; *odous*, a tooth.

† Gr. *dis*, two; *odous*.

‡ Gr. *tetra*, four; *odous*.

§ Gr. *gonia*, an angle; *odous*.

‖ Gr. *chaite*, a hair; *odous*.

racters by which the different genera may be distinguished from each other, or by which individuals belonging to the same family may be brought together.

Müller has employed the teeth, together with the arrangement of the breathing organs, and the number and position of the fins, to define the subdivisions, families, and genera under which he has arranged the various members of the Squalidæ or Sharks. But, the very fact that individuals belonging to different groups may yet possess the same dental characters is of itself sufficient to show the secondary importance of these organs in these lowest members of the Vertebrata as a means of classification.

With regard to the fossil species of fish which have been found in the different strata of the earth, many of them having belonged to the cartilaginous fishes, their remains have entirely perished, with the exception of the teeth; the consequence is that they have been named from some peculiarity in their position, their structure, or their form. Thus the term Acrodus * has been applied to certain cartilaginous fishes known only by their teeth, which are met with in the strata ranging from the Triassic system to the Upper Chalk. These teeth are supposed to have been aggregated about the extremities of the

* Gr. *Akros*, summit or extremity; *odous*.

jaws, in the same manner as those of the existing Cestracionts of the Australian seas. Dendrodus,* or tree-tooth, is the name that has been given to some fossil teeth from the Old Red Sandstone, and has reference to the dendritic appearance presented by their microscopic structure. The Pycnodonts,† or thick-toothed, constitute an extensive group of ganoid fishes occurring in the mesozoic strata. The mouth was furnished with a dense pavement of thick, round, or flat teeth, for the purpose of crushing the shells of the mollusks and crustacea upon which they fed. Sphærodus,‡ in which the teeth were circular, and arranged in regular rows, may be taken as an example of this group.

If the teeth of the fish cannot be relied upon for the purpose of classification, yet they often indicate the nature of the food, and to a great extent the mode of life, of the individual. When, therefore, we meet with fossil teeth bearing a close resemblance to those of certain existing species, it is only a legitimate and reasonable inference to suppose that they bore the same relation and proportion to the body of the former inhabitants of our globe that they do in the existing species, and that the habits and mode of

---

* Gr. *dendron*, a tree ; *odous*.

† Gr. *pyknos*, thick ; *odous*.

‡ Gr. *sphaira*, a sphere ; *odous*.

life of the extinct animal resembled that of its living representative. The following instance may serve as an example of this kind of inferential knowledge, and shows to what extent the presence of a fossil tooth may open to our contemplation the history of the past :—

The Great White Shark, *Carcharias vulgaris*, one of the most powerful and formidable of its class, attains a length of from twenty-five to thirty feet; the mouth is armed with a series of triangular flat teeth, with cutting or finely-serrated edges. In the United Service Museum there was preserved a jaw of this species of shark, now in the collection of the College of Surgeons, the upper one of which measured four feet, and the lower one three feet eight inches following the curvature. The largest of the teeth measured two inches in length, and one inch nine lines in breadth; the entire length of the animal was thirty-seven feet. Fossil teeth have been found in the Tertiary strata of both the Old and New Worlds exactly resembling those of the existing Carcharias, but measuring six inches in length, and five inches across the base. These fossils, therefore, reveal to us the presence of an animal in those ancient oceans which probably exceeded one hundred feet in length, and possessed the formidable powers and voracity of the shark.

The remarks that have been made upon the teeth of the fish in regard to classification will also apply, although in a somewhat diminished degree, to the class Reptilia. The teeth are now confined to the cavity of the mouth, that is, there are no throat teeth ; they are attached to a smaller number of bones, and are reduced in number. The cone, or some modification of it, is still the prevailing form.

The following table of the Reptilia is introduced for the convenience of reference, and not as a complete classification of the class, only those orders and families being introduced which are referred to in the paper, and which are distinguished by some peculiarity in the dental system. Those printed in italics are fossil.

CLASS REPTILIA.

- Batrachia . *Labyrinthodont.*
- Ophidia . . { Non-poisonous. / Poisonous.
- Sauria . . . { Scincidæ . . . . . Cyclodus. / Iguanidæ . . . . . { Pleurodonts. / Acrodonts. } / *Iguanodon.* / Lacertidæ . . . . { Pleodonts. / Cœlodonts. } }
- Pterosauria. *Pterodactylus.*
- Crocodilia . { Crocodilidæ. / Alligatoridæ. / Gavialidæ. }

Most reptiles are carnivorous, feeding upon a living prey, or upon the decomposing remains of

animal life that are carried down by the tropical rivers, on whose margins the larger species, such as the Crocodiles and Gavials, reside. Many of the smaller lizards are insectivorous, while some are herbivorous, feeding upon the tender and succulent parts of the plant, such as the leaf, the flower, and the fruit. In the carnivorous and insectivorous species the teeth perform the same functions as in the fish, and serve to seize, hold, and lacerate the prey; but in the vegetable-feeding Iguanians the conical teeth of the maxillary bones are expanded at the apex, assume somewhat of a trilobate form, and are notched at the edges, conditions which render them better adapted to crush and masticate the vegetable food upon which these animals live.

In the Batrachia the teeth vary so much in the different species that they cannot be employed as a means of classification; and this division of the Reptilia might have been passed over without any further remarks, had it not been for the discovery of certain fossil teeth belonging to gigantic animals whose nearest alliance amongst existing animals is with the Batrachia.* This, however, is not the reason for referring to them on the present occasion, but because the history of these

* This is the case, at least, in regard to some of the bones of the head and the distribution of the teeth. It is, no doubt, more correct to arrange them as a distinct order of the class Reptilia.

teeth shows in a remarkable manner the value of the microscopic characters as a means of identifying fossil teeth which may be met with in widely-separated localities, and also the important bearing which fossil teeth may have in determining certain geological questions.

In the Keuper division of the Triassic system, in Germany, some teeth, together with portions of the skull of an unknown reptile were found by Professor Jäger. A question had arisen as to whether the light-coloured sandstone of Warwick was the equivalent of the Keuper, that is the upper, or of the Bunter, that is the lower, of the three groups into which the Triassic system of Germany is divided. In the Warwickshire sandstone only a few teeth, or rather fragments of teeth and a portion of a vertebra had been found, these fragments constituting the only evidence the geologist possessed to guide him in his investigations.

The outward appearance of the fossils bore too close a resemblance to the ordinary type of reptilian teeth even to determine the question of relationship, much less of identity. It was under these circumstances that Professor Owen proceeded to make sections of the teeth supplied him by Professor Jäger. Upon examining a transverse section, the most remarkable and complicated arrangement of the pulp, dentine, and cementum of the tooth was presented to his

view, which had hitherto rewarded his extensive and elaborate investigation of the dental tissues, whether amongst living or extinct animals. The complexity referred to arises from the pulp of the tooth sending off processes which again subdivide or branch off; around each of these pulp processes or branchings there is formed a layer of dentine, which is in like manner invested by a layer of cementum; the consequence is that long undulating tracts of dentine are seen with an external coating of cementum, bending in from the circumference towards the central portion of the tooth, suggesting to Professor Owen the name of Labyrinthodont* as descriptive of this peculiar maze-like or labyrinthic interblending of the tooth pulp and of the dental tissues.

On making sections of the Warwickshire teeth, they exhibited the same subdivision of the tooth pulp, and the same complex arrangement of the dentine and the cement, leaving no doubt of the identity of their possessors, and equally determining the geological question as to the correspondence of the Warwickshire sandstone to the Keuper division of the German Triassic system.

The Ophidian reptiles, for our present purpose, may be divided into the poisonous and non-poisonous. The former are at once distinguished

---

* Gr. *labyrinthos*, a place full of intricate passages; *odous*, a tooth.

by the presence on the anterior extremity of the maxillary bone of a hollow conical tooth, commonly called the poison fang, through which the venom is conveyed into the wound. This peculiar form of tooth is produced by the bending of the pulp into a circle or ring, around which the dentine is arranged so as to leave a tubular passage passing from the base to the terminal poir of the tooth, where it opens immediately beneath the apex. The only teeth which could be mistaken for a poison fang are the posterior maxillary teeth of some of the non-poisonous snakes (*Dryophis*, *Dipsus*, and *Bucephalus*), which are traversed along their anterior convex side by a longitudinal groove. This groove may possibly convey an irritating secretion into the wound which the animal inflicts, but has no connection with any poison-secreting gland, as is the case with the hollow fang of the true poison snakes.

But, while the presence of a poison fang clearly indicates the habits of life of the individual, its absence, being merely a negative character, is of no essential value to the classifier, and no use has been made of the dental characters in this division of the Reptilia, excepting as one amongst several other peculiarities, which, when taken together, serve to distinguish the different families from each other.

In the upper jaw of the Ophidia teeth are present on the pre-maxillaries, the maxillaries, and

the pterygoid bones, in the Pythons, Boas (fig. 1), and other non-poisonous serpents, so that upon

Fig. 1.

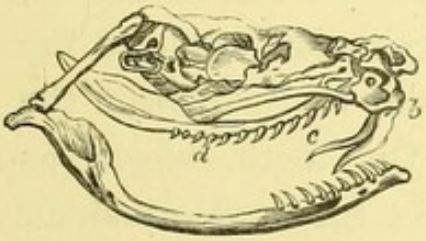
Half of the base of the Tiger-boa (*Python tigris*) : *a*, intermaxillary bone ; *b*, maxillary ; *c*, palatine ; *d*, pterygoid.

looking into the mouth there is seen four rows of sharp pointed recurved teeth, passing from the anterior to the posterior part of the palate. The two outermost rows correspond to the margins of the upper jaw, the two central ones to a line midway between the margin of the jaw and the central line of the palate.

In the typical poisonous snakes, such as the Crotalus (fig. 2) and others, the pre-maxillary bones being edentulous, and the maxillary bones having only the solitary poison-fang attached to

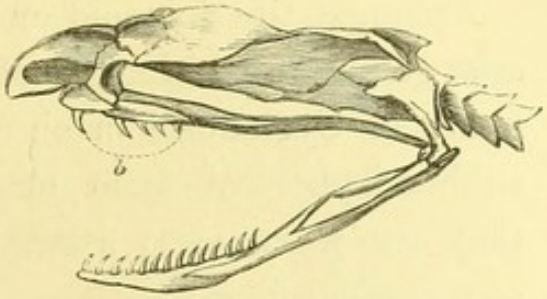
its anterior extremity, the rows of teeth are reduced to two in number, and this has been suggested as a means of distinguishing between the poisonous and the non-poisonous snakes. This distinction is invalidated by the fact that

FIG. 2.



Skull and teeth of a Rattlesnake (*Crotalus horridus*): *b*, maxillary bone and poison-fang; *c*, pterygoid teeth.

FIG. 3.



Dissected head of *Hydrophis striatus*: *b*, maxillary teeth.

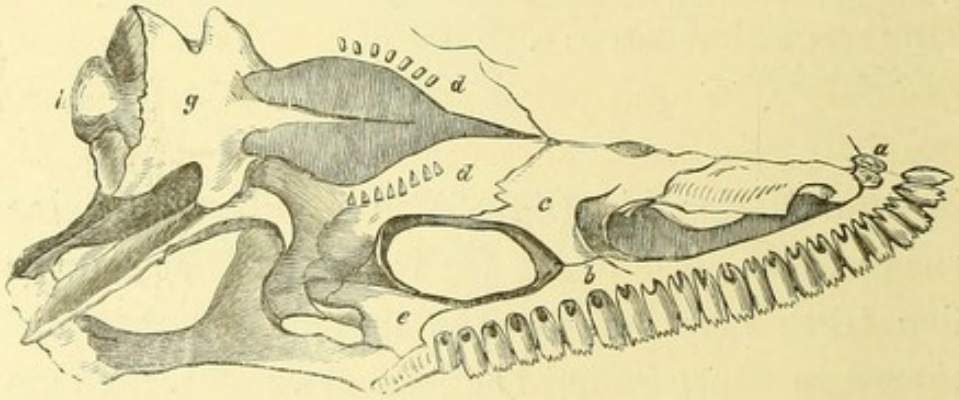
in the Hydrophis (fig. 3), a family of marine snakes, the poison-fang (*b*) is followed by four or five teeth attached to the maxillary bone, and therefore reproducing the four rows of teeth that are seen in the non-poisonous boas and pythons. So also in the Colubriform poisonous serpents of the land, behind the venom-fangs there are some smaller grooved teeth in the maxillary bones; there are three such teeth in the *Bungarus pama*, and five in the *Bungarus annulatus*. In the Hamadryas, or great hooded poisonous tree snake of India, the venom-fang is relatively as large as in the typical poisonous serpents, but three or four

smaller grooved teeth are implanted behind it on the maxillary bone.*

In the majority of the Saurian reptiles the teeth are confined to the margins of the jaws, but in some teeth are also placed upon the palate, not, however, supported by the palatine, but by the pterygoid bones.

Amongst the Scincoid or smooth scaled lizards, one genus inhabiting Australia has received the name of Cyclodus,† or circular toothed, from the subhemispherical form of the teeth, which as they are worn away assume a tubercular instead of a conical form.

FIG. 4.



Half the base of the skull of the *Iguana tuberculata*: *a*, intermaxillary bone; *b*, maxillary; *c*, palatine; *d*, pterygoid supporting teeth.

The Iguanidæ, which have already been referred to as examples of vegetable feeding lizards, constitute an extensive family inhabiting both the

---

* "Odontography." By R. Owen, F.R.S. p. 228. London, 1840-1845.

† Gr. *kuklos*, a circle; *odous*.

Old and the New World. These animals are distinguished by the presence of a membranous expansion or pouch, which hangs down from the under surface of the throat, forming a kind of dewlap. The family is best known by the common *Iguana tuberculata*, which inhabits the greater part of South America and attains a length of four or five feet.

MM. Dumeril and Bibron have divided this family into two great sections, which are distinguished by the manner in which the teeth are attached to the jaw bones, this distinction also corresponding to their geographical distribution.

In the one, and it is that containing the largest number of species; the teeth are lodged in a common alveolar groove and are united by their basis to the inner surface of the outer wall of the groove in the maxillary bones; these are the *pleurodont* * Iguanians. The majority of the pleurodonts are further distinguished by the possession of pterygoid teeth; † a smaller number have the palate edentulous; ‡ they are all inhabitants of America.

---

* Gr. *pleuron*, the side; *odous*.

† According to MM. Dumeril and Bibron the following genera possess pterygoid teeth: *Polychrus*, *Urostrophus*, *Amblyrhynchus*, *Iguana*, *Metopoceros*, *Cyclurus*, *Brachylophus*, *Leiosaurus*, *Hypsibates*, *Proctotretes*, *Ecphymotes*, *Stenocerus*, *Oplurus*, *Anolis*, *Corythophanes*, *Basiliscus*, and *Aplophonotus*.

‡ The following genera have no pterygoid teeth: *Hyperanodon*, *Tropidolepis*, *Phrynosoma*, and *Callisauros*.

In the other division the teeth are anchylosed to the summit of the alveolar ridge of the jaw, and are termed *acrodonts*.*

The Iguanidæ present another well-marked example of the value of the dental characters in determining the nature and alliances of certain extinct animals. The late Dr. Mantell, in the course of his investigations of the sandstone of the Tilgate forest, discovered, amongst other fossils, some teeth, which were distinct from any that had previously come under his notice, and which he was unable to identify with those of any living animal. Specimens of these teeth were transmitted to Baron Cuvier, and his reply to Dr. Mantell was to the effect that the teeth were unknown to him, that they certainly did not belong to a carnivorous animal, and that judging from their simple form, the notching at the edge, and the thin layer of enamel with which they were invested, that they were reptilian. Have we not here, he asks, a new animal, an herbivorous reptile, and as amongst the existing terrestial mammals the herbivorous species are the largest, so with the reptiles in former times, when they were the only terrestrial animals, would not the largest amongst them be vegetable feeders?

Pursuing his inquiries in this direction, on comparing the fossil teeth with those of the

---

* Gr. *akros*, the summit; *odous*.

existing Iguana, he found that they possessed the same form and structure.

"Like the teeth of the recent Iguana, the crown of the tooth is acuminated; the edges are strongly serrated or dentated, the outer surface is ridged, and the inner smooth and convex; and, as in that animal, the secondary teeth appear to have been formed in a hollow in the base of the primary ones, which they expelled as they increased in size." *

Guided by the dental characters, Dr. Mantell bestowed upon the extinct reptile the title of Iguanodon.† This gigantic creature, whose total length has been estimated at seventy feet, of which the tail occupied fifty-two feet, was an inhabitant of the geological strata, which are met with in the Wealds of Kent and Sussex. These deposits appear to have been formed in a brackish estuary where a coarse but abundant vegetation prevailed. The teeth of the Iguanodon were well adapted to crushing this kind of vegetable food; and the articulation of the lower jaw indicates a true act of mastication, the glenoid cavity being so constructed as to allow of a horizontal movement of the jaw, by which the irregular surface of the antagonizing teeth were drawn across each

---

* Philosophical Transactions, 1825. Mr. Mantell. Notice on the Iguanodon.

† Gr. *iguana* and *odous*.

other; while the size of the foramina, through which the nerves of the face passed out, show that the animal was provided with more muscular and better developed cheeks and lips than any existing crocodiles or lizards,* conditions which must have greatly facilitated the thorough mastication of its vegetable food.

The family of the Lacertidæ, or true lizards, represented in this country by the small sand lizard, *Lacerta agilis*, which is usually about seven inches in length, and by the viviparous lizard, *Zootika vivipara*, which is usually somewhat smaller, have been divided by Bibron into two groups, distinguished from each other by the construction of the teeth.

In the first group the teeth are solid, having no cavity in their interior, and are firmly anchylosed by their base to the alveolar groove, upon the inner side of the jaw; these constitute the *pleodont*,† or full-toothed lacertians.

In the second group the teeth are excavated by a kind of canal, and are attached to the outer alveolar wall, but do not adhere by their base: these constitute the *cœlodont*,‡ or hollow-toothed lacertians.

Allied to the lizards is the extraordinary race

---

* *See* Pictet's Paléontologie, vol. i., p. 471.

† Gr. *pleos*, full ; *odous*.

‡ Gr. *koilos*, hollow ; *odous*.

of extinct reptiles, the Pterodactyles, which were endowed with the power of flight by means of true wings. These animals, when their remains were first discovered, were placed by different naturalists amongst the birds, the mammalia, and the reptiles, to the latter of which they are now universally admitted to belong. Here, again, as in so many other instances, the characters of the teeth served to guide Cuvier to a correct determination of the nature of the animal. "The teeth," says this writer, "by which the examination of an animal should always commence, here present nothing equivocal. They are all simple, conical, and closely resemble each other, as in the crocodiles, the monitors, and other lizards."*

The last division of the reptiles is that containing the crocodiles. It was seen that in the lacertian reptiles the teeth were reduced in number, and, as a rule, confined to the margins of the jaws. In the present division the only bones which support teeth are the pre-maxillaries and the maxillaries in the upper jaw, and the premandibular portion of the lower jaw. The teeth do not vary in number to the same extent as in the previous orders. In the individual the teeth will vary in number, within certain limits, in consequence of the constant loss and reproduction

* Ossem. foss. Ed. 1836, tom. x., p. 225.

which go on throughout the life of the animal, but the entire number of teeth that can be in use at the same time is definitely fixed. The teeth are no longer anchylosed to the jaws, or contained in an open alveolar groove, but each is received into its separate compartment or socket. They are of a conical form, somewhat recurved, and have often a sharp anterior and posterior edge. The surface is marked by longitudinal grooves and ridges; and, when the mouth is closed, those of the two jaws interlock. The teeth of the Crocodiles and Alligators are relatively larger than those of the Gavials.

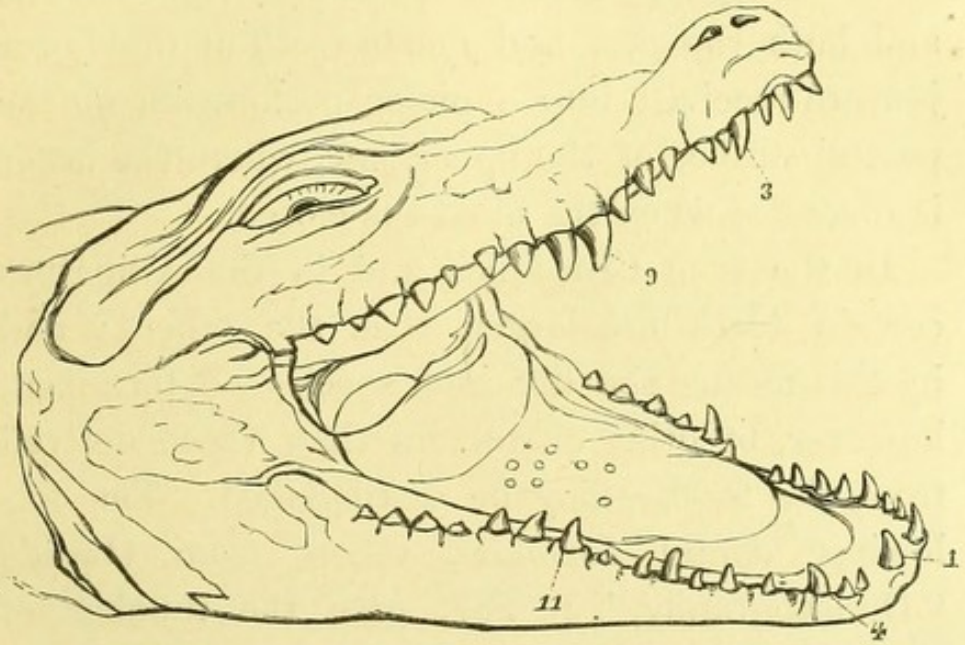
The Crocodilia may be subdivided into three sections, consisting of the true Crocodiles, the Alligators, and the Gavials: these may be distinguished from each other by the form and proportions of the head, and by certain characters presented by the teeth. "The best and most readily recognisable characters by which the existing Crocodilians are grouped in appropriate genera are derived from modifications of the dental systems." *

The true Crocodiles, of which the Crocodile of the Nile, *Crocodilus vulgaris* (fig. 5), is the most familiar, have the snout oblong, obtuse, and flattened. The *first* tooth (1) in the lower jaw perforates the palatine process of the intermaxil-

* Owen, *opus cit.*, p. 286.

lary bone when the mouth is closed; while the *fourth* tooth (4) is received into a notch in the

FIG. 5.

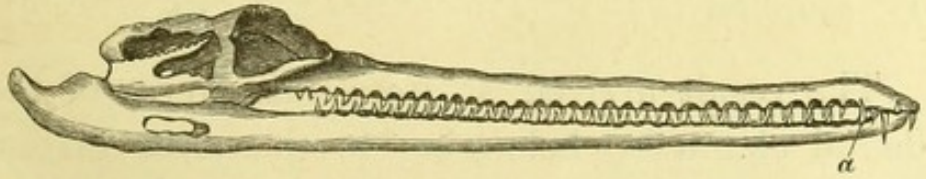


Skull of Crocodile: 1, large anterior tooth, received into a pit or perforation of the upper jaw; 4, received into a groove in the upper jaw, and visible when the mouth is closed; 3 and 9 mark the largest teeth in the upper jaw.

side of the alveolar margin of the upper jaw, and is *visible* when the mouth is closed.

In the Gavials (fig. 6) the jaws are elongated and slender; the teeth are numerous, of nearly

FIG. 6.



Skull of a Gavial: *a*, fourth tooth of lower jaw, received into a notch of the upper jaw when the mouth is closed.

equal size and similar form in both jaws, and both

the *first* and *fourth* tooth (*a*) pass into a *groove* in the margin of the upper jaw when the mouth is closed.

The Alligators have the snout broad and obtuse, and both the *first* and *fourth* teeth of the lower jaw are received into a pit or perforation on the palatal surface of the upper jaw, where the latter is *concealed* when the mouth is closed.

In the true Crocodiles and in the Alligators certain teeth are larger than the others; and by this means the different species—determined, however, by other characters than those derived from the teeth—may be distingished. The following dental formulæ, taken from Owen's "Odontography," p. 287, give the number of teeth in each jaw, distinguishing those which are the largest in two species of alligators and in two species of crocodiles:—

Alligator palpebrosus $\frac{19-19}{21-21}=80\ \frac{2,5,7,10}{1-4}$ largest.

Alligator lucius $\frac{20-20}{20-20}=80\ \frac{4,5,8,9,10}{1,3,4,11,12,13}$ largest.

Crocodilus vulgaris $\frac{18-18}{15-15}=66\ \frac{3-9}{1,4,11}$ largest.—*See* fig. 5.

Crocodilus bifurcatus $\frac{18-18}{15-15}$ or $19-19=66$ or $68\ \frac{2,3,8,9}{1,4}$ largest.

The result arrived at from this survey of the dental characters belonging to the class Pisces, and to the several orders of the Reptilia, may be briefly summed up by saying: that, from being very numerous and attached to all the bones which

enter into the formation of the floor and roof of the mouth, those forming the base of the skull, and those surrounding the entrance to the œsophagus, they have become restricted to the margins of the jaws; and from being mere repetitions the one of the other, and indefinite in number, they are now limited, and are beginning to assume special and distinctive characters by which certain teeth may be distinguished from the rest of the series, and assigned to a particular position in the jaws. The teeth are no longer lodged in an open groove, or attached by anchylosis or by ligament to their supporting bones, but each is provided with its separate socket; and, while at first they enabled the naturalist to do little more than predicate the class to which the animal belonged, it is now possible, within certain limits, to determine not only the class, order, and family, but even the species to which the individual belonged. It must, however, be understood that the characters derived from the teeth in the present classes do not possess that general application which is necessary in those upon which the primary divisions of a class are based. We must, therefore, be content to adopt those divisions in the arrangement of the museum which have been established by the naturalist on other grounds, but at the same time give prominence to those dental peculiarities which have just been pointed out.

The class Mammalia, which has now to be examined, contains the most highly organised members of the animal kingdom—those which are endowed with the most numerous faculties, and possess the greatest amount of intelligence. These animals are distinguished by the female having two or more mammary glands, whose office is to secrete the milk upon which the young are nourished at the period of birth, and for some time after.

The majority of these animals are inhabitants of the land, where some pursue a living prey, or devour the decaying remains of the dead; the smaller and feebler species feed upon the multitudinous tribes of insects; others are vegetable feeders; and some partake of a mixed diet of animal and vegetable food, corresponding to what are commonly termed the carnivorous, insectivorous, herbivorous, and omnivorous races. Others of the Mammalia are adapted to an aërial existence, while some live exclusively in the water; both of these divisions may be divided into animal feeders and vegetable feeders. Another series lead a kind of amphibious life, residing sometimes in the water and sometimes on the land, so that the Mammalia are adapted to every mode of life that is met with in the fish, the reptile, or the bird.

As the nature of the food varies, so do the characters of the teeth. And, as the general

structure and organization of an animal is modified in accordance with its habits of life, then, since the principal occupation of the irresponsible and unreasoning animal is to provide itself or its young with food, it is evident how greatly its general structure must also be influenced by that pursuit which fills up the greater part of its existence. If the teeth are modified in accordance with the food; and if the general structure of the animal is also governed by the same condition, then it will almost follow as a matter of necessity, that the one must become the index to the other, and that consequently from the character of the teeth the rest of the organization may in a great measure be inferred. It is this correlation of structure which affords the clue to the paleontologist by which he is able to unravel the history of those fragments of animal life which have been aptly termed the "medals of creation."

In all the Mammalia, when the teeth are present, they are confined to the premaxillary, maxillary, and mandibular bones.

In the Cetacea, which resemble the fish in their mode of life, and in some of the lower forms of the terrestrial mammals, such as the Armadillos, the teeth are uniform in their appearance, and excessive in number,* presenting an example of that kind of

* Some of the Armadillos have as many as eighty or ninety teeth. In a specimen of the *Priodontes gigas*, in the College of

vegetative or irrelative repetition, which has been already referred to as indicating, either a low grade of development in the individual, or an imperfect condition of the organ. In the remainder of the class the teeth never exceed forty-four in the Placental,* or fifty-four in the Implacental† division.

The majority of the Mammalia are furnished with two sets of teeth, and these Professor Owen

---

Surgeons, the writer counted seventy-eight teeth in the two jaws. In the true Dolphins (*Delphinus*) there are as many as from one hundred to one hundred and ninety teeth, the latter number being present in the common Dolphin (*Delphinus delphis*). These teeth are not placed in separate sockets, but, like those of the lower vertebrata, are contained in an open groove; and when the gum is stripped off, the teeth come with it.

* Amongst existing animals this number is present in the common Hog (*Sus scrofa*, fig. 10); it is regarded as representing the typical number of teeth belonging to this division of the Mammalia, and was present in the *Anoplotherium* (fig. 14), and in a large number of extinct animals. In addition to this, in the *Anoplotherium* the teeth formed a continuous series in both jaws, without any break or interval between them, a character which is now confined to man. The following is the typical dental formula of the Placentalia:

$$\text{In. } \frac{3-3}{3-3}\text{; c. } \frac{1-1}{1-1}\text{; p. } \frac{4-4}{4-4}\text{; m. } \frac{3-3}{3-3} = 44.$$

† This number is met with in the *Myrmecobius fasciatus* of Waterhouse, the only existing representative of the family. The dental formula is,—

$$\text{In. } \frac{4-4}{3-3}\text{; c. } \frac{1-1}{1-1}\text{; p. } \frac{3-3}{3-3}\text{; m. } \frac{6-6}{6-6} = 54.$$

has named the Diphyodont* mammalia. The few that have only one set he terms Monophyodont† mammalia.

The teeth no longer resemble each other, but assume special forms and functions, and, what is of no less importance, hold distinct positions in the jaw bones, by which they can be homologically determined in the different animals; also in the same animal, first in regard to the upper and lower jaws; and, secondly, in regard to the two sides of the same jaw.‡ The mode of development and the order of succession have also an im-

---

* Gr. *dis*, twice; *phuo*, I generate; *odous*.

† Gr. *monos*, once; *phuo* and *odous*. Professor Owen included in his monophyodonts the orders *Monotremata*, *Bruta*, and the true *Cetacea;* but Mr. Flower has recently shown that the common nine-banded Armadillo—*Tatusia peba*, Desm.—is furnished with two sets of teeth. In a fœtal specimen he found the germs of seven milk teeth in both jaws.—*Proceed. Zool. Soc.*, June 11th, 1868.

‡ In a paper "On the Nomenclature of the Mammalian Teeth," by Mr. H. N. Moseley, B.A., and Mr. E. Ray Lankester, first read at the meeting of the British Association at Norwich, and since published in the *Journal of Anatomy and Physiology* for November, 1868, the homologies and nomenclature of the teeth, as at present received, are called in question. The subject is one of too much importance, and would occupy too much space, to be discussed within the limits of a note. I cannot, however, think that their objections, except in a few isolated cases, are valid, or that on account of these zoologists will forego the advantages of a more definite dental nomenclature than the one they propose to substitute for our present system.

portant bearing upon the homologies of the teeth. From these peculiarities the teeth of the Mammalia have been divided into four series, which have received the names of incisors, canines, pre-molars, and molars. These names, with the exception of the term pre-molar, were originally derived from the form or function of the teeth, but are now arbitrarily applied to the teeth situated in certain parts of the maxillary bones, whatever their form or function may be.

The term incisor, applied in the first instance to teeth adapted for cutting, is now given to all teeth situated in the pre-maxillary bones, and in the corresponding portion of the lower jaw. Thus the tusks of the Elephant, although weapons of attack and defence, and in no way connected with the food, further than as they may be employed to uproot the trees upon whose foliage the animal feeds, are nevertheless termed incisors, because they are situated in the pre-maxillary bones.

The term canine, derived from the circumstance that these teeth are largely developed in the dog, and are highly characteristic of the feline tribe, is always applied to the *first* tooth succeeding the incisors, which is situated in the maxillary bone.

The name of pre-molar—the bicuspid of the human anatomist—is given to those teeth which take the place of the molar teeth of the temporary

set; * they are also termed "false molars" and "small molars;" they are placed in the maxillary bones between the canines and the true molars. These teeth are never more than four in number on each side of the jaw and frequently one or two of them are suppressed; they are numbered from before backwards, and when any of them are suppressed it is the first or second; the third and fourth, or the two in front of the first true molar, being the most constant.†

The term molar is applied to the teeth situated at the back of the mouth, and are superadded to those which take the place of the temporary teeth. There may be only two, but there are never more than three on each side of the jaws in the Placental division of the Mammalia. When these teeth are below the typical number it is the posterior that are suppressed.‡

The pre-molars and the molars are usually im-

---

* Some of the teeth which have received the name of pre-molars have no milk predecessors, as has been shown by Mr. Flower in the case of the Dog and the Pig. The same thing occurs in the Badger, as stated by Mr. H. M. Moseley and Mr. E. R. Lankester in the paper just referred to.

† See the article "Teeth," in the "Cyclopædia of Anatomy and Physiology," vol. iv., page 903. Mr. Flower, in a paper, read at the last meeting of the British Association, "On the Homologies and Notation of the Teeth of Mammalia," stated that it is not always the case that when the pre-molars fall short of the typical number the absent ones are from the fore part of the series.

‡ *Ibid.*

planted in the jaw bones by two or more roots, which are received into distinct sockets. This character is peculiar to the Mammalia, and is therefore an important guide to the paleontologist in determining the nature of a fossil in which it is present.

In consequence of the intimate relation which has been shown to exist in the Mammalia between the teeth, the food, and the general structure of the animal, the definite position the different kinds of teeth hold in the pre-maxillary, maxillary, and mandibular bones, and the mode in which the two sets of teeth succeed each other, these organs are of the utmost importance for the purpose of defining the different families, and also of grouping them together.

Aristotle, in his "Natural History of Animals," makes frequent reference to the teeth, and establishes some important generalizations in regard to these organs. He recognizes three kinds of teeth, and mentions that those which are called canine teeth are placed between the cutting and the molar teeth.* Again, he observes, animals which have horns do not possess teeth in both jaws, for they have no front teeth in their upper jaw; while no animal has both tusks and horns.†

---

* "Aristotle's History of Animals," translated by R. Cresswell, M.A., p. 31, ¶ 13. London, 1862.

† Opus cit., p. 30, ¶ 9.

Animals that have not cutting teeth in both jaws ruminate, as the Ox, Sheep, and Goat;* and amongst viviparous quadrupeds, those that are wild and have pointed teeth are all carnivorous.†

These statements indicate an extensive and accurate knowledge of the teeth of the Mammalia, for without it the writer could not have arrived at those general laws whose correctness the researches of subsequent observers have only served to confirm. Aristotle, to a certain extent, also made use of the teeth for the purpose of classification.‡ He divided his Zootoka, which were equivalent to our Mammalia, according to the nature of their locomotive organs, into the Dipoda, or two-footed; the Tetrapoda, or four-footed; and into the Apoda, or footless animals; the latter corresponding to the Cetacea.

The Tetrapoda, or quadrupeds, were further subdivided into two great groups, distinguished by the characters of the extremities; these corresponded to what are now known as the Unguiculata, or animals whose digits are furnished with nails, and into the Ungulata, or those which are provided with hoofs.

The further division of the Unguiculata was

---

* Opus cit., p. 278, ¶ 6.

† Opus cit., p. 204, chap. vii., ¶ 1.

‡ The following account of Aristotle's classification is taken from the article Mammalia, "Cyclopædia of Anatomy and Physiology," vol. iii., p. 284.

based upon the characters of the teeth. The first group consisted of those Unguiculates which have the front teeth terminating in a cutting edge, and the back teeth with a flattened or triturating surface, as in the case of the Apes and the Bats. The second group was composed of animals provided with pointed canine or carnivorous teeth. The animals corresponding to the order Rodentia were characterised by the absence of the canines.

This arrangement will be best seen by presenting it in a tabular form.

ARISTOTLE'S ARRANGEMENT OF THE ZOOTOKA OR MAMMALIA.

Dipoda	... ...		Homo.
Tetrapoda	Unguiculata	Front teeth cutting, back teeth triturating	Quadrumana.
			Cheiroptera.
		Teeth acuminated or carnivorous	Carnivora.
		Canines absent	Rodentia.
	Ungulata	... ...	Pachydermata, &c.
Apoda	... ...		Cetacea.

No advance was made in zoological classification from the time of Aristotle until that of Ray, to whom we are indebted for the first improvement during this long interval of more than two thousand years. Ray's classification related only to the Mammalia with four feet, the Cetacea being

classed with the fish, an error which Aristotle had avoided.

Like Aristotle, the English naturalist selected the limbs as the basis of his classification, and divided the quadrupeds into the Ungulata or hoofed animals, and into the Unguiculata, or those having nails or claws. Amongst the latter he distinguishes the Carnivora, as having many incisors, and the Rodentia, as having two very large incisors.

The following table exhibits Ray's arrangement of the Unguiculate division of the Mammalia.

UNGUICULATA.*

(HAVING NAILS OR CLAWS.)

BIFID (Ruminantia).—The foot cleft in two, as the Camel.

MULTIFID.—The foot cleft in several parts.

With digits undivided, cohering by a common skin ; their extremities protruding only at the margin of the foot, and covered with obtuse nails, as the Elephant.

With digits somewhat separated. These are either *wide-nailed*, as the Monkeys, or *narrow-nailed*, with fore or INCISIVE teeth in each jaw.

Analoga (*Many Incisors*).—These animals are all carnivorous, or live promiscuously on insects and vegetables, as the Lion, Dog, Weasel, &c.

Two prominent Incisors.—All these are phytivorous, as the Hare, &c.

Anomola.—In these the teeth are either *absent* or *peculiar* agreeing neither in form nor disposition with the others, as the Tamandua, Hedgehog, Mole, Bat, &c.

---

* "Natural History of Man and Monkeys," by W. C. Linnæus Martin, F.L.S., p. 180. London, 1841.

The classification of Ray was followed by that of Linnæus, the first edition of whose "Systema Naturæ" was published at Leyden in 1735, and of which the fifteenth edition, the last that appeared during the author's lifetime was published in 1766. The classification of Linnæus, although not free from errors, exhibits a marked advance over that of Ray. His primary subdivisions are founded on the structure of the feet; while the ordinal characters are taken almost exclusively from the teeth, of which Linnæus makes much greater use than any previous writer. At the same time it must be remarked that the Rhinoceros, the Elephant, and the Walrus cannot be associated with the order Bruta, nor do they belong to the Unguiculate subdivision of the Mammalia.

LINNÆAN ARRANGEMENT OF THE CLASS* MAMMALIA.

The primary sub-divisions founded on the structure of the feet; the ordinal characters taken from the teeth.

Sub-division 1. UNGUICULATA.

(WITH NAILS OR CLAWS.)

Order I. PRIMATES.—*Characters:* With four front incisive teeth in each of the jaws; upper four parallel and a canine on each side of both; mammæ pectoral. *Genera:* Homo, Simia, Lemur, Vespertilio. (Man, Monkey, Lemur, and Bat.)

II. BRUTA.—*Characters:* With no fore-teeth in either jaw; the feet protected by stout nails. *Genera:*

---

* Opus jam cit., p. 181.

Rhinoceros, Elephas, Trichicus, Bradypus, Myrmecophaga, Manis, Dasypus. (Rhinoceros, Elephant, Ant-eater, Manis, &c.)

III. Feræ.—*Characters:* With two, six, or ten, but generally six, conical front teeth in each of the jaws; one canine, separated from, and longer than, the others, on each side, in both; and the cheek teeth having conical projections; the feet armed with sharp, hooked claws. *Genera:* Phoca, Canis, Felis, Viverra, Mustela, Ursus, Didelphis, Talpa, Sorex, Erinaceus. (Seal, Dog, Lion, Bear, Mole, Hedgehog, &c.)

IV. Glires.—*Characters:* Two incisive front teeth in each of the jaws, approximated, and remote from the grinders; no canines; feet adapted for running. *Genera:* Hystrix, Lepus, Castor, Mus, Sciurus, Myoxus, Cavia, Arctomys, Dipus, Hyrax. (Hare, Beaver, Mouse, Squirrel, &c.)

Sub-divison 2. Ungulata.

(with hoofs.)

V. Pecora.—*Characters:* No incisive teeth above; six or eight below, apart from the molars. *Genera:* Camelus, Moschus, Cervus, Capra, Ovis, Bos. (Camel, Musk-deer, Deer, Goat, Sheep, Ox.)

VI. Belluæ.—*Characters:* Incisive teeth, obtuse and truncate. *Genera:* Equus, Hippopotamus, Sus, Rhinoceros. (Horse, Hippopotamus, Hog, Rhinoceros.)

Sub-division 3. Mutica.

(with feet like fins for swimming.)

VII. Cete.—*Characters:* Teeth in some horny, in others bony; spiracles on the top of the head, pectoral fins in place of feet, and a horizontal flattened tail.—*Genera:* Monodon, Balæna, Physeter, Delphinus. (Monodon, Whale, Cachalot, Dolphin.)

The last classification which will be given is that of Baron Cuvier, as published in the second edition of the "Règne Animal." Like Linnæus, Cuvier employs the modifications of the extremities upon which to found his primary divisions of the Mammalia, and separates them into the Unguiculata, Ungulata, and Mutica.

The orders, which are nine in number, are established upon various anatomical distinctions, amongst which the characters of the teeth hold a prominent and important position. But, besides making use of the teeth to distinguish the orders and families into which he has divided the Mammalia, Cuvier has also employed them for the purpose of grouping together the different orders belonging to the Unguiculata into three sections, distinguished from each other by the number and characters of the teeth. The following table exhibits the results of Cuvier's arrangement; but it has not been thought necessary to give in detail the use he has made of the dental characters in defining the different orders and families into which his primary groups are subdivided.

MAMMALIA.

UNGUICULATA	With three kinds of teeth	Bimana.	
		Quadrumana.	
		Carnivora	Cheiroptera.
			Insectivora.
			Carnivora.
		Marsupialia.	
	Without canines	Rodentia.	
	Without incisors	Edentata.	
UNGULATA	Non-ruminants	Pachydermata.	
	Ruminants ...	Ruminantia.	
MUTICA		Cetacea	Herbivora.
			Cetacea.

Such is the use which some of the most distinguished naturalists have made of the teeth, for the purpose of defining and classifying the families of the Mammalia up to the time of Cuvier. The more accurate and extended knowledge which has been obtained since that period of the Marsupial animals, and also of the Monotremes, animals which Cuvier arranged with the Edentata, has necessitated an entire revision of his classification, which has resulted in the Mammalia being subdivided into three great groups or subdivisions, based upon the peculiar modifications of the reproductive organs in the female. These are the Monodelphia or Placentalia, containing the ordinary forms of mammalian life; the Didelphia, or Implacentalia, which contains the Marsupial

or pouched animals; and the Ornithodelphia or Monotremes, which includes those peculiar animals, the Echidna and the Ornithorynchus.

In a paper read before the Linnæan Society in February, 1857, Professor Owen proposed to subdivide the Mammalia according to the characters presented by the brain. The resulting classification cannot be said to have been favourably received; nor does it lead to such an arrangement of the orders as is in accordance with the expressed views of naturalists in general; in addition to which there are many instances where it would be very difficult to determine from the character of the brain alone, to which of the proposed divisions the animal belongs.

Professor Huxley,* in one of his lectures, delivered in the theatre of the Royal College of Surgeons, and entitled, "The Sub-divisions of the Mammalia larger than Orders," after adopting the three-fold division based upon the characters of the reproductive organs, proposes to adopt the structural peculiarities of the placenta as a means of grouping together the different orders which compose the Monodelphia or placental division of the Mammalia. Striking and interesting as are some of the results arrived at from the investigations of the embryologist,

* "Elements of Comparative Anatomy," p. 87. By T. H. Huxley, F.R.S. London, 1864.

they cannot be said, at least in the present state of our knowledge, to lead to sufficiently uniform and definite results; nor have they, any more than the cerebral characters, been generally accepted.

There is one very obvious and practical objection to the adoption of such anatomical and structural peculiarities as a basis of classification, namely, that in the case of a newly discovered animal it is only after careful dissection we can positively assert in which group, or subdivision, it should be placed. In the case of the placental classification, this involves the dissection of the impregnated female.

The more easily a character can be ascertained and recognised, the more permanent and enduring its nature, the more intimate and extensive its connection with the general structure of the animal, the better it is adapted for the purposes of the comparative anatomist, the naturalist and the paleontologist. No part of the animal possesses these qualities in a greater degree than the teeth; and with these advantages it remains to be seen whether they can be employed for the purpose of grouping together the different orders of the placental division of the Mammalia in a convenient and natural manner.

I have endeavoured to do this by dividing the Placentalia into three groups or sub-divisions, to

which I have given the names of Monoidodonts,* Diidodonts,† and Triidodonts,‡ or those having one kind of teeth, two kinds of teeth, and three kinds of teeth. I must, however, repeat what I have previously remarked that no single character will afford the basis for a perfectly natural classification, and, therefore, certain exceptions will be met with, but I do not think that they are either more marked or more numerous than those which arise from a cerebral or placental classification.

ARRANGEMENT OF THE PLACENTAL MAMMALIA FROM THE CHARACTER OF THE TEETH.

- Mammalia
  - Placentalia
    - Triidodonts
      - Bimana.
      - Quadrumana.
      - Cheiroptera.
      - Insectivora.
      - Carnivora.
      - Ruminantia.
      - Pachydermata.
    - Diidodonts
      - Rhinocerina.
      - Rodentia.
      - Proboscidia.
      - Sirenia.
    - Monoidodonts
      - Cetacea.
      - Bruta.
  - Implacentalia. Marsupialia.
  - Ornithodelphia. Monotremata.

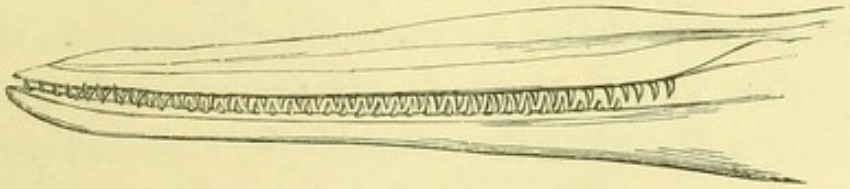
* Gr. *monos*, one ; *eidos*, kind ; *odous*, a tooth.

† Gr. *di*, two ; *eidos* and *odous*.

‡ Gr. *treis*, three ; *eidos* and *odous*.

In the Monoidodonts the teeth are either absent or are of one kind only, consisting of those which

FIG. 7.



Jaw of Dolphin, showing the type of the Monoidodont dentition.

are developed in the maxillary bones and in the corresponding portion of the lower jaw. This division contains two orders, Bruta and Cetacea.

The order Bruta includes the Ant-eater (*Myrmecophaga*, Lin.), the Scaly Ant-eaters or Pangolins (*Manis*, Lin.)—these are edentulous—the Armadillos (*Dasypus*, Lin.), the Orycterope or Cape Ant-eater (*Orycteropus*, Geof.), the Sloths (*Bradypus*, Lin.), together with the extinct Megatherium, Mylodon, Glyptodon, and some other allied forms which have been found in the diluvial deposits of the American continent.

In this order we meet with the following exceptions to the dental characters assigned to the group. In the existing genus Dysapus of F. Cuvier, the first tooth in the upper jaw is placed in the intermaxillary bone, while the two first in the lower jaw close in front of it; these teeth must therefore be regarded as incisors. In the extinct Chlamydotherium, the two anterior teeth in the upper jaw, and the three anterior in the

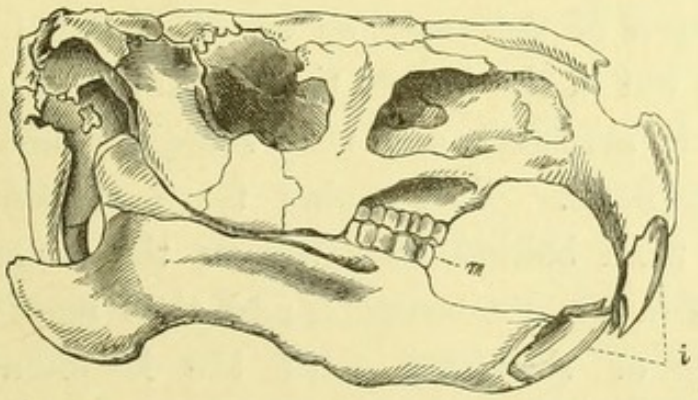
lower jaw, are, by position, incisors. So also in the Glyptodon a fragment of the lower jaw shows that the teeth extended to the symphysis, and there is, therefore, every probability that teeth were present in the intermaxillary bone. In the Unau, or Two-toed Sloth (*Bradypus didactylus*, Lin.), the first tooth in the upper jaw is placed close to the intermaxillary suture, is separated by a considerable interval from the other teeth, and has a pointed form. It is the same in regard to the first tooth in the lower jaw, and both—it cannot be said incorrectly—have been termed canines; but at the same time it is to be observed, that the upper tooth closes in front of the lower, an arrangement which is the reverse of what usually occurs in other animals, where the lower canine always passes either in front or to the inside of the corresponding tooth of the upper jaw. Practically, even these exceptions could scarcely be a source of error, inasmuch as the simple form and uniform appearance of the molar teeth would clearly indicate the natural affinities of the animals.

In the Cetacea the teeth are of a conical form, and are placed in the maxillary bones and in the corresponding portion of the lower jaw. In the Spermaceti Whale (*Physeter macrocephalus*) the teeth are confined to the lower jaw. The same thing occurs in the Great Bottle-nosed Whale (*Hyperoodon*), and some others in which the teeth

are reduced to two in number. The Whale-bone Whale (*Balœna mysticetus*) is edentulous and is provided with plates of whalebone in the place of teeth; but even these animals, as was first shown by Geoffroy St. Hilaire, have the germs of teeth developed in the open groove of the jaw bone during the fœtal state. In the Narwhal, or *Monodon*, a simple, long, spirally twisted tusk is developed in the male animal on the left side, which is lodged in the intermaxillary bone,* and is, therefore, an incisor; but, with this exception, the remainder of the order conforms to the definition of the group.

In the Diidodonts only two kinds of teeth are

Fig 8.



Skull of Capabyra, showing the type of the Diidodont dentition; *i.* incisors, *m.* molars.

* Very rarely both the right and left tusks are developed in the male. A specimen of this kind is contained in the museum at Amsterdam. In the female the development of both tusks is arrested at an early period of their growth, and they remain concealed in the intermaxillary bones, fully ossified, but functionless teeth.

present, namely, Incisors and Molars. These teeth are separated by a considerable interval from each other, the canines never being developed in the animals which compose the orders belonging to this group. This division includes the Sirenia, or herbivorous Cetacea, the Proboscidia, the Rodentia, and what I have ventured to term the order Rhinocerina, and of which more will be said presently.

The Sirenia, or herbivorous Cetacea, consist of the Manatees and the Dugong. The dentition of these animals is somewhat peculiar and irregular. In the young Manatee, a single deciduous tooth is developed in each intermaxillary bone; but when this falls out it is not succeeded by another. In the Dugong two incisors are developed in the upper jaw of the male, so as to project from the gum; but in the female the development of these teeth is arrested, and they remain concealed in the jawbone. The molar teeth succeed each other from behind forwards in the same manner as in the Proboscidia, and thus manifest the affinity of the Sirenia to the Elephants and Mastodons, next to which they are placed in the table.

In one species, *Rhytina Stelleri*, now supposed to be extinct, but which only disappeared at the close of the last century, the teeth were absent, and in their place the animal was provided with a pair of bony plates in the anterior portion of

the mouth, one of which was attached to the palate, the other to the lower jaw.

The transition from the herbivorous Cetacea to the large terrestrial Proboscidia is accomplished by means of the extinct *Dinotherium*. These animals were provided with a proboscis. There were no incisor teeth in the upper jaw, but a series of five molar teeth in each maxillary bone; the three true molars being characterised by transverse ridges, similar to those that are seen in the molars of the Tapir. The most characteristic portion of the skull is the lower jaw, which at its anterior portion and at the symphysis is deflected, and supports two long curved tusks that are directed downwards. The largest species, the *Dinotherium giganteus*, is estimated to have measured eighteen feet in length, and exceeded the size of the largest fossil Elephant. The Dinotheres, like the Hippopotami, were semi-aquatic. Their peculiar tusks served as weapons of defence, for the purpose of digging, and probably assisted them to ascend the banks of the freshwater lakes and rivers, which they frequented during the middle portion of the Tertiary period. The form of the occipital bone, says Dr. Buckland, approximates to that of the Cetacea, the Dinotherium in this structure affording a new and important link between the Cetacea and the Pachydermata. In the Elephant only the upper jaw is furnished with

tusks; but it is interesting to find that in the male of some species of Mastodon (*Mastodon angustidens*) there were also two tusks in the lower jaw.

In regard to the succession of the orders, I would observe that both Bruta and the Cetacea have been placed at the bottom of the Placentalia by previous writers; while De Blainville, although he gave them a higher position in the series, associated them together under the common title of Edentata: distinguishing the Bruta as *normal*, and the Cetacea as *abnormal* Edentata.

The connection which is admitted to exist between the Sirenia and the Cetacea is clearly indicated by their familiar title of "herbivorous Cetacea," and both Cuvier and Illiger formed them into one order. I have just pointed out some of the characters by which the Sirenia are linked to the Proboscidia; a union which was adopted by Professor Owen in his first, but abandoned by him in his last, published classification of the Mammalia. De Blainville, a writer of no mean authority, constituted his order *Gravigrade* for their reception. The position of the Sirenia in the present arrangement serves to indicate their alliance to the true Cetacea, but associates them with the Proboscidia, to which they would appear to be most closely allied.

The position of the Rodentia, next to the

Proboscidia, is an evident innovation upon the linear arrangement that has been generally adopted of the orders belonging to the Placentalia, but it is one which I believe may easily be justified. The connection existing between the two orders has been recognised since the time of Cuvier, who, when describing the skull of the Pachydermata, says, "The head of the Elephant is intimately related to that of the Rodentia. The size of the intermaxillary bones, the position of the maxillary bones, that of the malar bone and its connections are the same."* It would appear from the remarks of Professor Huxley, that the same association of the Rodentia with the Proboscidia would result from the adoption of a placental classification; and I cannot urge a stronger argument in favour of the present arrangement than by quoting the following passage from the lecture already referred to:—"So far as the case of the Elephants is concerned, I must confess that I see no difficulty in the way of an arrangement which unites the *Proboscidia* more closely with the *Rodentia* than with the *Artiodactyla* and *Perissodactyla;* the singular ties which unite the Elephants with the Rodentia having been a matter of common remark since the days of Cuvier." †

The Rodentia (fig. 9) are always provided with

---

* Leçons d'Anatomie Comparée, vol. ii., p. 427; Paris, 1837.

† Opus cit., p. 111.

two scalpriform incisors in both jaws. Only in the case of the Leporidæ two additional and diminutive incisors are developed immediately behind those of the upper jaw.

The next and only other change which has been made in the usual plan of classification, and in the succession of the different orders, is that of raising the family Rhinoceridæ, which is generally classed with the Pachyderms, to the rank of a distinct order, dividing it into the following families and genera. Those printed in italics are fossils.

Order.	Family.	Genera.
Rhinocerina	Rhinoceridæ	*Elasmotherium.*
		Rhinoceros.
		Acerotherium.
	Hyracidæ	Hyrax.

As this alteration is one of importance, it is necessary to state the grounds upon which such a step has been taken. When we consider the presence of the nasal horn in the Rhinoceri—forming as distinctive, although not so influential or constant, a character, as the proboscis of the Elephant;—the strongly marked external form of the animals; the peculiarities of their dental system; and the variety of species by which they were formerly represented; and if, at the same time, such a change should offer a possible means of reconciling the conflicting opinions that have

been put forth with regard to the affinities of *Hyracidæ*, concerning which the most opposite views have been and are still entertained, at least some reasonable grounds have been shown for the change that has been made.

The Hyracidæ, of which three species are known at present, were first anatomically described by Pallas from the Cape Hyrax (*Hyrax Capensis*),

Fig. 9.

Cape Hyrax (*Hyrax Capensis*).

the only species with which he was acquainted. This animal is about the size of a small hare, and has the external form, the habits, and all the appearance of one of the Rodentia, the order in which it was placed by Pallas. Cuvier, from an examination of its anatomical characters, and more especially from the form of the molar teeth, placed it with the Rhinoceridæ; a position which has since been generally assigned to it. Professor

Huxley,* and some other naturalists, seem to regard the Hyrax as the type of a distinct order; while Professor J. F. Brandt † appears inclined to restore it to its position amongst the Rodents. In an elaborate and valuable paper by Dr. Murie‡ and Mr. St. George Mivart, "On the Muscular System of the Hyrax." At the conclusion of their paper, after mentioning certain points, "which tend rather to confirm than otherwise those ungulate affinities which have been attributed to the *Hyrax*," add: "but, on the other hand, we find so many resemblances to the Rodentia, as exemplified in the Guinea-pig (especially selected by us for comparison as the most Pachyderm-like of accessible Rodents), that we are indisposed, from the consideration of the muscular structure alone, definitely to assign the Hyrax to one or other of the *existing* orders constituting the class Mammalia."

The dentition of the Hyrax (fig. 10) consists of two incisors in the upper jaw; the number that is met with in the Rodents, and in the one-horned Rhinoceros (*Rhinoceros unicornis*); they have a triangular form, and terminate in a point. In the lower jaw the incisors project obliquely forwards, like those of the Hog; they are four in

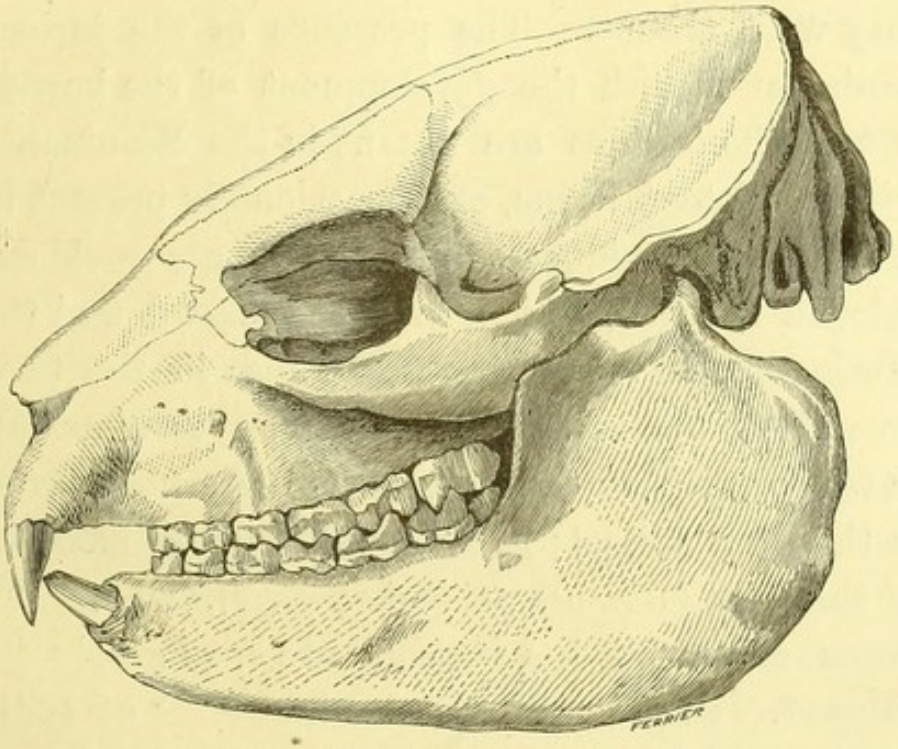
* Opus cit. p. 111.

† Bulletin de l'Académie Impériale des Sciences de St. Petersbourg, tome v, No. 7, p. 508.

‡ Proc. Zool. Soc. 1865, part ii., p. 329.

number, deviating in this respect from the Rodent type of dentition, but not more than the Leporidæ

Fig. 10.



Skull and Teeth of the Hyrax Capensis.

do by possessing four upper incisors. The construction of these teeth is the same as that of the ordinary incisors of the Mammalia, and not like that of the scalpriform incisors of the Rodentia. The molar teeth are seven in number on each side of the upper and lower jaws, resembling those of the Rhinoceros both in form and number.

In the Rhinoceridæ only incisor and molar teeth are developed; but the former are not present in all the species. It should be borne

in mind that the number and size of the horns vary in the existing species of Rhinoceros; while in the extinct species, *Rhinoceros incisivus*, and in the aberrant genus *Acerotherium* of Dr. Kaup they were absent. The presence of the incisor teeth varies with the development of the horns; just as the canines are absent in the Ruminants with persistent horns, are occasionally present in those with deciduous horns, and are well developed in those which, like the Camel and the Musk-deer, have no horns. Thus, in the two-horned Rhinoceros of Africa (*Rhinoceros bicornis*), in which the horns are large, there are no incisors in the adult animal; in the two-horned Rhinoceros of Sumatra (*Rhinoceros Sumatrensis*), where the horns are small the incisors are moderately developed. In the one-horned Rhinoceros of India (*Rhinoceros Indicus*) they are well developed, while in the extinct hornless species they attain their greatest dimensions.

It is curious, and somewhat interesting, to find this irregular development of the incisors occurring in two families; namely, the Manatees and the Rhinoceridæ; which, if the characters of the teeth are admitted as a basis of classification, are brought together into the same group; while not a single instance of a similar irregularity is to be met with in any of the orders or families belonging to the other divisions.

The normal number of incisors in the Rhinoce-

ridæ is two in each intermaxillary bone, and the same number in the corresponding portion of the lower jaw, but the late Dr. Falconer discovered a fossil species of Rhinoceros in the Himalayan Tertiary beds, in which there were six incisors in each jaw.

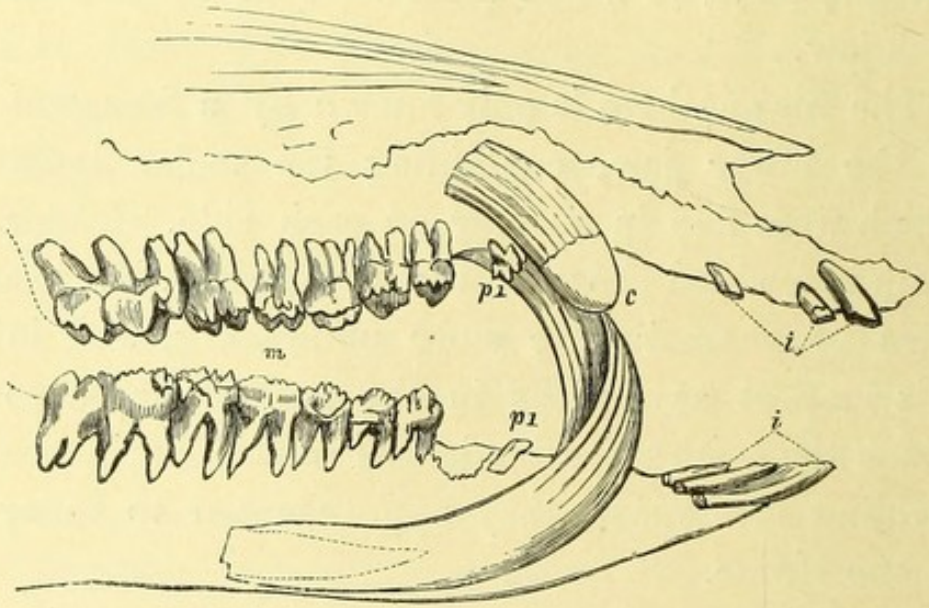
The Elasmothere is only known by a fragment of the lower jaw, containing the molar teeth which were five in number on each side. These teeth resembled those of the Rhinoceros, but the folds of enamel were more undulating, and in this respect as well as in the greater depth to which the teeth were implanted in the jaw before dividing into roots, they approximated to those of the Horse.

By adopting the proposed order Rhinocerina with its subdivisions, we have the Hyrascidæ brought into immediate proximity to the Rodentia, which they unquestionably resemble in many points, while they still remain connected with Rhinoceridæ, to which they are allied by several anatomical characters; and especially by the pattern of the molar teeth. The horned Rhinoceri constitute the typical members of the order, while the hornless species from the first transition to the Tapirs and the Elasmothere may be considered as leading to the Equidæ.

The third and last division is that of the Triidodonts, in which the three kinds of teeth, incisors, canines, and molars are all present.

This form of dentition is shown in fig. 11, representing the head of the common Hog (*Sus scrofa*). This animal has been previously men-

FIG. 11.



Dentition of the common Hog, showing the type of the Triidodont dentition. *i*, incisors. *c*, canines. *p*, pre-molars. *m*, molars. From Owen's "Odontography."

tioned (p. 104) as exhibiting the typical number of teeth belonging to the placental Mammalia, consisting of three incisors, one canine, four pre-molars,and three molars on each side of the two jaws, a number rarely met with in the existing species, but characteristic of a large number of animals that existed during the Tertiary period, and which formed so many links connecting the Suidæ with the existing Ruminantia.* This division includes seven orders.

* The following list of extinct genera which possessed the

The first of these, the Pachydermata, consist of the Hippopotami, the Equidæ, the Tapiroids, and the Suidæ. In the first and last of these families the canine teeth are developed in excess, as seen in the tusks of the Wild Boar, and in the well-known canines of the Hippopotami; in the Tapirs they are of a moderate size, while in the Horse they are small, and in the Mare rudimental.

In the majority of the Ruminants, which constitute the second order, there are no incisors in the intermaxillary, nor canines in the maxillary bones. This is the form of dentition which is met with in the hollow-horned Ruminants, consisting of the families *Bovidæ*, *Ovidæ*, *Capridæ*, and *Antelopidæ;* it also prevails in the periodically hornless Deer.

In the Deer (*Cervidæ*) canines are occasionally present in the male and sometimes also in the female; but in the latter they are smaller than in the male. In the little Muntjak (*Cervulus*

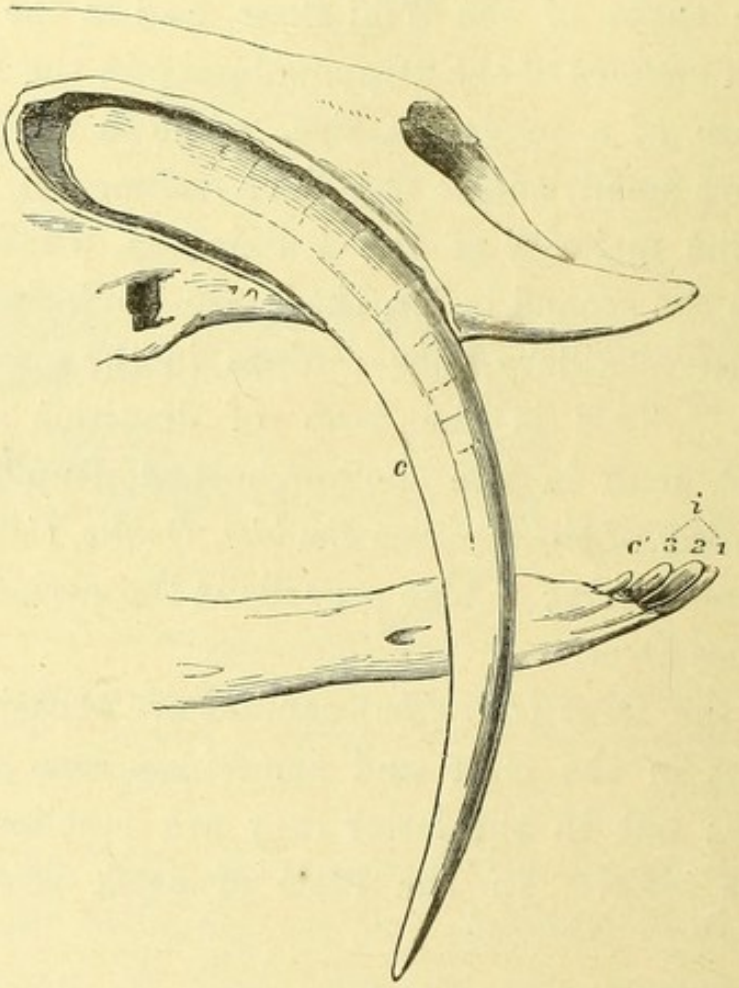
---

typical number of teeth is given by Professor Owen in his "Palæontology," 2nd edit., p. 361, Edinburgh, 1861:—

Palæocyon, *Coryphodon*, *Pachynolophus*, *Lophiotherium*, *Pholophus*, *Hyracotherium*, *Palæotherium*, *Anoplotherium*, *Anchitherium*, *Dichobune*, *Ziphodon*, *Dichodon*, *Microtherium*, *Amphitragulus*, *Amphimeryx*, *Dorcatherium*, *Chalicotherium*, *Aphelotherium*, *Anthracotherium*, *Hyopotamus*, *Anchilophus*, *Bothriodon*, *Palæochrus*, *Chæropotamus*, *Chæromorus*, *Poëbrotherium*, *Hippohyus*, *Hippotherium*, *Hipparion*, *Heterohyus*, *Entelodon*, *Hyænodon*, *Pterodon*, *Arctocyon*, *Galethylax*, *Amphicyon*, *Chærotherium*, *Rhagatherium*.

vaginalis), the canines of the upper jaw are well developed, and in the Musk-deer (*Moschus*

FIG. 12.



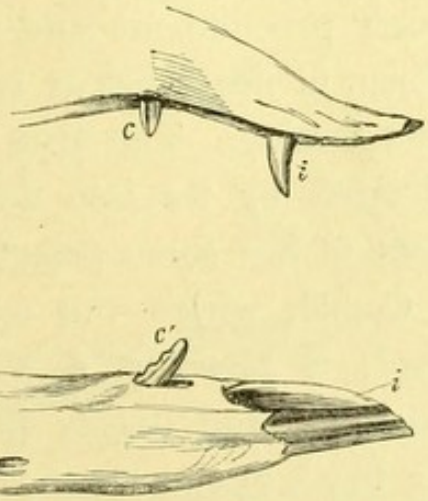
Anterior portion of the maxillary bones of the Musk-deer. *i*, 1, 2, 3, incisors. *c*, upper canine. *c'*, lower canine. After Owen.

moschiferus), (fig. 12), they form long, curved teeth, sweeping downwards from the upper jaw, and project beyond the lower when the mouth is closed.

In the *Camelidæ*, a single pointed incisor is developed in each intermaxillary bone, and a

canine in the maxillary; these teeth are feebly developed in the Llamas and Vicugnas, (fig. 13),

Fig. 13.



Anterior portion of the maxillary bones of the Vicugna (*Auchenia vicugna*). *i*, upper incisor. *c*, upper canine. *i'*, lower incisors. *c'*, lower canine. After Owen.

but assume larger and more important proportions in the Camel (*Camelus bactrianus*).

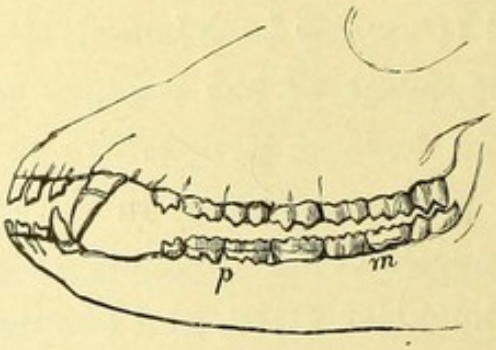
The development of the canines in the Ruminants is in an inverse proportion to that of the horns; thus they are absent in the horned ruminants, are occasionally present in some of the periodically hornless Deer, and constantly present in those species which, like the Musk-deer, Camel, Dromedary, Llamas, and Vicugnas, never have the horns developed. The same kind of relation was shown to exist between the development of the horns and of the incisor teeth of the Rhinoceri.

In the lower jaw of the Ruminants four teeth

are present on each side of the symphysis, the three innermost are incisors, corresponding to the typical number of these teeth that is present in the Placentalia. The fourth or outermost tooth, although procumbent and resembling the incisors in form, is nevertheless regarded as representing the canine. The true nature of this tooth is indicated by its late development; in many instances it has some peculiarity of form; and in the Camel, where the upper canine is well developed, it assumes a conical form, a semi-erect position, and passes in front of the corresponding tooth of the upper jaw.

A still stronger argument in favour of this interpretation of the anterior teeth of the Rumi-

Fig. 14.

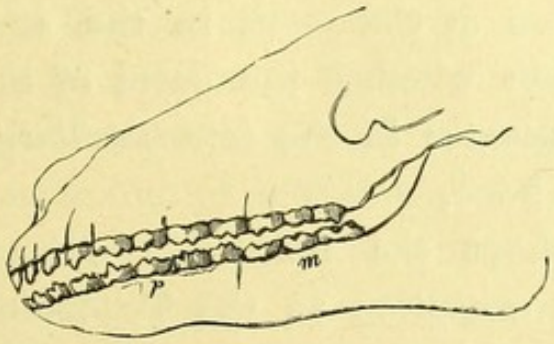


Skull of Palæotherium.

nants, is to be derived from the dentition of the Palæotherium (fig. 14), the Anoplotherium (fig. 15), and some other extinct animals which are so evidently intermediate between the Ruminants and the Suidæ, that it is difficult to say whether

the stomach was adapted for ruminating or not. In these animals incisors, canines, and molars were present in both jaws. In the Anoplotherium (fig. 15) no tooth projected beyond the

Fig. 15.



Skull of Anoplotherium.

others, there was no interval between any of the teeth, a character which is now peculiar to man; and the pattern of the molar teeth approximated to and prefigured that of the molar teeth of the existing Ruminants, of which these animals were the precursors and flourished during the early and middle portions of the Tertiary period.

Amongst the diminutive Insectivora a few instances occur, as in the Mole and the Potamogale, in which zoologists are not agreed upon the determination of the canine teeth. These cases are so few that I can scarcely think they will eventually prove exceptions to the general rule, which so universally prevails throughout this extensive order as to the presence of canine teeth. Should it, however, be otherwise, this

will hardly form a sufficient reason to reject the employment of the canine teeth as a distinctive character, or as a means of classification, in the very numerous instances in which they are clearly and easily recognized. In the cases referred to the question can only be decided by a careful examination of the teeth in the embryo so as to ascertain whether the germ of the disputed tooth originates in the *intermaxillary* or in the *maxillary* bone.

Throughout the remaining orders, there is only one exception to the Triidodont form of dentition; this occurs in the Aye-Aye of Madagascar (*Cheiromys Madagascariensis*), an animal belonging to the order Quadrumana. In the Aye-Aye the dentition assumes the type of that which has been described as characterising the Rodentia, and consists of two scalpriform incisors in the upper and lower jaws, separated by a vacant space from four simple molars on each side the upper, and three on each side the lower jaw. This animal is a stumbling-block to the classifier whatever characters are taken, and it has been variously placed by different writers; but is now generally admitted to belong to the Lemurs, these animals themselves constituting an extreme form of the Quadrumana.

In conclusion, I would observe that the proposed classification originated in my endeavours

to ascertain the best means of arranging the specimens in the museum, so as to exhibit not only the characters of the teeth in each species, but also the relation in which these organs stand to the general plan of animal organization.

In every attempt to establish a linear arrangement of the families and orders of the Mammalia, we must expect to meet with exceptional forms that will not accord with our artificial systems, and also with abrupt transitions from one type of life to another, which we are unable to connect by intermediate grades of development, whether the classification is based upon the characters of the brain, the placenta, or the teeth. At the same time it should be remembered that several of these gaps have been filled up by the discovery of fossil forms, which possessed characters that at the present time belong to distinct orders of the Mammalia, and which they served to link together, in the same manner as we have seen the Dinotherium uniting the herbivorous Cetacea to the Proboscidia. How far the further researches of the Palæontologist may lead to the discovery of other extinct animals that shall supply the missing links, it is impossible to say.

The object of every classification should be to embody in a clear and simple manner the actual knowledge which is possessed of the animal kingdom, or of that portion of it with which the classification is concerned. To what

extent this may be considered to be fulfilled by the classification that has now been proposed must be left to the judgment of others. It at least possesses the important qualities of clearness and facility of application. The arrangement of the different orders does not differ materially from what has been previously adopted by other writers. The relation in which the teeth stand to the general organization of the animal is brought more prominently forward, and the classification, although it should not be accepted for the general purposes of the zoologist, would seem to be well adapted for arranging the specimens in a dental museum.