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COMPARATIVE DENTAL ANATOMY

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BY

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SECOND EDITION

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TO

HELEN MOON THOMPSON

WHOSE DEVOTION AND ATTENTION TO DR. ALTON
HOWARD THOMPSON IN HIS LAST DAYS
WERE AN INSPIRATION TO HIS
MANY FRIENDS

THIS VOLUME IS DEDICATED.

PREFACE TO FIRST EDITION

My apology for the presentation of this little book as a candidate for the favor of my colleagues, the teachers in the Dental Colleges of the United States, is, that there is a real and pressing need for a concise compendium of Comparative Dental Anatomy for the use of dental students. The general works on this subject are not adapted to the special needs of the student of dentistry, and it is the mission of this manual to select and arrange for him just the material he will require for the illumination of his studies of the human teeth by comparison with the teeth of lower animals and the philosophy of tooth forms, without going into the elaborate and cumbrous details of the subject. These details can be found in the larger works if he should desire to pursue the subject further.

The sifting out of the special matter here presented from the mass of material bearing on the subject in the literature of zoology has been the work of years, and represents the gleanings from many fields. Its matter and methods have been slowly evolved through the needs of the work of teaching this branch in the class-room, and it is with the hope that it will be useful to the teachers of this branch that this little manual is offered to them.

Many branches of science are laid under contribution to supply material for our special needs as dentists, and it is the province of dental text-books and teachers to select from the general store of accumulated facts just those which will be of service to the dental specialist; so Comparative Dental Anatomy is drawn upon for the sidelights it throws upon human odontography, as to both tooth forms and functions, as well as for the scientific study of the evolution and philosophy of tooth forms. The time was when it was necessary to apologize for the intrusion of Comparative Dental Anatomy into the curriculum of dental education; but it is a matter of congratulation that the value of this branch as an element in our professional education is now generally recognized. The study of the forms and functions of the teeth of other animals than man, as a means of conveying a better understanding of the forms and functional purposes of the human teeth, is now fully appreciated. It is also recognized that this study furnishes the only scientific elucidation of the origin and principles of these forms and functions, which had heretofore been taught by the study of the human teeth alone.

In regard to the general scheme of the book, it must be stated that some liberties have been taken with the usual zoological classifications in order to have an arrangement in a scheme that would be harmonious with the progressive advance of the perfecting of tooth forms, for convenience of description. It is to be hoped that this breach will be overlooked, as well as the zoological errors that may have crept into the pages, but which will probably not affect the value of the lessons to be drawn from the main principles.

While this book will furnish the various facts and principles of Comparative Dental Anatomy, it will be necessary for the teacher to enlarge upon and elaborate the subject by the use of the general works of the anatomists and zoologists. It will also be necessary to illustrate the lessons by the use of accessories such as skulls, charts, sketches, and especially the lantern, which is the best of all for illustration in the class-room.

The best place for this branch in the curriculum will be as a preliminary study in the course on Dental Anatomy, preceding and leading up to human dental anatomy. It begins with the lowest form of life and leads up to the highest in regular gradation,—taking the teeth seriatim from the lowest types, and showing their progressive evolution from simple to complex forms.

It would be impracticable to append references to authorities in a condensed work of this character, for economy of space; but the writer takes pleasure in acknowledging his indebtedness to the leading authorities upon odontography and zoology for the many drafts he has made upon the rich stores they have accumulated and placed at the disposal of students and teachers. He wishes also to acknowledge the courtesy of Mr. C. H. Ward, of Ward's Natural History Establishment, Rochester, N. Y., who kindly furnished specimens for most of the illustrations.

A. H. Thompson.

Topeka, Kansas.

PREFACE TO SECOND EDITION

In a conversation with Dr. Thompson several months before his death, we discussed the advisability of the republication of his book on Comparative Dental Anatomy which had been out of print for some time.

At Dr. Thompson's request I undertook the task of preparing this new edition, feeling that there was a need among dental students and teachers for a text upon this subject.

Such changes as have been found necessary in this edition have the full approval of Dr. Thompson. Conflicting theories have been omitted and we have attempted to state only proven facts. Many new and original illustrations have been added, but we have tried to use only those which show some interesting feature in the evolution of the dental apparatus.

A number of rœntgenograms are shown which were made by Dr. E. H. Skinner from specimens in my private collection.

If this volume should prove an aid to the student and teacher of dentistry, it will have served its purpose.

Martin Dewey.

CONTENTS

COMPARATIVE DENTAL ANATOMY

CHAPTER I

GENERAL ZOOLOGY AND COMPARATIVE ANATOMY

The *Animal Kingdom* is divided into two sub-kingdoms,—viz., (a) *Invertebrates* and (b) *Vertebrates.* These sub-kingdoms are further subdivided into classes; classes are divided into orders; orders into families; families into genera; and genera into species. Species is the last division into which animals can be classified, but if the individuals of a species vary much from the normal type, they may be classed as sub-species or varieties. All animals are grouped with reference to their plan of structure, and classification is made according to the system of organization, and without regard to superficial characters or resemblances except so far as external features may have reference to functions.

Vertebrates and Invertebrates are distinguished from each other by the presence or absence of a vertebral column or backbone. The

Vertebrates have a cerebro-spinal axis and a strong bony column composed of separate pieces called vertebræ, which are connected together by ligaments and are more or less movable. The sub-kingdom of the Invertebrates comprises all classes of animals which do not have a vertebral column, whatever their various plans of structure may be. The class of the Vertebrates is therefore homogeneous, and that of the Invertebrates very heterogeneous.

The sub-kingdom of the *Invertebrates* includes all animals which have no internal backbone or vertebral column; such as the Infusoria, Hydroids, Radiata, Worms, Insecta, Crustacea, Mollusca, etc.

There is no spinal cord with its anterior enlargement, the brain in Invertebrates, but instead the nervous system consists of chains of ganglia scattered throughout the system, arranged in rows or circles connected by cords of nervous substance and giving filaments to various parts of the organism.

The digestive system is simple. The stomach may be a single sac with but one opening as in the Hydroids, or a complete alimentary canal with two openings,—the oral and anal,—as in the worms, insects, mollusks, etc. In the lower forms specialized digestive glands do not appear, but are present in the higher orders.

The circulation is a mere water vascular system in the lowest aquatic forms, in which there is no corpusculated or true blood, and no circulatory organs. In the higher Invertebrates there is true blood, colorless or greenish, with true veins and arteries. In the insects there is a distinct heart with one ventricle. In the mollusca there is a heart with one valve which propels the blood both ways alternately. Some forms have a bilocular heart.

Respiration is performed in the lowest forms by tentacles or cilia, and the higher aquatic forms have cilia or gills. In the insects the blood is aërated by circulation of the air in the pulmonary tubes which ramify throughout the body. The snails breathe by means of an air-sac with a ciliated lining.

Locomotion is performed by various means: by tentacles and cilia in the lower forms; by legs and wings in the insects; by legs in the crustacea; by a fleshy peduncle in the mollusca, etc.

Reproduction is performed by fission, budding, etc., in the lowest forms; the laying of gelatinous eggs in the higher orders, etc. Some forms, as the insects, undergo a series of metamorphoses before attaining the mature stage.

The sub-kingdom of the *Vertebrates* comprises all animals which have an internal backbone or vertebral column composed of articulated vertebræ. It includes the *Fishes, Reptiles, Birds*, and *Mammals.* From the vertebral column the limbs are suspended, and by it the vital organs are held in place. It is the central structure and mainstay of the framework of the body.

A transverse section of a vertebrate body reveals two cavities or tubes, which are separated by the vertebral column. The upper cavity or canal, which is formed by the arches of the vertebræ, contains the spinal cord and brain, and so is called the *neural arch* or cavity. The lower and larger cavity or tube is below the vertebral column, is formed by the ribs and abdominal

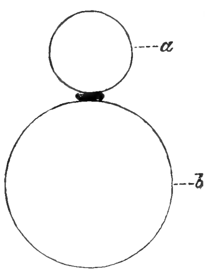


FIG. 1.—Section of Vertebrate. *a*, The neural arch; *b*, The visceral arch.

walls, and contains the vital organs: the viscera. Hence it is called the *visceral arch* or cavity.

The nervous system of Vertebrates consists of the spinal cord and the brain, which is covered by the especially developed cranium. Nerve branches and filaments are sent from the cerebro-spinal axis to all portions of the body. Many of the lower forms of Vertebrates, as the *Amphioxus,* have no bony spinal column, but only a cartilaginous structure; but the spinal cord is present, looking like the notochord of the embryos of all Vertebrates in the first stages of existence.

The alimentary canal has its beginning at the oral opening, the mouth, which is armed by the teeth of a great variety of forms in the Fishes, Reptiles, and Mammals for the securing and reduction of food preparatory to digestion. There is a digestive stomach and an intestinal canal, which is more or less complicated in the different classes, that leads to the anal opening at the posterior extremity of the organism.

The circulation is complete in all forms of Vertebrates. The blood is corpusculated, and is generally red in color. The heart has from two to four chambers.

Respiration is performed by gills in the Fishes, by gills and lungs in Reptiles, and by lungs only in the Birds and Mammals.

The external covering in this sub-kingdom presents a great variety of forms. In the Fishes and Reptiles the skin is bare or is protected by scales or spines of great variety in size and shape. In Mammals there is a tough leathery skin or dermal plates, or fur, hair, or bristles. The birds are covered with feathers, which on the wing and tail are enlarged and modified to assist in the performance of aërial flight. The limbs in the Vertebrates are suspended from the vertebral column, and constitute the appendicular skeleton. There are never more than four limbs, sometimes they are reduced to two, and in the snakes are absent entirely. When present they are modified to perform a variety of functions: such as swimming in the water, flying in the air, running upon the ground, climbing trees, seizing objects, etc.

Reproduction is performed by laying gelatinous eggs by the fishes and batrachian reptiles by eggs with a more or less hard shell in the higher reptiles and birds,—hence oviparous,—and by the young being born alive in some reptiles and nearly all mammals,—hence viviparous.

Comparative Anatomy is the study and comparison of the anatomy of lower animals with the anatomy of Man.

The comparative method of study is the only scientific method, for one branch cannot be studied alone, but must be illuminated by comparison with kindred branches. Man is but an insignificant part of nature, and is connected in the closest way with the animal kingdom. His body is identical with those of animals in its functions, and with all Vertebrates, especially mammals, in its structure. Therefore his anatomy can only become truly scientific through comparative anatomy and his physiology through comparative physiology.

The structure and functions of his organs are only to be fully understood by comparison with those of lower animals.

The leading principles of comparative study are *Homology* and *Analogy.* In biology those organs or parts in different animals are said to be *analogous* which, however different their origin, have a general similarity of form and especially of function, while those are called *homologous* which, however different their general appearance and however various their functions, are but modifications of the same part altered for different purposes. For example, the wing of the bird and the wing of the butterfly are analogous organs, for they look somewhat alike and have the same function,—flying; but they are not homologous, for they are not the same in structure and are dissimilar in origin. But the forelimbs of all Vertebrates, whether the forepaws of a reptile or a mammal, the wings of a bird or bat, the arm of a man, the flipper of a whale,—though so different in form and function,—are homologous parts. They have the same general structure, are composed of the same pieces and undoubtedly have the same origin; they are but modifications of the same structure for different functions. They are homologous but not analogous parts. Again, the lungs of a mammal and the gills of a fish are analogous organs, since they have the same function,—the aëration of the blood,—but they are not the same organs. Therefore, homology has reference to community of origin, and analogy to similarity of function only.

Comparative Dental Anatomy is the study of the teeth of lower animals as compared to man. The observation and comparison of their forms and functions will illustrate the understanding of the human teeth, because the teeth of man can only be studied scientifically by comparison with lower forms of the same organs,—just as in studying other organs, by the comparative method. Thus homologies with the teeth of lower forms can be demonstrated, and analogous structures in other locations will throw light upon their variations, by these studies. This will illustrate the principles which have controlled their growth and organization, and explain the varied details of function.

The *teeth of man* have, in the course of their evolution to present forms, passed through the transitional stages common to all organs in all animals. In consequence they, like other organs, still retain many features that indicate relationship with the teeth of lower animals. The teeth of man have been much reduced in size and strength, and are more or less rudimentary and much less specialized, as compared with the highly developed teeth of other animals. Comparative study will therefore point out the relationship of the teeth of man, indicate the path of their development, and explain the causes of their present degradation.

CHAPTER II

THE TEETH IN GENERAL

Definition. The term teeth is applied to all hard, usually calcified substances placed at the orifice of the alimentary canal. They are generally confined to the cavity of the mouth, but are sometimes found in the pharynx and rarely in the œsophagus. The name is, however, confined to those structures located in the oral cavity which contain a calcified tissue known as dentin.

Origin. The teeth of animals are derived from the layers of the skin and hence are but specialized dermal structures. In the Invertebrates, they are evolved from the superficial layers of the derm, and are therefore called *ecderonic,* while the teeth of Vertebrates are derived from the deeper portions, the corium of the integument, and are hence called *enderonic.* The dentin is derived from the mesoderm, but the enamel is a calcified substance derived from epithelium, which is readily demonstrated by its histological elements.

Tissues. The dental tissues are three in number,—*enamel, dentin* and *cementum.* The cementum is a mere osseous tissue, and in all of its elements resembles true bone. It surrounds the roots of the teeth and is in contact with the alveolo-dental periosteum or peridental membrane. The dentin constitutes the main body of the tooth, and is but modified bone as to its histological elements. It has the same organic basis as bone,—i.e., gluten. In many lower forms it is the only tissue of the tooth, the enamel not being yet organized. In the higher forms the enamel is the main working element of the tooth, for which the other tissues are mere supports. It appears to have been developed to supply the demand for a more resisting structure as the function of mastication became more specialized. It is developed from the epithelium, and consists of calcified rods, with the organic basis: keratin, like horn, nails, hairs, and other epithelial structures.

Functions of the Teeth. The functions of the teeth can be divided into primary and secondary.

The *primary function* of the teeth is the securing and preparing of the food for digestion and assimilation. For this purpose they were called into existence and such modifications as we find in animals is always one which will enable the animal to eat a certain class of food. It has been said that the food of the animal has been responsible for the change in the shape of the teeth; whether this is exactly true or not, we can say without fear of contradiction, that only those animals have existed whose dental apparatus has been able to change to meet their needs. We find many fossils, which have disappeared because their dental apparatus was not suited to their particular needs.

The first function in the securing of the food is prehension, or the seizing of the food substances. It is the only function which the teeth perform in some fishes and reptiles. The second to appear in the animal kingdom was deglutition. Deglutition is the principal function of the teeth located on the vomer and palates of most of the fishes and is one of the principal functions of the teeth of the non-poisonous snakes. Incision, or the cutting of the food into pieces, was the next function to appear. In some animals, we find incision has to a certain extent taken the place of prehension; this may be said of the teeth of man, as the incisors are well developed. In some of the lower animals, the anterior teeth are shaped like incisors, an example of which is the sargus. The next step or function was the crushing of the food, which was first done by blunt flat teeth or by pavement teeth. Then came the function of grinding the food or mastication, which was performed by teeth of various shapes, depending upon the class of food. Insalivation is the last function of the teeth and is the mixing of the food with the saliva. This function is also performed by the tongue and cheeks.

Of the *secondary functions* of the teeth, warfare is the most important. The canines of the carnivora are developed for prehensile purposes but they are also used in combat and to destroy animal life. The nature of an animal can be told by the teeth. Associated with warfare for protection and securing of the food is sexual warfare. We find the teeth of some animals are better developed in the males than in the females. In some animals we have the function of sexual attraction closely associated with sexual warfare. The canines are well developed in some males, e.g., the boar, but the growth of those teeth is checked by castration and the teeth of the castrated males become no larger than the teeth of the females. Teeth are also used as tools, an example of which is the beaver, which uses the teeth to gnaw off trees which are used in the making of their dams and houses. The lower anterior teeth of the lemur are used to dress their fur and have a modified cosmetic function. In man we find the teeth have a function in speech; they also have an esthetic function and through the esthetic function also have a function of sexual attraction.

The *food-reducing mechanism* of animals presents great variety when viewed throughout the entire animal kingdom. In no set of organs is the invention of nature so varied or the capacity for change so great as in the teeth. This variation is due to the modifying influences of the qualities of the various substances employed by animals for food, for the teeth and jaws are adapted to the particular manner of reduction that the food of each species requires. It is an adaptation of tools to material, not of material to tools. Therefore there has arisen, in response to the demands of food selection, a great variety of forms of teeth.[1] The different kinds of food have dictated the different kinds of tooth forms.

The *force that dictates the tooth form* is still a matter of some dispute. The older writers believed that the shape of the tooth was influenced by the movement of the jaw and a study of fossils seems to bear that out. However, a study of the embryology and histology of the teeth and jaw seems to indicate that the shape of the tooth has been responsible for the shape of the jaw and the shape of the temporo-mandibular articulation. The development of the tooth precedes the development and final shaping of the jaws. Thus in the carnivorous animals we find a tooth which is long and the cusps of which are sharp, the movement of the mandible is vertical and the

1 Teeth which are suited to the particular food have enabled the animal to live, but there may have been many animals of the past whose teeth did not change and the animals perished.—*Editor.*

temporo-mandibular articulation is a mere hinge, admitting of opening and closing of the jaw without any lateral motion. The jaw is short and stout to sustain the force of hard biting, and the teeth are developed vertically, with long points and blades, in such a manner as to resist the greatest strain. In the other extreme form—the Herbivorous mammalia—the teeth are broad and flat and we find the temporo-mandibular articulation is open to allow extreme lateral movement of the mandible. The jaw bones are light and the surfaces of the teeth are roughened to produce a good grinding surface and there is less strain on the jaws than in the carnivorous animals. In the elephant we find the dental tissue arranged in plates and the tooth is more effective by an antero-posterior movement and the jaws and articulation are arranged for that purpose. So in all animals there is a close relation existing between the shapes of the teeth and the jaw movements.

Tooth Forms. The original and primitive form of the tooth is that of the single, simple cone, as illustrated in the teeth of fishes and reptiles, which are simple cones with but little modification. From this primitive form all other forms have been derived by modification and duplications of the single cone. Thus the incisors of man are formed of a single cone, the base of which is compressed to form the wide cutting edge. The canine is a single cone, the base of which is compressed into a trihedral, pointed prism. The bicuspids are formed of two cones fused together,—the base rounded to make the cusps,—and two cones are distinct the entire length of the tooth. The typical upper molar is formed by the coalescence of three cones, which are plainly marked, and the lower molar of four cones. Thus the teeth of all animals, even the highly complex and specialized tooth of the higher mammals, are evolved. As Cope says, "The transition from single to complex teeth is accomplished by repetition of the simple cone in various directions. First, there are cylindrical incisors, then flat ones, then divided roots; then internal repetition of a root and cusp; then posterior repetition. Very complex teeth, as multitubercular molars, are formed by both posterior and lateral repetition." Thus the primitive form of tooth is that of a simple cone, from which all subsequent forms, however complex, have been derived by repetition, duplication, and modification of cones and cusps.

CHAPTER III

THE TEETH OF INVERTEBRATES

The teeth of this sub-kingdom present as many variations and extraordinary forms as the organic designs of the heterogeneous mass of animals composing this great division. Not many of these lower forms possess teeth, but when present the form presented and the analogies suggested are very instructive. They are analogous to the teeth of Vertebrates, as the teeth are usually oral organs in the Invertebrates and perform the same functions as in the higher sub-kingdom,—i.e., the prehension and reduction of food, preparatory to digestion; but they are not homologous with the teeth of Vertebrates, however, as they do not have the same origin or structure. Almost every group, in some of its forms, exhibits some sort of a dental apparatus for the reduction of food, though few are homologous with true teeth. Most of the lower forms are without a masticating armature.

Origin. The food-reducing mechanism of Invertebrates, whether oral organs or modified limbs, is composed of calcified connective tissue or of chitin, and is derived from the superficial layer of the derm. They are therefore *ecderonic*. In insects and crustaceans the food apparatus is modified from the chitinoid external covering.

The *forms* of the food apparatus present great and heterogeneous variety in this division. The so-called teeth of Invertebrates are often but serrated jaws placed about the oral opening. The margin of the mouth may be raised into folds and armed with cuticular plates. In the insects and crustacea the jaws and modified limbs are formed from the exo-skeleton. In some—as the cuttle-fish—there is a strong beak. In the Sea-urchin there are five teeth set in true alveoli. In the mollusks the teeth are supported by a movable band, called the odontophore.

Functions. Prehension is performed in this sub-kingdom by cilia in many of the lower forms, in the worms and gastropods by a suctorial form of the mouth, in others by tentacles, and in insects by their chitinoid jaws and modified limbs. Cutting and dividing food is performed by jaws and mastication by gizzards, when performed at all. No true masticating teeth exist in the entire sub-kingdom. Some have the food apparatus developed for the purposes of combat or sexual attraction, some for drilling through shells to get the juices of the animal within, or even to drill into rock.

Descriptive. All of the lowest forms, infusoria, etc., are without any food-reducing apparatus, except some which have an internal cylinder of parallel rods for the crushing of food. In the Rotifera, oral denticles are present in the shape of denticulated plates placed transversely of the mouth, which crush and comminute the food, which is principally infusoria.

In the *Echinoderms,* we meet with the Sea-urchin, which has a highly developed and effective

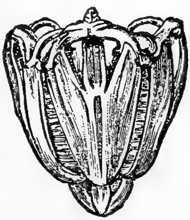


FIG. 2.—Dental Apparatus of Sea-Urchin (Aristotle's Lantern).

dental apparatus of complicated mechanism. It is very remarkable to find this highly organized apparatus at this low stage of animal life, for it is one of the most wonderful dental structures in the entire animal kingdom (Fig. 2). It is popularly called "Aristotle's Lantern." It consists of five rodent-like incisors of continuous growth, arranged in the form of a pyramid, with their points centering and finding exit in the middle of the test. These teeth are hard and calcareous, with the enamel thicker on one side than on the other, so as to insure continued sharpness from wear. They are set in alveoli of bony structure, and are moved by sets of strong muscles in various directions. The entire apparatus consists of twenty pieces,—i.e., five teeth, five alveoli, five rotalæ, and five radii. It is concealed within the test in life with only the points of the teeth projecting, which are very effective for cutting shells, boring into rocks, and reducing food substances.

The *Annuloida* comprise the segmented worms, some of which possess so-called teeth, but these partake more of the nature of serrated jaws than of teeth. These jaws are located on the second or buccal segment, which may be protruded from the mouth a considerable distance. These jaws are of chitinous structure, commonly paired and of an infinite variety of forms. In the Leeches, the mouth is provided with three lenticular jaws, with the projecting edges finely serrated. The medicinal leech has two rows of serrations, which make three radiating slits. The strong suctorial power draws an eminence of skin into the mouth, which is slit by the serrated jaws.

The *Nereis* and *Philodace* have strong jaws like the carnivorous beetles, which are cruelly effective in attacking lower Invertebrates (Fig. 3). Their jaws are serrated and opposite, and are worked by powerful muscles.

In the *Arthropoda*—including the Insects and

Crustacea—we have an approach to true jaws, but they work laterally instead of vertically, as in the Vertebrates. The mandible and maxillæ are very dense chitinous material, and the "teeth" are merely serrations on the edges. In the insects one pair of each—mandibles and maxillæ—make four jaws, which work trans-

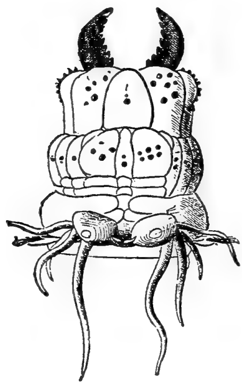


FIG. 3.—Head and Jaws of *Nereis virens*.

versely in addition to the labia, which merely cover the mouth. These organs are modified in endless variety for various purposes,—from strong jaws for cutting purposes to the long suctorial tubes of the butterflies. The so-called dental plates lining the crops of insects and crustacea further comminute the food, and hairs keep the larger particles back until finely crushed. In the lobsters, crabs, etc., the "pinchers" (Fig.

4) are but modifications of the limbs translated from the locomotive series and set apart for special mouth organs. In the higher crustaceans the stomach is provided with calcareous plates or stomacholiths, with molar-like prominences for grinding food by means of the powerful muscles which move them. These are interesting structures, as they show how similar functions may

FIG. 4.—X-ray of the claw of Lobster, modified for dental purposes.

develop analogous structures in dissimilar parts which have no homology whatever.

In the *Mollusca* we find that the bivalves (the clams, oysters, mussels, etc.) are entirely without head or dental apparatus. The other groups, however, present some form of dental structure in most of their members. In the *Cephalopoda* the organs of mastication include a corneous beak, resembling that of a parrot, but reversed; within the oral opening there is a fleshy tongue, which is armed with many transverse rows of recurved, spinous teeth. This is called the odontophore. This organ is controlled and moved by powerful muscles which draw it backward or forward, or even protrude it, as in the snail. The teeth vary greatly in number in the many various species. Thus the nautilus may have but thirteen, and the snail 12,000 to 40,000. As the teeth are worn off or lost, the ribbon-like tongue is uncoiled and new

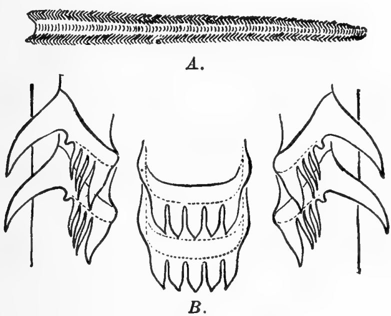


FIG. 5.—*A*, Radula of Winkle; *B*, Two rows of teeth, enlarged.

teeth are brought into use. The upper part of the mouth is usually lined with a horny substance, against which the sharp-toothed tongue works with a rasp-like motion (Fig. 5). The teeth vary in form, but are usually composed of a base, a shank or stem, and a cutting edge, the latter simple or variously denticulated. The middle row of teeth is called the rachidian; the lateral rows, the pleural teeth, and when an additional row occurs outside of this it is called the uncini.

The highest type of these molluscan teeth is called the Toxoglossal, or arrow-tooth, from its narrow, round form, often barbed, sometimes hollow to inject poison. They have but two rows,—the middle or rachidian being absent. The Rachiglossa have only the middle row, or rachidian teeth. The teeth are small and varied in form, and prettily denticulated on the cutting edge. They are few in number. The Ptenoglossa, feather-toothed, is a small group. They lack the middle rows, but have numerous small teeth on the side of the tongue. The Docoglossa, chevron-toothed, is a large group, and presents considerable variation among its members as to the presence or absence of the different rows of teeth. The Raphidoglossa, needle-toothed, have large numbers of uncini teeth, the other rows varying in different groups. They usually have a well-developed mandible, or jaw, which is hinged in the middle. The Tænioglossa, bent-toothed, includes the greater number of fresh-water snails. The teeth vary in number and are often absent entirely. The common Helix, or air-breathing snails, often present a pavement-like form and arrangement of the teeth, which are often of a very pretty pattern, or, again, are a mere hardened mass. The lingual ribbon, beset with such teeth, is well adapted for filing off or rasping food and drawing it backward into the mouth. Be-sides that use it is also employed by some sea mollusks for boring into shells to abstract the juices of the animal within

CHAPTER IV

THE TEETH OF VERTEBRATES

In this great sub-kingdom true teeth are the rule and not the exception. They are enderonic structures, because they are derived from the deeper portions of the derm, or corium of the integument, and possess a calcified tissue called *dentin.* This is the main tissue of the teeth in all Vertebrates, but in the higher forms the crown is covered and protected by a calcified epithelial tissue called *enamel,* and the root in the higher forms is surrounded by a calcified osseous tissue known as *cementum.* The teeth of the lower Vertebrates, the Fishes and Reptiles, are composed mainly of dentin, and to this the other tissues, enamel and cementum, are added in the higher forms.

In *position* the teeth in the Vertebrates are mostly confined to the oral cavity and to the bones and cartilages of the head and face. In the higher Vertebrates they are supported by the upper and lower jaws,—the maxillæ and mandible only. In the lower forms they may extend to the thorax (or even to the œsophagus, as in some snakes), being supported by various bones and cartilages about the oral cavity. The palates and vomer (Fig. 6) often carry teeth in the fishes and

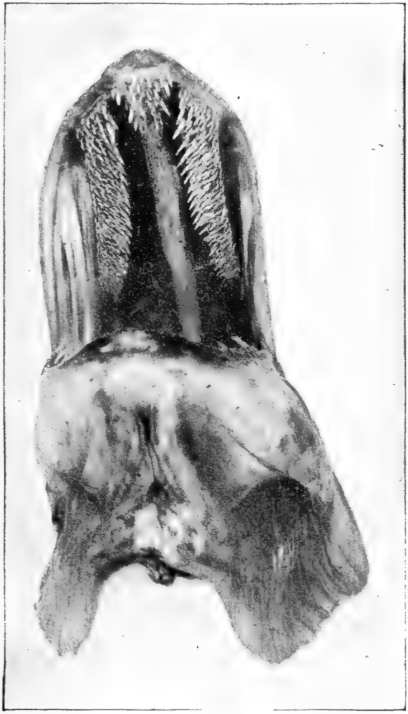


FIG. 6.—Teeth of Pickerel (*Esox lucius*), showing teeth on vomer and palates.

some calcified structures are on the gill arches. In the sawfish there is a special development of the premaxillary bones which carry teeth for defense only (Fig. 7).

The *Attachment of Teeth* in vertebrates presents four varieties or methods which grade into one another in different degrees. They are as follows:

1st. By means of a *Fibrous membrane* (as in the Sharks and Rays—Fig. 8), in which the teeth are imbedded, and which carries them up over the edge of the jaws. The teeth are brought up from

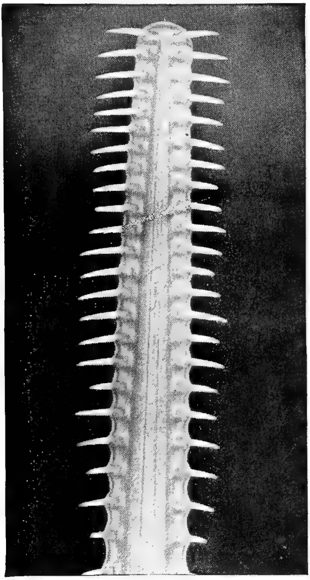


FIG. 7.—Snout of Sawfish (*Pristis pectinatus*), showing teeth for ripping open its prey.

the floor of the mouth and rise up to replace those which are lost from accident or use. These teeth arise from the thecal fold.

2nd. By *Elastic Hinge* (as in many fishes, the

Pike, Cod, etc.). The hinge is composed of strong fibrous ligament. Such teeth yield to pressure as

FIG. 8.—Jaws of Shark (species unknown), showing teeth attached by fibrous membrane.

the prey passes over them, and then spring up to hold it while struggling. There are two types of

Elastic Hinge. In one type we find the tooth is attached to the pedestal of bone by means of fibrous membrane which is located on the lingual side of the tooth and bony support. The base of

FIG. 9.—Hinged tooth of Pike (species unknown). (After Tomes.)

the tooth is attached to the bone by means of elastic fibres. When the tooth is bent toward the oral cavity the elastic fibres pull it back to an upright position. If the fibres are cut the tooth will remain wherever placed, which shows there is no elasticity in the hinge. The other form possesses no special elastic fibres but the hinge is elastic (Figs. 9 and 10).

3rd. By *Ankylosis,* when there is no interven-

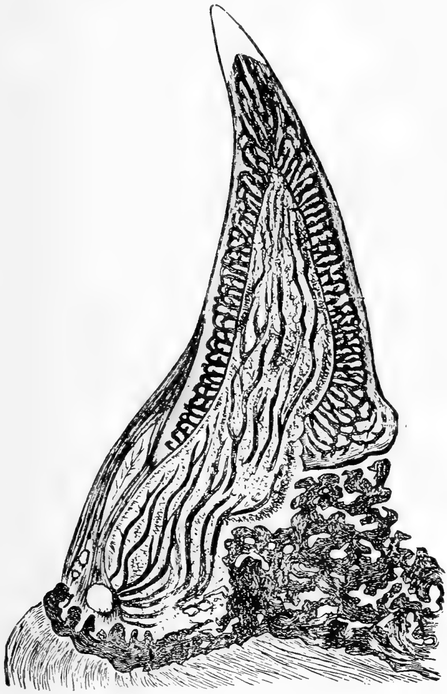


FIG. 10.—Hinged tooth of Hake (*Merluccius*). (After Tomes.)

ing membrane, but the teeth and the jaw-bone are ossified into one continuous piece like an ankylosed joint. Such teeth are sometimes but slightly attached, or, again, so strongly as to bring away a piece of bone when detached. Ankylosed teeth are found in many fishes and reptiles. There are three forms of ankylosed teeth: Acrodont, Pleurodont and Thecodont.

In the *acrodont tooth*, a pedestal of bone develops to support the tooth. During the process of development, the tooth is developed in the thecal fold and moved into position on the ridge

FIG. 11.—Radiograph of head of Pickerel, showing acrodont ankylosis. (By Dr. E. H. Skinner.)

of the jaw. After the tooth is well in position, the bone develops to support the tooth. When the tooth is lost the bony support is lost also (Fig. 11).

The *pleurodont tooth* is attached to the side of the bone and may get directly above the ridge of the jaw. The top of the tooth projects above the jaw so as to enable the animal to use the tooth (Fig. 12).

The *thecodont tooth* is ankylosed in a socket and is the type found in the higher reptiles and a few fishes. The tooth is more firmly supported in this form than in any other (Fig. 13).

4th. By *Implantation in a bony socket,* as

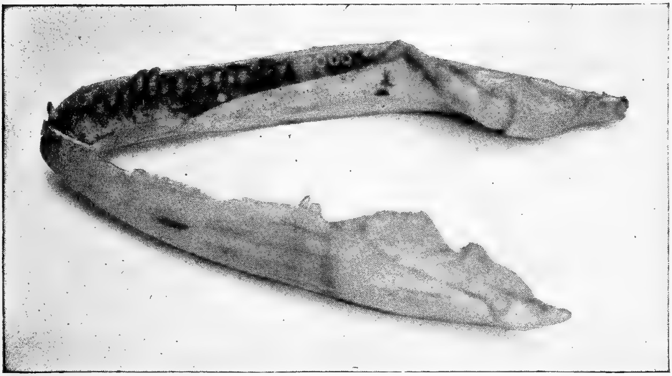


FIG. 12.—Mandible of Eel (*Anguilla rostrata*), showing pleurodont attachment of teeth.

found in some Reptiles and in the entire class of Mammalia. It is the method of attachment in man. There is an intervening membrane, a modified periosteum, between the root of the tooth and its alveolus, and a special bone of attachment, called the alveolar process, which is raised up around the root to support the tooth as it comes into place, and is absorbed when it is lost (Fig. 14).

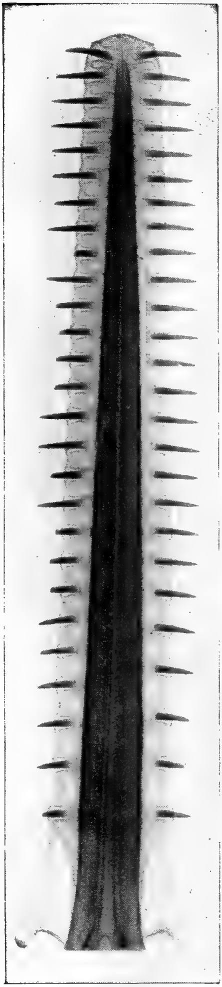


FIG. 13.—Beak of Sawfish (*Pristis pectinatus*), showing thecodont ankylosis.

There are three forms of the tooth which are attached by *gomphosis*. The brachydont tooth, the hypsodont tooth and the tooth of continuous growth.

In the *brachydont tooth,* the length of the root exceeds that of the crown. The crown, very early in the life of the tooth, emerges from the gum. In those teeth we also find that the enamel covers the crown of the tooth and the cementum only extends to the gingival border of the enamel. The teeth of man is an example of this form of attachment. Fig. 14 also shows brachydont teeth.

The *hypsodont* is characterized by the length of the crown being as great or greater than the root. The entire crown does not emerge from the socket and gums as one, but as the crown is worn off the tooth continues to erupt. The tooth is of continuous eruption but not of continuous growth. Figs. 15, 65, 70 and 71 are examples of hypsodont teeth. In most of these teeth we find a layer of cementum over the enamel.

The *tooth of continuous growth* is one in which there is a persistent tooth germ and has been called a tooth with a "persistent pulp." There is a persistent pulp but there is also a persistent enamel organ. In all of the teeth which are attached by gomphosis, there is a persistent cementum organ. With the tooth of continuous growth the dentin, enamel and cementum continue to develop and the tooth continues to emerge from the socket. A great many of the animals which have teeth of continuous growth have but one set of teeth. All of the rodents have some teeth which are of continuous growth. Fig. 16 shows the incisor of a squirrel.

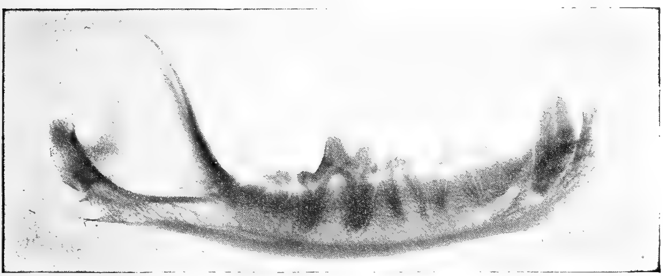


FIG. 14.—Radiograph of the mandible of a Wolf (*Canis lupus*), showing brachydont tooth attached by gomphosis.

Tooth Forms. The forms of the teeth in the Vertebrates present great variety. In the lowest classes, the Fishes and Reptiles, the simple conical

FIG. 15.—Roentgenogram of an antelope (species unknown), showing hypsodont teeth attached by gomphosis.

form predominates, as the teeth in these low types are modifications of the simple cone. This is the primitive typal form of tooth from which all later and complex forms were derived. There is considerable variation of the cone, however, in these classes, some fishes, as the Rays, etc., having plates or a pavement of teeth of flattened shape. Others are of cylindrical or prism-like outline, but the majority of fishes and reptiles exhibit modi-

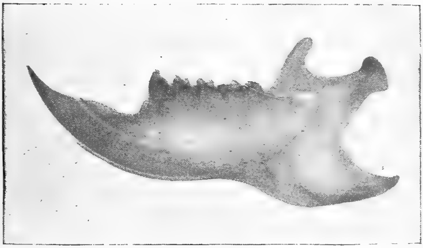


FIG. 16.—Roentgenogram of the mandible of a Squirrel (*Sciurus niger*), showing the incisor of continuous growth and brachydont molars and premolars.

fications of the simple cone, which is employed for prehension only.

In the Mammalia there is a greater variety and more complex forms of teeth. These are formed by evolution of the primitive typal cone, by duplication and modification of the cone to form bicuspid, tritubercular, quadritubercular, etc., forms, as of the molars. Teeth are developed from the primitive cone for various functions: thus the incisors are molded from a single cone by flattening of its base, to cut substances; the canine is a single cone elongated and sharpened, to seize and tear flesh; the premolars (bicuspids), as in man, are formed by the addition of a second lingual cone to the primitive buccal cone, to crush food, or by the addition of a third cone to form the tritubercular molar, or of the fourth to form the quadritubercular molar, etc., to grind food. There is sometimes special development of special teeth for secondary purposes, as of the incisors of the Elephant, Sirenia, Narwhal; or the canines of the Walrus, the extinct carnivora, the wild boar; or of the blades of the premolars of the carnivora. The premolar and molar teeth were evidently developed by the duplication of cones by fusion or addition, which are traceable back along the paths of their development through geologic ages, to simple conic reptilian forms. There was first the simple cone alternating with that of the opposite jaw, as in the living reptiles (*Haplodont* form); then the double cone, formed by the addition of a second cone (as the premolars of man); then the third cone was added to form the triconodont type, which was modified to the tritubercular form of molar (the primitive type of all molars); then the projecting heel or cingule (talon) led to the formation of the fourth tubercle (the *quadritubercular* molar); then the addition of the fifth and other tubercles formed the additional types. Thus the cones were duplicated and tubercles added to form the multitubercular types. These molar tubercles are rounded (*Bunodont*), as in Man, the Bears, Mastodon, etc.; raised to form cutting blades in the carnivora; or folded and duplicated (*Lophodont*) in the herbivorous mammalia to form broad triturating surfaces, etc.

The *Number of the Teeth in Vertebrates* varies greatly in different classes, and may even vary in the same genera. Some fishes are entirely without teeth of any kind; others have but one (as the Myxine and other parasitic forms), which is used as a lancet to cut the flesh for the purpose of drawing blood; others have a few teeth, and the number increases up to the thousands, in the bony fishes, and which may stud the mouth in every conceivable position. These are of continuous succession, so that the numbers are always indefinite. The reptiles have fewer teeth than the fishes, but these succeed one another continuously, and the exact number cannot always be determined. Different individuals of the same species will present great variations. In the mammals the number can be determined with greater precision, as each species, especially of the higher forms, has a definite number. In the lower mammals, as with the reptiles, the number is somewhat indefinite, but with the advance in the scale it becomes more exact. Some species are devoid of teeth entirely, as in some Ant-eaters. Others have but one tooth, as the Narwhal. A Dolphin has but two; the Elephant has but two incisors, and but four molars in use at one time. Some rodents have but two incisors and four molars in each jaw; the Sloths have but eighteen teeth; Man, the old world Monkeys, and some other Mammals have but thirty-two teeth, etc.

The number increases in various families to an excessive degree: thus some of the Armadillos have ninety-eight; some Whales sixty; the common Porpoise eighty to ninety; the Gangetic Dolphin one hundred and twenty, and the true Dolphin one hundred to two hundred.

While there is thus great variation in the numbers of teeth in the various classes of Vertebrates and even among the members of the same genera and families, there is a rule governing all which renders their study intelligible. This is based on a scientific classification and arrangement by means of which all teeth and tooth forms can be properly understood.

Vertebrate teeth are *classified* into various divisions having references to their forms, position, and functions. In the fishes and reptiles the teeth are adapted mainly for seizing and tearing, and consequently are undifferentiated as to position and function. There is little variety in different parts of the jaw as to the forms of the teeth, but only as to size, and there is not sufficient differentiation to admit of classification. But one function is performed in these low classes, that of prehension, for mastication is not yet developed. In the higher Vertebrates, the Mammalia, however, the teeth are more differentiated and special forms are evolved for special uses. Thus the teeth situated in the front of the oral cavity, from their form, are called *incisors,* or cutters, and their function is to cut or divide food. The large conical teeth situated immediately distally of the incisors are called the *canines* (from being extra well developed in the dog and other carnivorous animals), and are used for seizing and tearing flesh. The next teeth are the *molars,* the crushers and grinders, which perform the function of mastication and insalivation. These are divided into two classes, the *premolars* and *true molars.* The premolars are the permanent teeth just distally of the canines which succeed the deciduous molars. These are called the *bicuspids* in man. After these are the full or true molars, which are the true grinding teeth. Thus the permanent teeth of mammals are classified into four groups,—(1) the *Incisors,* (2) the *Canines,* (3) the *Premolars,* (4) the *Molars.* With this arrangement it is convenient to express in a mathematical scheme the number of the teeth of any mammal by means of what is called the *Dental Formula.* In this scheme the teeth are represented by numbers in the form of fractions,—those of the upper jaw being the numerator and those of the lower jaw the denominator. Thus the dental formula of Man is, for the permanent teeth,—

$$\text{i. } \frac{2\text{–}2}{2\text{–}2} \quad \text{c. } \frac{1\text{–}1}{1\text{–}1} \quad \text{p.m. } \frac{2\text{–}2}{2\text{–}2} \quad \text{m. } \frac{3\text{–}3}{3\text{–}3} = 32,$$

reading that he has on each side of each jaw 2 incisors, 1 canine, 2 premolars (or bicuspids), and 3 molars,—the initial letter of each class being used for abbreviation. The teeth of mammals may be expressed in the same way. The deciduous teeth of Man have the formula,—

$$\text{i. } \frac{2\text{–}2}{2\text{–}2} \quad \text{c. } \frac{1\text{–}1}{1\text{–}1} \quad \text{m. } \frac{2\text{–}2}{2\text{–}2} = 20,$$

there being no premolars or bicuspids in the deciduous series. The formula of the Elephant is,—

$$\text{i. } \frac{1\text{–}1}{0\text{–}0} \quad \text{c. } \frac{0\text{–}0}{0\text{–}0} \quad \text{m. } \frac{6\text{–}6}{6\text{–}6} = 26,$$

or of the Rat,—

$$\text{i. } \frac{1\text{–}1}{1\text{–}1} \quad \text{m. } \frac{3\text{–}3}{3\text{–}3} = 16.$$

The teeth of all mammals may be expressed in the same manner.

Single teeth are described in this system as follows with reference to the upper or lower series: thus the left upper central incisor is noted $\text{i}|^{1}$,—

i.e., the first incisor to the left of mesial line and above fraction line. The same tooth below would be $i\lceil_1$. The right upper first molar $\underline{{}^1m|}$, the lower left second molar $\overline{|m_2}$, the right upper second premolar $\underline{2\ pm|}$, the left lower third molar $\overline{|m^3}$; the number being distal of the initial letter and the line mesial.

The *classes of the teeth in Mammals.*

The *Incisors* take their name from the office they perform in the function of mastication,—i.e., to *incise,* to cut, but the term is applied to the upper teeth located in the premaxillary bone anterior to the intermaxillary suture, whatever their form, in mammals. The teeth in the mandible which occlude with the upper teeth (in the premaxillary bones) are also incisors. Thus the tusks of the elephant are incisors, although their cutting function is completely aborted and these teeth are employed as tools and weapons only. The function of cutting or dividing food is performed by various organs throughout the animal kingdom. Teeth for this purpose are developed very low in the scale of life, as the cephalopods have cutting teeth; the sea-urchin has highly specialized incisors; the insects and worms cut by means of the mandibles, jaws, etc. The beaks of turtles and birds are employed as cutting implements, but these are not true teeth. The fishes and reptiles have no true incisors, as the teeth are of simple conical shape and are employed for prehension only. The "sheep-head" possess anterior teeth which resemble the incisors of a sheep and round crushing teeth in the posterior region. Most of the lower mammals are deficient in regard to cutting teeth, the teeth being all of the molar type for grinding. The higher forms possess well-marked typical incisors. Thus the incisors of the *Herbivora* are well developed for cutting purposes. In the *Carnivora* the incisors are reduced, for the cutting function is usurped by the long blades of the sectorial premolars and molars. In the *Marsupials, Insectivora, Rodentia, Cheiroptera,* and others the incisors are specially developed for special purposes. In the *Quadrumana* they foretell the form of these teeth in man, which they resemble, in whom incisors are formed by the modification of the single cone,—the base being flattened to form a cutting edge.

The *Canines.* This tooth is the first succeeding the incisors, and is immediately distal to the intermaxillary suture. It is implanted in the maxillary bone proper above, and is probably modified from the premolar series. It is called the Canine from being extra well developed in the dog and other carnivorous animals. It is the principal prehensile tooth in mammals, and is therefore first in function, though second in position in the dental series. It is implanted by a single root, usually, and is modified from a single cone. It is the most primitive type of tooth, being nearest to the cone shape as found in the fishes and reptiles in all parts of the jaws. In the mammals it still preserves the primitive form, though modified variously in different classes. The lower mammals have no canines, but the Dolphin and Cetacea have conical canine-like teeth in all positions like the Reptiles. In the Marsupials it begins to assume specialized forms. It is absent in the *Proboscidæ* and *Rodentia* and in some of the *Ruminants*. In some of the *Herbivora* it is of incisor-like form, and is ranged with these teeth for cutting purposes. It is excessively developed in the Musk-deer, Boar, Walrus, and other animals, for battle or other secondary purposes. But it is in the *Carnivora* that the canine attains its greatest glory. In its monstrous development in some fossil carnivores it extended far beyond the lower jaw, and was of a saber-like form which is recalled in lesser degree in the extinct Cave Tiger and the Lion and Tiger of today. In the *Felidæ* these teeth are long, curved, and piercing, for tearing flesh and destroying life. In the *Canidæ* they are reduced in size, and are round and stout. In the Baboon they are still of large size, though reduced in the Monkeys and Apes, and are lowered to the level of the other teeth in Man. In man the canines are reduced in form and size, but still retain suggestions of the features of these teeth in the Carnivora.

The *Tubercular* and grinding teeth. The very lowest form in which grinding organs appear are the cusped prominences on the triturating plates of the Crustacea and some insects, but these are not true teeth. They are, however, analogous to true grinding teeth, as they are employed for the same purpose. Very few of the Invertebrates possess triturating apparatus of any sort. In the Vertebrates, crushing teeth appear in some forms of fishes, which have well-developed pavement teeth of various forms for crushing the shells of mollusks and crustaceans. These are not true molars, however, as they do not triturate food nor insalivate it. Tuberculate teeth proper do not appear until in the higher forms of reptiles, as some of the lizards have teeth, which are slightly tubercular, and these are the beginnings and forerunners of the molar series in the Mammalia. The lizards show the first tendency to the duplication of cusps, which are repeated over and over in various directions in the Mammalia. In the Mammalia the molar series of the permanent teeth is divided into two sections,—(a) the premolar (or succedaneous teeth), and (b) the true molars, which have no deciduous predecessors. The grinding teeth of the deciduous set are molars. The premolars are the small grinders which are found between the canines and true molars among mammals, and vary in number in different species. They are the principal crushing members of the dental series, and are placed midway of the cutting and grinding teeth proper. In man the upper premolars (or bicuspids) are of simple form, being composed of two or three cones united together. The lower premolars vary from this form. In the higher Apes the premolars are of the same form as in man, but are coarser and larger. In the lower Quadrumana they are reduced to simple crushing teeth with the outer cusp enlarged and the inner reduced. In the *Carnivora* they are highly specialized on account of the tubercles being raised into large cutting blades. In the *Herbivora* they are similar to the true molars in form, and are developed for triturating purposes. In the *Insectivora* they are very variable in shape, but possess, like the true molars, long, sharp cusps for crushing insect coverings. In the *Rodentia* they are entirely absent in most of the species of this extensive order, as there is a large vacant space between the incisors and the grinding teeth. The true molars are found alone in the Mammalia, and are highly specialized teeth, being developed for the performance of the function of mastication. In the *Bruta* the teeth are all molars of a simple form, for crushing purposes. Some low forms have flat tooth-shaped plates of horn which answer the purpose of grinding teeth. In some of the anteaters, the tongue and roof of the mouth are armed with horny plates for crushing. In the Insectivora the molars are highly developed, with many long, pointed cusps for crushing the hard coverings of insects. In man, the molars are of simple tuberculate form of a lower grade of organization. His molar teeth are indeed of the type of the early Eocene mammals. In the Carnivora the molars are reduced in size and number, and the premolars are highly developed. In the more omnivorous species the number of molars is increased, and they have rounded tubercles for grinding a mixed diet. In the Herbivora the molars are highly developed for the mastication of an extreme diet, with pleatings and foldings of the dental tissue which insure a constantly rough face for the difficult reduction of resisting vegetable fiber. In the Quadrumana the molars are similar to these teeth in man, being simply tuberculate for a mixed diet.

The molar teeth of the Mammalia are classified as follows, according to shape:

Haplodont. The crown undivided or simple (as in the single teeth of the Cetacea, Carnivora, Rodentia, etc.).

Ptychodont. The crown folded on the sides (as in the Rodentia molars).

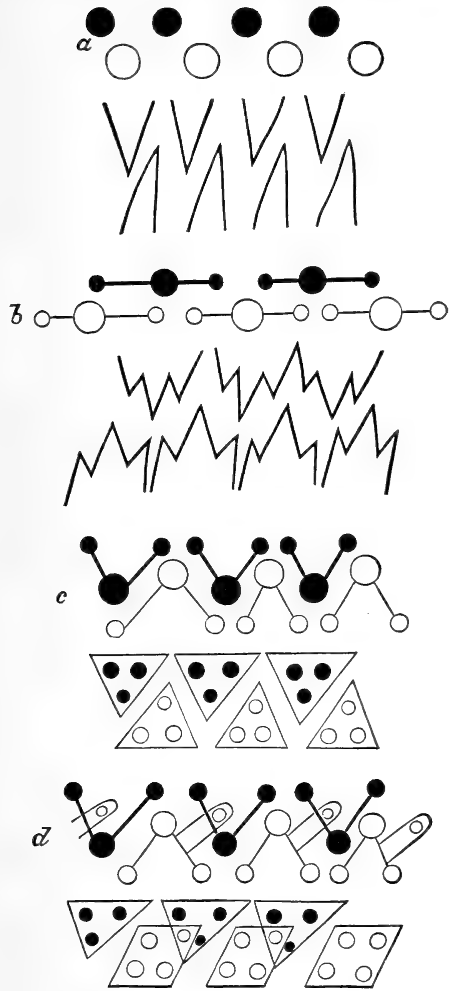


FIG. 17.—Phyletic History of the Molar Cusps. (After Osborn.)

a, The Reptilian stage. (Haplodont.)
b, Early Mammalian stage. (Triconodont.)
c, Triangular stage. (Tritubercular molar.)
d, Quadritubercular molar.

Bunodont. Crown supporting tubercles (as in Man, Carnivora, Mastodon, etc.).

Lophodont. Summit of crown with transverse or longitudinal folds (as in Herbivora).

The Evolution of Teeth. The molar teeth present great varieties among mammals, but all have been derived in some manner from the primitive cone. All investigators are not agreed as to the exact manner of the evolution of the molars. In studying the evolution of the teeth, we are forced to gain our knowledge from three sources; viz., anatomy, embryology and paleontology. Each one of these sciences cast some light upon the evolution of the teeth and these sciences all go to prove that the teeth have evolved from the simple cone.

From the study of paleontology, different investigators do not agree as to the exact manner of the evolution of the molars. All agree that the molars have started from a single cone, but they do not agree as to the exact detail. From the study of the teeth of fossils, it seems to the writer that it may be possible that all of the molar teeth did not evolve in the same manner, but have been the result of radiation. By radiation in biology is meant that the plant or animals of a certain class all begin from a common center and branch off in different directions until we have many plants that resemble each other but very little, and each group must be traced back to the original center in order to show their relation between the different groups. In the study of the teeth, it seems as if radiation has played an important part. Beginning with the primitive cone, we have three theories for the evolution of the molar, each of which has probably played a part in the animal kingdom. Some of the animals have probably had their molar teeth follow one plan of evolution and some have followed another.

The Cingulum Theory. This is one of the oldest, if not the oldest theory of tooth evolution. It is based on the fact that all primitive teeth show a tendency to form a ridge that develops near the gingival margin of the tooth, or at the neck, which is a ridge of enamel on the teeth of the higher mammals. The cingulum theory is that upon this ridge developed small cusps or cingule which increased in size in later generations and resulted in the extra cusps. The strongest evidence in favor of this theory is that we find a great many cingule on the teeth of fossils and upon the teeth of some of the modern animals. There is very little proof that the molars of modern mammals are evolved in this manner.

The Concrescence Theory. This theory is based on the fact that the reptiles and fishes possessed a great many teeth and it has been proven very conclusively that the mammals have evolved from the reptiles. The concrescence theory is that the large number of teeth which we find in the fish and reptiles have fused together and made a number of large teeth with a varying number of cusps. There is very little to support this theory except a few fossil forms that have been found in various parts of the country. The teeth of the mastodon and mammoth seem to be made up of a number of cusps fused together. The plates of the elephant's teeth might also come under this form of evolution, but there is nothing to prove that the majority of mammals have had their molars evolved in that manner. Briefly, the argument against the concrescence theory is that the number of teeth have decreased from the fishes to reptiles and we find the primitive reptiles having single conical teeth. The majority of the teeth of the fishes were located on the palates and vomer and in the higher reptiles and mammals the maxillæ and mandible carry the teeth. The low forms of mammals generally have few teeth and they are all conical as in the ant-eaters and armadillos. As we reach the higher forms we find that the cusps begin to appear on these conical teeth.

The Tritubercular Theory. The tritubercular theory is that the molars of mammals have evolved from a molar with three cusps. This theory as first advocated has been modified some by various investigators until it may be briefly stated as follows: Realizing that all teeth have developed from the primitive conical teeth which we find in the reptiles by the addition of other cones, this first or primitive cone is called the *protocone* in the upper arch and the *protoconid* in the lower. In the evolution of the premolars, such as we find in the upper teeth of man, the protocone becomes the lingual cusp (some writers claim the protocone becomes the buccal cusp in the upper premolars but there is little to support that theory), and the second cusp becomes the buccal cusp and is called the *deuterocone.* In the lower premolars the protoconid becomes the buccal cusp and the deuteroconid becomes the lingual cusp. Some of the premolars, often the lower second premolar of man, are three cusp teeth, made so by the addition of the third cusp which is called the *tritoconid,* and when present in the upper arch is called the *tritocone.* In some of the mammals, a fourth cusp is found which is called the *tetarocone* in the upper and the *tetaroconid* in the lower. In the carnivora, we find the cusps of the premolars arranged in a row antero-posteriorly.

In the evolution of the true molars, there is added to the protocone a small anterior cusp which is called the *paracone* and a small posterior cusp which is called the *metacone,* in the upper arch. In fact the upper cusps are distinguished

FIG. 18.—Occlusal view of teeth of Opossum (*Didelphis virginiana*), showing triangular molar crowns.

by the ending "cone" and the lower cusps by the ending "conid." This gives three cusps in an antero-posterior line, forming a three-cusped crown called the *triconodont* form. This is the type of the early forms of the mammalian molar teeth and is still preserved in some of the carnivora, seals, lemurs and other living species. The next stage is the shifting of the cusps so as to alter their relative positions to form a triangle. In the upper arch the protocone shifts to the

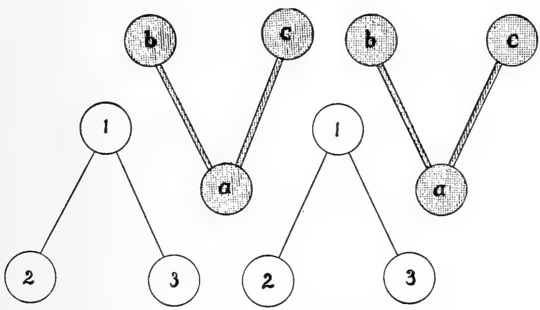


FIG. 19.—Diagram showing the occlusion of the trigon and trigonid.

1. Protoconid (Buccal cusp).
2. Paraconid (Mesio-lingual cusp).
3. Metaconid (Disto-lingual cusp).

a. Protocone (Lingual cusp).
b. Paracone (Mesio-buccal cusp).
c. Metacone (Disto-buccal cusp).

lingual and becomes the mesio-lingual cusp, leaving the paracone and the metacone on the buccal side. The paracone is the mesio-buccal cusp and the metacone the disto-buccal cusp. This is the tritubercular molar crown of early geological times from which all other molars of the present mammals are probably developed. This triangular molar crown is still present in the opossum (Fig. 18), some insectivora, lemurs, and others.

This triangular arrangement of the cusps forms the trigon of the upper molars.

In the lower molar, the primitive cusp is called the *protoconid* and moves to the buccal side and becomes the mesio-buccal cusp. The *paraconid* becomes the mesio-lingual cusp and the *metaconid* becomes the disto-lingual cusp, thereby forming the *trigonid* of the lower molar. Thus the tri-

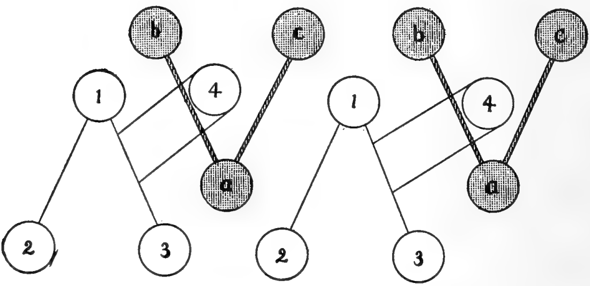


FIG. 20.—Diagram showing the occlusion of the talonid of the lower molar in the trigon of the upper.

1. Protoconid (Mesio-buccal cusp).
2. Paraconid (Mesio-lingual cusp).
3. Metaconid (Disto-lingual cusp).
4. Hypoconid (Disto-buccal cusp).

a. Protocone (Lingual cusp).
b. Paracone (Mesio-buccal cusp).
c. Metacone (Disto-buccal cusp).

angles of the upper and lower molars alternate (Fig. 19),—the apex of the upper one being directed lingually and the lower one buccally,—so they pass in a shear-like motion. The next step is the addition to the trigonid (of the lower molar), on the disto-buccal surface, of a heel or *talonid,* which may support one, two or three cusps. The buccal is called the *hypoconid,* the disto-buccal the *hypoconulid,* and the disto-lingual the *entoconid.* The position of the talonid is such that the hypoconid falls in the center of the trigon of the upper molar (Fig. 20). There is then developed on the disto-lingual surface of the trigon (upper molar) a talon which carries a cusp called the *hypocone,* thus making a quadritubercular molar as seen in the upper molars of man. This fourth cusp falls between the lower cusps as

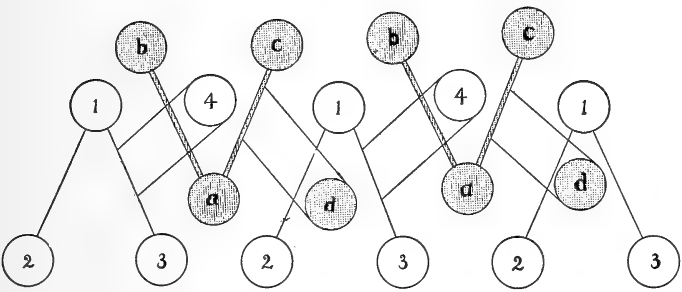


FIG. 21.—Diagram showing the position of the talon of the upper molar.

1. Protoconid (Mesio-buccal cusp).
2. Paraconid (Mesio-lingual cusp).
3. Metaconid (Disto-lingual cusp).
4. Hypoconid (Disto-buccal cusp).

a. Protocone (Mesio-lingual cusp).
b. Paracone (Mesio-buccal cusp).
c. Metacone (Disto-buccal cusp).
d. Hypocone (Disto-lingual cusp).

shown in Fig. 21. The cusps of the lower molar continue to develop and change. The paraconid becomes reduced in size and is missing in the lower permanent molars of man, but exists in the deciduous lower first molar as a small cusp. The paraconid can also be seen in the lower teeth of the opossum. The position of the paraconid and the cusps of the talonid, as seen in the lower first deciduous molar of man, is shown in Fig. 22 with the cusps named. The lower first deciduous molar shows the gradual reduction in size of the paraconid better than any other tooth of man.

In the lower first permanent molar of man, the paraconid is absent and the talonid carries three cusps,—the *hypoconid,* the *hypoconulid* and the *entoconid.* The hypoconid is the buccal cusp and falls in the center of the talon of the upper molar

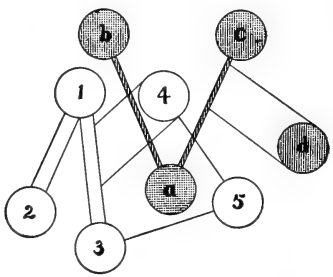


FIG. 22.—Diagram to show the paraconid of the lower first deciduous molar in the relation of the talonid and trigon of the upper molar.

1. Protoconid.
2. Paraconid.
3. Metaconid.
4. Hypoconid.
5. Hypoconulid.

a. Protocone.
b. Paracone.
c. Metacone.
d. Hypocone.

(Fig. 23). In the four-cusp molar of man, as seen in the lower second molar, there is some question as to which cusp is lost or fails to develop. These forms are further complicated in some of the mammals, especially in the herbivora; however, the history of the molar cusps can be traced with considerable accuracy through the various steps of their evolution from the early geological times to the present day.

Evolution of Occlusion. The teeth have been evolved from a single cone to the more complex types and likewise the arrangement of the teeth have changed. In the fishes we find only an occlusion of tooth-bearing surfaces. There may be teeth on the maxillæ and mandible which occlude with each other as a mass. There may be teeth on the palates and vomer which occlude with

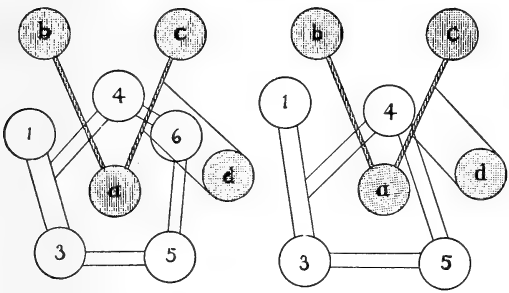


FIG. 23.—Diagram to show the relation of the upper first and second molars and the lower first and second molars with the cusps named.

1. Protoconid.
3. Metaconid.
4. Hypoconid.
5. Hypoconulid.
6. Entoconulid.

a. Protocone.
b. Paracone.
c. Metacone.
d. Hypocone.

masses of calcified substances on the tongue. This arrangement is called occlusion of tooth-bearing surfaces, an example of which is seen in the myliobatis (Fig. 24).

The next step is the occlusion of rows of teeth. In the non-poisonous snakes, as the python (Fig. 25), we find two rows of teeth above and one below. The lower row occludes between the upper rows. One of the upper rows is situated on the maxillæ and the other on the palates. In the alli-

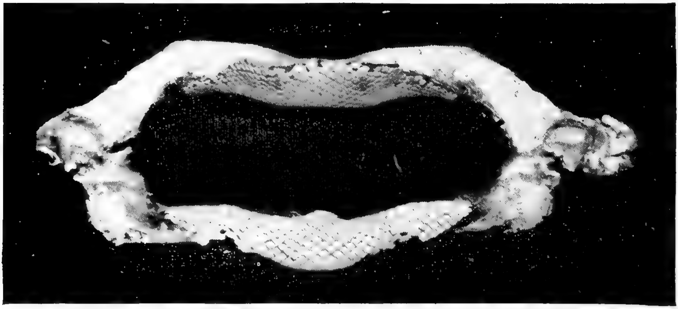


FIG. 24.—Myliobatis, showing occlusion of tooth-bearing surfaces.

gators and crocodiles there is one row above and one below, but no occlusion of the individual teeth.

FIG. 25.—Skull of Alligator (*Alligator mississippiensis*), showing occlusion of rows of teeth.

The teeth of some of the primitive birds were also arranged this way (Fig. 25).

We next find occlusion of individual teeth, on which there has been no development of extra cusps. Such an example is seen in the armadillo and the teeth may be said to represent the original protocone and protoconid (Fig. 26).

FIG. 26.—Skull of Armadillo (*Euphractus minutus*), showing occlusion of rows of teeth.

In the occlusion of cusps, which is the type of occlusion found in higher mammals, we find the teeth have evolved so as to present a tooth with

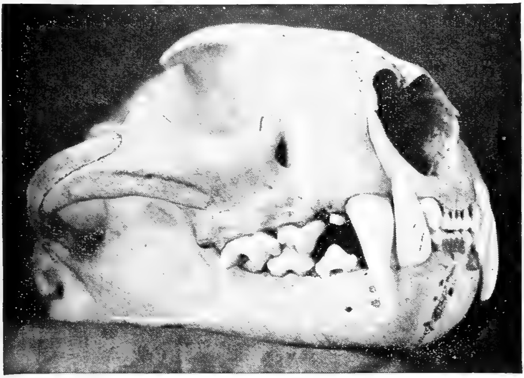


FIG. 27.—Skull of Mountain Lion, showing occlusion of cusps.

many cusps which is so arranged as to occlude with the cusps of the opposing tooth. This gives a tooth which has a great amount of grinding surface (Fig. 27).

Evolution of the Temporo-mandibular Articulation. With the evolution of the tooth forms and the occlusion of the teeth we notice a corresponding change in the jaw forms and the temporo-mandibular articulation. In those animals which have occlusion of tooth-bearing surfaces, the temporo-mandibular articulation is very loosely constructed and the condyle and glenoid fossa have very little shape. In those animals which have occlusion of rows of teeth, there is more of a condyle and glenoid fossa. In the alligators, owing to the anatomical structure of the animal, we find that the condyle is concave and the glenoid fossa convex and the mandible is the more stationary bone when the mouth is opened. In those animals with occlusion of the cusps, we find the articulation influenced by the shape of the cusp. In the animals which have long cusps, the glenoid fossa is decidedly concave, and in those in which the cusp is short the glenoid fossa is only slightly concave and often entirely flat. When we find the cusps of the teeth so arranged that the tooth has a long antero-posterior diameter the condyle has a great bucco-lingual diameter. The greatest diameter of the tooth is always the opposite to the greatest diameter of the condyle. In man, we find that the shape of the condyle changes as the occlusion changes. In fact, in young animals of whatever family, the temporo-mandibular articulation does not assume a definite shape until after the teeth are in occlusion.

The Succession of the Teeth in Vertebrates. The Fishes and Reptiles have the teeth supplied in endless succession. When teeth are lost, others rise to take their places by various processes. In the Sharks and Rays, the teeth are supported by a fibrous membrane which carries them up over the edge of the jaw (Fig. 28), bringing new ones into place as the old teeth are lost. Hinged teeth are replaced as lost by new ones which are constantly developed at the base of the old teeth. Ankylosed teeth are replaced by the successive teeth being raised up beside or in the place of the old teeth, and new bone of attachment is reproduced to support them. Socket teeth are replaced by the advance of new teeth from within the body of the jaw when the old teeth are lost, as in man. In the Fishes and Reptiles many sets of teeth are developed during the life of the individual. In the higher forms the teeth arise *de novo* from the mucous membrane. The number is constant and indefinite.

In the present Mammalia there is generally but two sets of teeth produced. The Elephant has six molars, each one of which may be taken as a set of teeth, as but one erupts at a time and never more than two are present at one time. Mam-

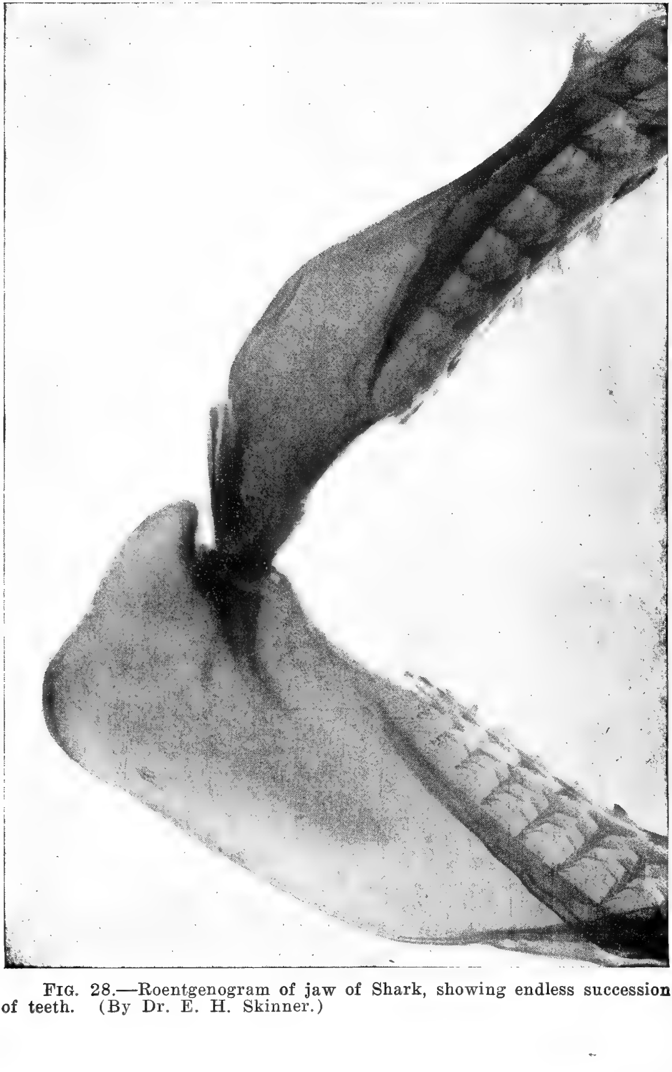
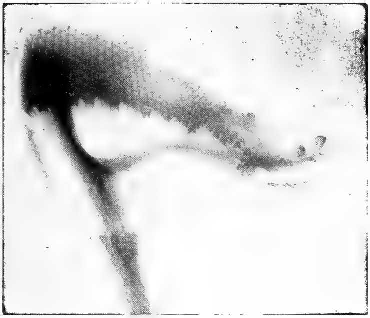


FIG. 28.—Roentgenogram of jaw of Shark, showing endless succession of teeth. (By Dr. E. H. Skinner.)



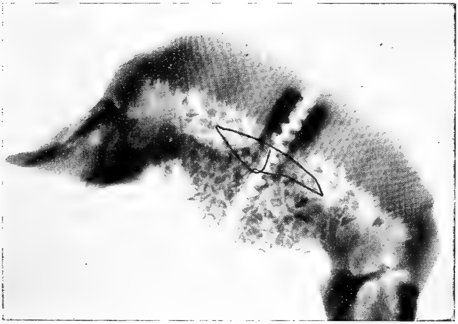


FIG. 28-A.—Roentgenograms of jaws of Parrot-fish (*Scaridæ*), showing continuous succession of teeth. (By Dr. E. H. Skinner.)

mals are divided into two classes in reference to the possession of one or two sets: those having but one set are called *Monophyodont,* those giv-

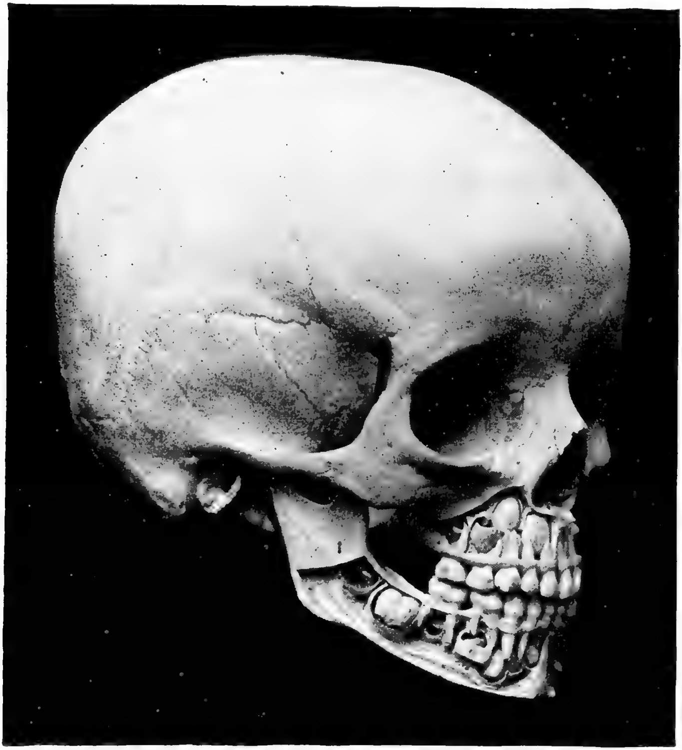


FIG. 29.—Teeth of human. Diphyodont and heterodont.

ing rise to two sets are called *Diphyodont.* The monophyodont mammals produce but one set, which persists through life,—as some Armadillos, Sloths, Cetacea, the common Rat, and others.

The first set remains permanently, is more or less continually growing, and is never displaced by a second set. The diphyodont mammals have first a deciduous set which supplies the dental wants of the individual during the first years of existence. It is then shed and replaced by the permanent set, which should remain during the lifetime of the individual. The teeth which succeed the deciduous teeth are called *succedaneous* teeth, but additional teeth are sometimes produced which have no deciduous predecessors. Thus in man the ten anterior teeth are shed and replaced by permanent teeth, but there are also six additional teeth, the true molars, in each jaw which erupt without displacing any deciduous teeth.

The monophyodonts are usually *homodonts,*—i.e., the teeth are all alike and of the same form in all parts of the jaw. The diphyodonts are *heterodonts,*—i.e., the teeth are of various and different forms in various parts of the jaw,—as the incisors, canines, premolars, and molars of the Mammalia. So as a rule homodonts develop but one set of teeth, and heterodonts two sets, although there are noted exceptions to this rule.

In mammals the deciduous set arises *de novo* from the mucous membrane, and the permanent teeth are given off from the dental lamina. As a rule each tooth of the first set is displaced vertically by a similar tooth of the permanent set.

There are examples, however, of milk teeth which have no successors, as some Rodent incisors, and of permanent teeth which have no deciduous predecessors, as the true molars. Some Rodents—as the rat—have but one set and are monophyodont. The elephant's molars succeed each other continuously from behind by lateral displacement. The Carnivora have a well-developed milk set. The Herbivora have also a milk set, but the true molars arise *de novo.* In the Quadrumana the two sets are similar to those of man.

CHAPTER V

THE TEETH OF FISHES

The first and lowest class of the Vertebrates is that of the *Fishes.* They are entirely aquatic in their habits, and breathe by means of gills. The body is bare, or covered with horny scales. The limbs are modified into organs for swimming. The nervous system is centralized in the spinal cord, but there is little enlargement of the cephalic portion. In the lowest forms, as the *Amphyoxus,* there is no enlargement at all. The osseous structures are soft and cartilaginous, and partake of the general low structure of the class. The vertebræ are cupped before and behind, except in the Pike and some other forms which show a step toward the reptilian character of being cupped in front and balled behind. The jaws are often movable and loose, and capable of protrusion and retrusion.

The Teeth of Fishes. The true fishes have true teeth. There are many kinds of teeth among the many species of fishes, which are developed in every conceivable position upon the various bones and cartilages of the head. They are sometimes produced in countless numbers, as in the Salmon and Pike, or may be reduced to only one tooth, as in the Myxine, or there may be none at all. There is no general rule as to the number, position, or form in this great class. They are very general in form and undifferentiated, and may vary extensively even among the individuals of the same species.

Forms and Function. The teeth of fishes are derived from the simple cone, by various modifications. The conical teeth present great variety,—from long, fine, hair-like forms, to short, stout cylinders, and in others they may vary from cone to cylinder, from cylinder to plate. The teeth of fishes are designed for prehensile purposes mainly, as there are no masticating teeth proper in this class, though some species have pavement-like teeth, for crushing purposes. The conical teeth are often fine or hair-like; or so short as to be only felt with the fingers; or long and slender; or long and strong; or stout and short,—such teeth being attenuated cones in shape. The cone may merge into the cylinder, this into the compressed triangular form (as in the Shark), or stout with rounded summits (as in the Wolf-fish), or flattened plates (as in the Ray) or incisor-like form (as in the Sargus). The arrangement is very general and indefinite.

Structure. The teeth of fishes are generally composed of vaso-dentin,—a soft dentin with a circulation,—the point of the tooth only being covered with enamel in some forms. This dentin is somewhat denser than the bone of the jaw, but is not so dense as the dentin of the higher Vertebrates. In some forms it is not covered, and in others, as the Sharks, it is protected by a shiny enamel-like substance, but this is not true enamel. In other forms, as in the Sargus, the dentin is yet harder, and is covered with a thick layer of dense substance developed by a distinct organ. Sometimes this enamel is covered by a layer of cementum. In others again there is a mere osseous substance which results from the calcification of the pulp.

The Development and Succession of the Teeth in Fishes. In the great majority of fishes the germs of the teeth are developed directly from the mucous membrane of the mouth, throughout the whole period of succession. This is peculiar to the class. In all species the teeth are shed and constantly renewed throughout the whole life of the individual. Generally there is more than one successional tooth developing, so that several teeth are in process of formation destined to succeed one another in regular order. The mode of succession varies with the method of attachment, however, of which there are several in this great class,—i.e., ankylosis, elastic hinge, and fibrous membrane. In ankylosed teeth, the most common form is for the new tooth to rise up under the old tooth and by absorption displace it; others displace the old tooth from the side by absorbing its supporting cone. Hinged teeth are developed in the folds of the mucous membrane, and as the old teeth are lost through use, new ones rise up to take their places. In the fishes having fibrous membrane attachment, the teeth are developed in the thecal fold on the inner side of the base of the jaw, and are perfected in growth as they are carried upward over the edge of the jaws by the membrane in which they are imbedded. Thus in the sharks the whole phalanx of the numerous teeth is ever marching slowly forward in rotary progress over the occlusal borders of the jaws, the teeth being successively cast off after having reached the outer margin and fulfilled for a longer or shorter period their appointed function, and are succeeded by others that rise up continually to take the places of those that are lost.

Descriptive. In the lowest forms of the cartilaginous fishes, as the Myxines, Lampreys, and other parasitic types, we find some destitute of true calcified teeth, but instead possessed of a horny structure of a conical sharp-pointed and often slightly recurved form. Some, as the Hagfish, have a lance-like tooth for piercing the victim to suck the blood. In others, horny teeth may be developed upon the roof of the mouth or palate, or upon the tongue, or may be supported by peculiarly developed labial cartilages.

The *Elasmobranchii* (the Sharks, Rays, etc.) have the body covered—when covered at all—by tooth-like structures which are small and close set, and the layer is called *Shagreen.* When larger and more scattered they form dermal plates or tubercles, and when they take the form

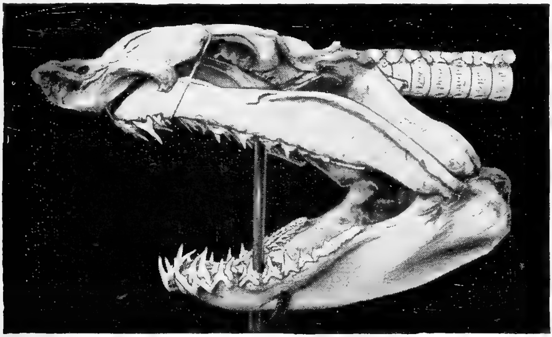


FIG. 30.—Teeth of Shark.

of spines are called *dermal defenses.* These coverings constitute the "placoid exo-skeleton," which in minute structure precisely resembles teeth. The protruding surfaces are frequently ornamented with an elegant sculpturing of various patterns. There are no true jaws, but instead cartilaginous forms of the palato-quadrate arch and of Meckel's cartilage. The teeth of sharks are always very numerous and arranged in concentric rows on the inside and summits of the mandible below and the palato-quadrate arches above (Fig. 30). They are imbedded in and borne upon the fibrous membrane which lines the inner surfaces of the arches, and by which they are carried forward over the edge of the jaws. The teeth lie flat against the membrane until brought to the edge, where the turning brings them upright for use. Thus the first row stands upright on the margin of the jaw and does service until lost, then those of the next row rise up to take the place of those lost, and the succeeding rows follow in regular orders,—the succession being endless. The teeth are developed from the bottom of a longitudinal fold of the lining membrane of the mouth at the lower edge of the jaws, called the *thecal fold,* from which they are continually carried up over the edge of the jaws. In all species the teeth are largest in the front or center of the jaws and diminish in size backward. The teeth of sharks are peculiarly adapted to the destructive habits of their possessors. The simplest form is that of a simple cone with a sharp point on a broad base, or it may be a triangular cone. In most of the sharks, however, the teeth are flattened into a triangular form, sometimes with serrated edges. The serrations are often deep and sharp and the tooth makes a very effective implement for cutting and tearing. The teeth vary greatly as to size, and in former geological ages sharks existed whose teeth, found in

FIG. 30-A.—Roentgenogram of tooth of extinct Shark. (By E. H. Skinner.)

the tertiary rocks, are of such large size that their possessors must have been enormous (Fig. 30-A). These teeth measure five by six inches. The general form of the teeth of sharks is that of a subcompressed triangle, but some forms have small accessory tubercles on each side of the central blade. Sometimes the blade is wide, short, and stout; again it is long and slender, or oval or leaf-shaped; the flat faces are sometimes smooth, and again grooved or wrinkled.

The Sharks merge into the *Rays,* in forms which have both cutting and crushing teeth. The teeth of all Rays are in pavement-like arrangement of various shapes, and are formed for crushing purposes. They are quite contact so as to form a more or less continuous sheath over the whole surface of the jaw. The shapes of the plate-like teeth are quite various, and sometimes present beautiful forms, in both recent and fossil species. Some are perfectly oval; some quadrangular (which fit closely together); in some—as *Myliobatis*—the teeth are of horny or bony structure, and are closely joined together; in some forms the teeth are rounded eminences; in all varieties they are formed in a thecal fold imbedded in a fibrous membrane, are carried up over the edge of the jaw, and are replaced as lost, just as in the Sharks.

The Saw-fish is a Ray, and is remarkable for the unique elongated snout, which is covered on both edges with true teeth, set in bony sockets and growing from persistent pulps. This fish sometimes attains an enormous size, with a snout six feet long and twelve inches wide (see Fig. 13).

The *Teleostei*, or true bony fishes, possess teeth which are ankylosed to the various bones of the head; some are hinged, and but rarely are they implanted in sockets. They consist usually of vaso-dentin with an irregular covering of enamel. The teeth are very numerous, and are scattered irregularly over most of the bones and cartilages of the mouth and head, even to the gills and occipital bones. In numbers they often run into thousands, as in the Pike where the mouth is covered with sharply-pointed conical teeth sloping backward to hold struggling prey. Some of these teeth are large on the sides of the mouth, and may be hinged, and arranged in rows or in groups. The marginal teeth are usually ankylosed, but the palatal teeth are often hinged. The bands or groups are all directed backward to assist swallowing. The usual shape is that of a simple cone, but this is varied greatly, and may be fine and small, or large and long and recurved as in the Pike, Cod, and related forms. Or again they may be rounded and blunt as in the Wolf-fish; or so small as to be mere denticles on the jaws; in the *Gymnodonts* the teeth and jaws are fused into one mass like a beak; hinged teeth are found in the Hake, Pike, Cod, Angle-fish, etc., which assist in holding struggling prey; the Sargus has teeth of incisor-like form (Fig. 31) ankylosed to the jaw. The Eel has small, conical, enamel-tipped teeth; the Herring has minute, sharp-pointed teeth on jaws and tongue; the Salmon has sharp-pointed teeth distributed over the bones and cartilages of the head, etc. Many varieties of teeth are found

FIG. 31.—Sargus, incisor-form teeth ankylosed to jaw. Heterodont. (Author's collection—Roentgenogram by Dr. E. H. Skinner.)

in this class, but all are related in arrangement and structure.

The Lung-fishes (*Dipnoi*) constitute a higher type which possess both lungs and gills which persist through life, in which they are closely related to the lowest form of reptiles, the Batrachians, and form the connecting link between fishes and reptiles. In the Lepidosiren there are two sharp-pointed recurved teeth, in the center of the jaw, and posterior teeth with molar-like cusps. Dentary plates are placed in the roof of the mouth, between which similar plates projecting from the mandible close for cutting purposes.

CHAPTER VI

THE TEETH OF REPTILES

The second class of Vertebrates is the *Reptilia,* which are more highly organized than the Fishes and approach Mammals in some of the higher forms. They are cold-blooded, breathe by means of gills in the lowest types and by lungs in the higher, and are covered with a tough, leathery skin or by horny scales.

The class is conveniently subdivided into two main divisions,—(1st) the *Batrachians* (or Amaphibia), and (2nd) the true *Reptiles.* The Batrachians are the lowest form of Reptiles, and approach the Fishes in the degraded structure they exhibit. They are the connecting link between the fishes below and the true reptiles above them. They breathe by means of gills, and are aquatic during the first or larval stage of existence, and later change to air breathers—as the common Frogs, Toads, and Newts—on attaining maturity, and live both on land and in water. Other forms —as the Proteus—retain the gills through life. The true Reptiles are lung-breathers, and live mostly upon land. They have four limbs, except one large order,—the *Ophidia,* or Snakes, which are without limbs.

The *teeth* in the class *Reptilia* are not so numerous nor so widely distributed as in the class Fishes. They are confined to the borders of the jaws, except in some of the Batrachians which resemble the Fishes in having the dentary bone and vomer carrying teeth also. Reptiles usually have an endless succession of teeth, which are replaced or shed as in the Fishes, and which are composed of hard dentin with a thin layer of enamel in some species. One entire order, *Chelonia* (Turtles), are without teeth, but have horny sheaths for the jaws instead, like the beaks of birds. The beaks of turtles differ according to the food habits of the species. The teeth of Reptiles, like those of Fishes, are employed for prehension and for holding struggling prey, for mastication is not performed to any extent in this class.

In the *Batrachians,* the teeth, when present, are disposed in rows upon the borders of the jaws and the two vomers above, between which the mandibular row closes. Some types, as the *Siren,* have the jaws ensheathed with horny beaks. In the larval stage the Frog (the "tadpole") also has the jaws covered by horny sheaths, which are lost at the time of the metamorphosis when the true teeth appear. The teeth are ankylosed to the bone like the teeth of fishes, which they much resemble.

In the common *Frog,* the teeth appear at the time of the metamorphosis, when the tail is lost and the legs appear, and the gills are aborted to be replaced by lungs. The teeth appear on the maxillary and premaxillary bones, but not on the mandible, as the frog has no perceptible teeth on the lower jaw. The teeth form a single row around the margin of the upper jaw,—their points projecting but little above the membrane,—against which the lower jaw closes, there being no lips. The teeth are ankylosed to the bones, each one being perched upon a little pedestal of bone. The successional teeth move up beneath the old ones and push them off. The teeth are mere delicate cones of hard dentin, with a thin layer of enamel.

The *Toads* are practically toothless, and have no compensating structures.

The *Newts* and *Salamanders* sometimes have conical teeth that are bifurcated at the points and are tipped with enamel. Some species have great numbers of teeth, like the Teleostei fishes.

The *Sirens* have horny sheaths on the jaws (like the larval form of all the *Batrachians*), and teeth also on the vomers and on the sphenoidal piece of the mandible.

The *Alleghany Mempomona* is a typical Salamander. There is a groove upon the edge of each jaw, in which the teeth rest by an enlarged base on the bottom and the points just rise above the margins of the groove. The teeth number sixty to eighty in each jaw; are about equal in size, sharp-pointed and recurved. They are attached by ankylosis to the outer walls of the groove,—a method of attachment called "Pleurodont," because of its resemblance to the attachment of the ribs.

The *Axolotl*—a peculiar Mexican lizard with permanent gills—has rasp-like teeth, of a fish-like character. The *Proteus* also has permanent gills. It has sharp, fine teeth in front and a horny palate behind. The teeth of some extinct Batrachians whose remains have been preserved in the rocks present some remarkable features. The *Labyrinthodont* form was so named on account of the extraordinary folding of the dental tissues, which were longitudinally crimped so that in a section of the tooth it looks like a roll of pleated and crushed cloth. The pulp-cavity was subdivided into a number of radiating branches which reached out into the folds.

The teeth of the true *Reptiles,* with few exceptions, present simple conical forms with more or less sharp points, which vary in length and are circular or oval on section. The teeth are long and the points sharp as in the snakes; or short and blunt as in the crocodiles; or tubercular, as in some lizards, etc.

Teeth do not exist in all reptiles, as one whole order, the Chelonia, and some snakes are edentulous. They may be present on the jaws only, —as in the crocodiles, lizards etc.,—or upon the palatine and pterygoid bones, or the intermaxillaries. Some toothless snakes have the inferior spinous processes of certain cervical vertebræ prolonged to project within the walls of the œsophagus for the crushing of the shells of eggs on which such species feed. The teeth are usually implanted in sockets in the true Reptiles, though the lizards and snakes often have them ankylosed to the jaw. The root is single, and never branches into fangs as in the mammals. They are continuous in succession like the teeth of Fishes and Batrachians, and this proceeds through life, teeth being shed and replaced without cessation. The teeth are composed of hard dentin with a thin layer of enamel on the apex.

The *Lacertilia* comprises the Lizards, Chameleons, Iguanas, etc. The *Iguanodon* and other great extinct lizards are also related to this order. They are distinguished from the other reptiles mainly by the presence of clavicles. The skull is intermediate between crocodiles and turtles. The teeth are attached by ankylosis, like the Batrachians, and in this and other features they approach that low type. The teeth are of simple conical form, of various sizes and shapes; sometimes the maxillary teeth have serrated edges and the beginning of tuberculated crowns. Only the apices were sometimes covered by enamel. The pulp-cavity sometimes has numerous divisions. The succession of teeth is constant,—new teeth being developed by the side of the old ones and displacing them by absorption, as is the usual form of succession in ankylosed teeth. The Lacertilia all possess teeth, which may be confined to the maxillary, premaxillary bones and dentary pieces of the mandible, or may in addition be developed on the palatine and pterygoid bones. The form is usually conical, but there is a suggestion of approach to mammalian types. Thus the Frilled Lizard has canine and incisor-like teeth, and other species have cuspidate crowns, or with cingules on the sides of the crowns. The *Stillio* (or little flying dragon) has long canine-like teeth, with tricusped crowns behind. The Chameleon also has cusped molars for crushing insects which it catches with its long tongue. The Monitor has sixteen teeth above and fourteen below, which are sharp-pointed and conical. The "Horned Toad" has conical teeth on the palatine and pterygoid bones as well as on the maxillaries. The horned *Iguana* has teeth in the posterior part of the jaw which have expanded crowns, with a blade of spear-like form with serrated edges. The "Gila Monster" (Fig. 32) (*Heloderma*) is a large lizard of Mexico and Arizona, which has teeth of thin, flattened spear-shape with apparent grooves, which increase in size from front to back. The bite is said to be poisonous, but its toxic effect may be due to the saliva only.[1] A New Zealand

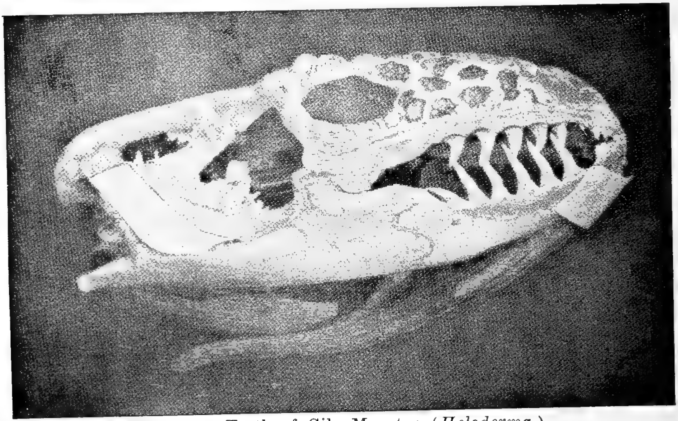


FIG. 32.—Teeth of Gila Monster (*Heloderma*).

lizard (*Hatteria*) has the intermaxillary bones armed with two teeth so large as to be as wide as the jaw, and which resemble the scalpriform teeth of the Rodents. When worn down to the jaw, the bone then comes into use and is worn away with the teeth. The African "Frilled" Lizard (*Dicryodon*) has sharp margins to the

1 Good authority claims the bite of the Gila Monster is only poisonous when it has been eating poisonous insects.—*Editor.*

jaws, and also large canine-like tusks projecting downward from the upper jaw which grow from persistent pulps,—a very rare thing in the Reptiles.

The extinct lizards were remarkable animals. The *Plesiosaurus* was a form of lizard with long neck and small head, and the limbs modified into paddles for swimming. They varied much in size, some being very small. The teeth were sharp-pointed, recurved, and the external surface of the crown striated. Each tooth was lodged in a distinct socket. Some were of triangular shape on section, with two cusps, and sometimes rounded off. The *Ichthyosaurus* is an extinct lizard of gigantic size, with paddle-like limbs, and was remarkable for the extraordinary enlargement of the eyeballs, which had ossified sclerotics. It had long, narrow, flattened teeth, formed of folded plates of enamel. The *Iguanodon* had remarkable teeth. Some were flat and spread out like a fan with serrated edges,—the base constricted and composed of folded laminæ of dentin and cementum, similar to the teeth of the Labyrinthodont. The *Pteryodactyls* were flying lizards with wings like a bat, which in large species reached the width of twenty-five feet. Most species were quite small, however. The jaws were armed with long, slender teeth for their whole length. The *Mososaurs* were marine lizards of great size, with large recurved teeth of simple form attached by rounded bases to the bones of the mouth.

The *Crocodilia* are related to the lizards, but much more advanced in structure in many respects. This order comprises the Crocodiles

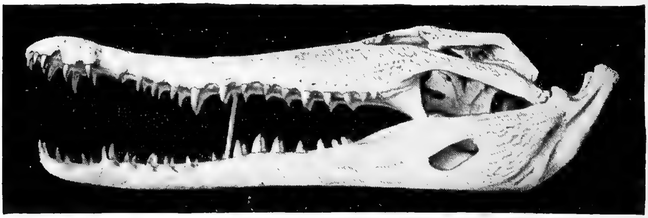


FIG. 33.—Teeth of *Crocodilus niloticus.*

(Fig. 33), Alligators (Fig. 34), Caimans, Gavials, etc. They are all covered with a dense exoskeleton of hard, calcified scutes forming a strong

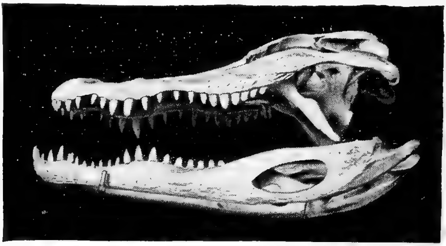


FIG. 34.—Teeth of *Alligator mississippiensis.*

coat of mail, and which are variously sculptured. The teeth are numerous, being confined to the margins of the maxillary, premaxillary, and the dentary bones and mandible. The upper and lower alternate and interlock when the mouth is closed, as with most reptiles. The teeth are rounded, conical, more or less compressed or oval in section, and rather blunt. The mandible and maxillary are long, the condyle of the mandible is hollowed and fit over a tuberosity on the temporal bone, being the reverse to what it is in the mammals. The teeth are much reduced from the long, cone shape of fishes and vary much in shape; some are long, curved, and acute; others are short and obtuse, and others have a flat, sharp edge which may be serrated. The forms are very erratic, even in the same species. They are composed of fine, hard dentin, covered with cementum and with enamel in some species, usually a thin layer confined to the point. The teeth are implanted in sockets which are formed by septi crossing the dental groove, which is open and continuous in most of the lizards. New successional teeth are being constantly developed beneath or at the sides of the old ones. As a new tooth erupts it presses against the base of the old one, causing its absorption, and, pushing it upward, carries it like a cap on its apex until it is lost. The successional teeth follow each other and become "nested" one with the other. In the Crocodiles proper the teeth are set on the margin of the jaw in distinct sockets, and are long, conical, somewhat pointed, and compressed to form sharp edges. The teeth vary much in size and form in different individuals, and also in the same individual at different times. They are small in front and increase in size to the side, and then diminish toward the back. The Crocodile differs from the Alligator partly by the presence of the notch on the side of the muzzle into which the so-called lower "canine" passes, instead of the fossæ of the Alligators. Both Crocodiles and Alligators are remarkable for the breadth and flatness of the muzzle and for the alternate increase and decrease of the teeth in the series from front to back. The alligator of the Mississippi has eighteen to twenty-two teeth on each side of the upper jaw. The teeth in front of the premaxillary bones are the smallest. These increase in size to the fourth, which is nearly twice as large as the others; the first of the maxillary teeth are the smallest; the third is the largest,—the so-called "canine,"—the ninth tooth from the median line. The eighth and tenth are sometimes as large or larger than the ninth. The teeth then decrease in size, then increase again to the seventeenth, then decrease to the end of the series. The posterior teeth are sub-compressed, with a more or less rounded eminence. The teeth of the lower jaw are likewise of unequal proportion, the smallest and largest alternating with the smallest and largest above. The largest caniniform tooth below is received into a deep fossa just inside of the fifth or sixth tooth above. In old individuals it sometimes happens that the lower teeth become of such a length as to penetrate through the upper jaw entirely and appear outside when the mouth is closed. This also occurs in the Caimans of South America, which are like the Alligators in regard to their dentition. The Gavials of India have a remarkable snout, which is elongated, narrowed from the cranium, and again enlarged to a spoon-shape at the end. Owing to the extra length of the jaw, it has more teeth than the crocodiles, and they are of more uniform size. The "canine" tooth fits into a notch on the side of the muzzle like that of the crocodiles. The extinct crocodiles were characterized by larger and more numerous teeth, which sometimes had longitudinal ridges upon the crowns.

The *Ophidia* comprises the serpents of all kinds, which are of well-known form, and have neither limbs, scapula, thoracic or pelvic arches,—except in the *Boas,* which have rudimentary pelvis and hind limbs. The skin is covered with glittering scales, which are smooth in the non-poisonous species and keeled in the poisonous varieties. The bones of the skull are loosely joined by elastic ligaments. This provision enables the snakes to open the mouth to a prodigious extent and to protrude and retract the jaws, so as to inclose and swallow prey as large or even larger than the body of the snake itself. A toad, twice or three times the diameter of a snake, can be swallowed by working the jaws up over it gradually, advancing first one jaw and then the other, the recurved teeth holding the bite as it progresses and thus forcing the object slowly downward into the œsophagus. The teeth of the serpents are very uniform,—of simple conical shape, recurved and very sharp,—and are used for prehension only. The cone-shape tooth attains its most perfect development, is largest and longest in this order, as illustrated in the poison fangs of serpents. The number of teeth varies extensively, and they are supported by the maxillaries, dentary, pterygoid bones and the mandible. The poisonous species are armed with the poison fang, which is long and sharp and grooved or is formed into a tube to inject the poison hypodermically (Fig. 35). Some poison fangs are erectile, as the Rattlesnake; others are upright and rigid, as the Cobra. They are connected by the basal opening of the tube with the poison sac, which occupies the temporal muscles when the mouth is widely distended. The tubular tooth through which the poison flows and is injected into the flesh is formed as if a conical tooth had been flattened into a thin sheet and then rolled so that the edges were brought together to form a tube, so that all the tissues are flat, even the pulp,—the inside of the tube being like the outside of the tooth, although the interior is not lined with enamel in all species. The tube opens a short distance from the point like a hypodermic needle, so that the point must be well implanted before injection can take place. These teeth are much recurved when erectile, and lie flat against the roof of the mouth in a fold of mucous tissue when not in use; they are raised by the moving backward of the lower

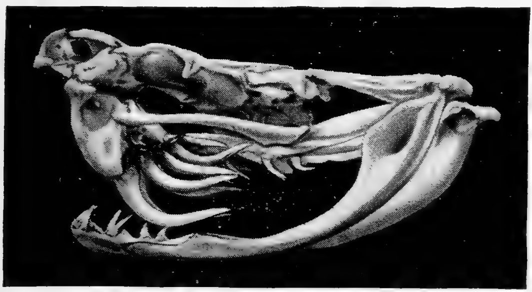


FIG. 35.—Teeth of Rattlesnake (*Crotalus adamanteus*).

jaw and quadrate bone, which pushes the upper maxillary forward and erects the fang when the strike is made. They are reproduced when lost by a vascular pulp situated posteriorly. In the Rattlesnake, ten reserve teeth have been found. All the viperine poisonous snakes—the Rattlesnakes, Puff-Adders, Vipers, etc.—have the poison apparatus highly specialized. The maxillary bone carries no teeth back of the poison fang. In the species having these teeth permanently erect, as the Cobra, they are also reproduced indefinitely as lost.

The non-poisonous snakes have two rows of teeth in the upper series and one in the lower, which are strongly recurved and irregular in size. They are ankylosed to the jaw, and reappear as lost. They are composed of hard dentin with a thin external layer of cementum and enamel. In the Boa Constrictors, the teeth are slender, coni-

FIG. 36.—Teeth of *Python regius*.

cal, and slightly recurved. This enables them to creep up with the alternating motions of the jaws over disproportionately large objects, and force them backward into the œsophagus. The teeth of the Pythons (Fig. 36) are all simple recurved cones. Some are grooved and perhaps constricted at the neck. In the Colubers the teeth are similar,—the largest being in front and diminishing in size backward.

The *Chelonia* comprise the turtles, land and water tortoises, etc. In these curious reptiles the

FIG. 37.—Roentgenogram of skull of Turtle (*Chelonia mydes*). (By Dr. E. H. Skinner.)

endo- and exo-skeletons are combined to form the very singular box-like structure, the *carapace,* which incloses and protects the animal's organs.

The skull is solidly combined in one piece (Fig. 37). The oral armature is remarkable in that there are no teeth whatever, but the maxillaries and mandible are inclosed in hard, bony cases which form beaks like the strong bills of birds. These beaks are variously formed, being in a general way sharp and thin-edged in the carnivorous species and adapted to cutting, and blunt and flat in the herbivorous types and adapted to crushing vegetable substances.

The *fourth class of Vertebrates,* the Birds (*Aves*), are warm-blooded and clothed with feathers, which by special modification and general structure enable them to fly through the air. Birds are closely related to the reptiles in many respects, and are probably descended from a common ancestral form with them.

This class is unique in that none of its living members are provided with teeth, but instead of which, the elongated maxillæ and mandible are covered with horny structures called bills or beaks, which take the place of teeth and perform the dental offices. The beak is the prehensile and cutting organ, and is variously modified to adapt it to the different kinds of food employed. Mastication, when necessary, is performed by the gizzard, a strong muscular stomach. The beak is short and strong in the grain-feeders; long and slender in the insect-eaters; short and gaping in the Swallows and Night-Jars; hooked, sharp, and strong in the Eagles, Vultures, Hawks, and other carnivorous species for tearing flesh; long and stout with a chisel-like point in the wood-cutting Woodpeckers; short, wide, and curved in the Parrots and others which crush nuts, etc.; long, tapering, and delicate in the Humming Birds for penetrating the corolla of flowers to suck honey; ponderous and ungainly in the Horn-bills and Toucans for cutting and crushing; long, strong, notched, or variously modified for catching fish in the Storks, Herons, Pelicans, Penguins, Kingfishers, etc.; flat, elongated, with soft sensitive edges, for separating food from sand and mud in the Swans, Geese, Ducks, Spoonbills, etc. In all birds, as in other animals, there is a direct adaptation of the tools to material,—or oral apparatus to the kind of food employed by each species.

While no living species of birds possess teeth, dental pulp are sometimes found in the jaws of bird embryos, as the Parroquet, showing that they retain a reminiscence of a former toothed stage in the history of their descent. That there was such a stage is now demonstrated, for fossil birds with teeth have been found. The Cretaceous formations of the West have yielded one hundred and fifty species. One group is called *Odontonithes,* some of which are quite small and had teeth in distinct sockets. Another group were very large swimming birds, and had teeth set in grooves. In *Ichthyornis,* the teeth are about twenty-two in each jaw, all sharp and recurved, with crowns flattened and covered with enamel. In *Hesperornis* the teeth were also socketed. The group presents a regular gradation from groove to socket in the methods of attachment of the teeth. The forms of these teeth are of distinctly reptilian type, and indicate the link between birds and reptiles.

CHAPTER VII

THE TEETH OF MAMMALS

The *Mammalia* are the highest of the Vertebrates and the most elevated in structure of the entire animal kingdom. They are more highly organized and the organs are more specialized than either Fishes or Reptiles, being the highest result of the evolution of life that has been progressing on the earth since its creation. They live upon the land and in the air and water, and the variety of organization is very great to adapt them to the varied life of these elements.

They are so named from possessing mammary glands, by which they suckle the young during the first stages of existence. Mammals are *viviparous,*—i.e., the young are born alive,—while all the classes below them are generally *oviparous,*—i.e., the young are born from eggs. They are first nourished by the milk of the mammary glands. In size mammals vary from that of the tiny harvest mouse of Europe (weighing scarcely an ounce) to that of the great whales or the extinct mammoth. The body is bare or is covered with a variety of hairy growths, or horny plates, as the armadillo. There are usually four limbs present, hence they are called quadrupeds,—four-footed animals.

The heart is four-chambered and the blood warm. Respiration is performed by cellular lungs. The osseous system is more rigid and stronger than that of the lower Vertebrates, owing to the coalescence of bones which remain distinct in the latter, and to the greater solidity due to a larger quantity of lime-salts. The bones of the skull and jaws are more solidly united, and the numbers of bones is reduced. The mandible arises from distinct centers of ossification (which represent distinct bones in the fishes and reptiles), but it usually consists of a single bone in the adult mammal. In most of the lower mammals the superior maxillaries are more elongated than in man, and the intermaxillary bones remain distinct through life. In man they are fused with the maxillaries.

The *teeth of Mammals* present great variety, as the food employed is varied, and highly specialized teeth are developed to accommodate the food habits. Some low forms are destitute of teeth, but nearly all mammals are possessed of true teeth. The offices of the teeth are also extended in this class, for while in the fishes and reptiles the teeth are mainly employed for the purpose of prehension only, in the mammals special forms of teeth are developed for the performance of special functions. Thus there are teeth for prehension, for cutting, for crushing, and for mastication. The grinding teeth are highly elaborated, for mastication has become an important factor in the more highly complicated digestive system. The teeth are important to the alimentary system, for by them food is secured and reduced to prepare it for digestion, so that their office is indispensable.

The teeth vary in number among mammals,—from the single tooth of the Narwhal to the hundreds of teeth of the Dolphins. The primitive form of teeth, the simple cone, is presented by the fishes and reptiles, with but little variation, but in the Mammalia there is wide departure from the primitive typal cone. This is modified and duplicated to an extensive degree to furnish the many forms found among mammals. The primitive cone is modified to adapt the teeth to the performance of their various functions,—i.e., prehension, cutting, and mastication.

The attachment of the teeth in mammals is by but one method,—that of implantation in a bony socket, or *Gomphosis.* The roots are single or divided into two or more fangs. Sometimes the roots are completed and the apex closed except the small foramen for the vessels supplying the pulp with nutrition, or again the pulp may be permanent and the tooth be of continuous growth.

Three tissues enter into the composition of the teeth of mammals. (1) The *dentin,* a dense osseous tissue like ivory, with radiating tubules which is formed in the submucous tissue; (2) the *enamel,* which covers the crown, which is developed from the epithelium of the mouth and consists of calcified rods and intercemental substance; and (3) the *cementum,* which encases the root, which is very similar to the true bone in structure and organization. These three tissues are found in most mammals in varying degrees of completeness, except that enamel is absent from the teeth of some low forms, as the anteaters, sloths, and others.

The relationship of the teeth of Mammals with those of the Fishes and Reptiles below them is well marked, and they present many resemblances as well as some differences. The earliest as well as some living lower mammals present reptilian characteristics. Thus the teeth of the Dolphin and other cetaceans are conical, curved, and more or less devoid of enamel like reptilian teeth. The highly specialized teeth of the higher mammals differ as much from those of the lower mammals as they do from the reptiles. There are some important differences between the teeth of reptiles and mammals. Thus reptiles never have more than one root, while mammals may have two or more distinct fangs. Implantation is the exclusive mode of attachment among mammals, but this is also imitated in the crocodiles and some other reptiles. Heterodontism (having teeth of different forms in the same jaw) is a mammalian characteristic, but the lizards also have this feature to a limited extent, in which the tubercular form begins to manifest itself. The number of the teeth is reduced in mammals, though some, as the dolphin, have a great number. Succession is reduced, as there are never more than two sets in the mammals and there may be many in the reptiles.[1] The elaboration of the crowns by the duplication of the primitive cone is an exclusively mammalian character, for the repetition must be shown in the root also. The primitive cone is of course reptilian, and from this all teeth, even the most highly specialized, were developed. The series is continuous throughout the vertebrate series, and the homologies are apparent in all stages.

Descriptive. The lowest order of the Mammalia is that of the *Monotremata,* which includes but two species, the *Ornithorynchus* (or Duck-bill mole) (Fig. 38) and the *Echidna* (ant-eater). These are, dentally, the lowest forms of living mammals, and present the anomaly—like the lowest species of fishes and reptiles—of possessing

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1 Some claim that each molar of the elephant represents a set of teeth, in which case there would be six sets.—*Editor.*

horny structures which take the place of teeth. The Ornithorynchus is a mammal living in Australia with a bill like a duck, and like the duck's bill transversely ridged to strain food from the water. Each jaw is provided with four horny teeth, of which the two front ones have long ridges and the back ones are tubercular and calcareous, somewhat like true grinding teeth. Their structure is a fibrous, horny substance, like hoofs or nails, with only three per cent. of earthy matter. The other member of the order, the

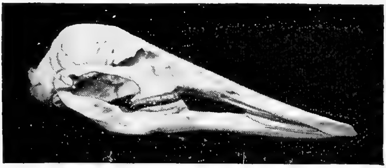


FIG. 38.—Duck-billed Platypus (*Ornithorynchus anatinus*).

Echidna, has an edentulous bill, but has the tongue and roof of the mouth covered with horny spines to crush the ants caught by its viscous tongue.

The next highest order of mammals is that of the *Bruta,* which comprises the Sloths, Armadillos, Ant-eaters, etc., which are of very low organization. They were first called *Edentata,*—without teeth,—and later were described as being without incisor teeth, as median incisors are absent in all the members of the order. The teeth are also destitute of enamel, the dentin alone being exposed to wear. The teeth are of continuous growth, and are usually monophyodont. Many of this order feed only on insects, the long whip-like tongue being covered with a viscous mucus to which the insects—principally ants—adhere. For this simple diet the teeth are reduced and degenerate in form and structure. The upper teeth are usually confined to the maxil-

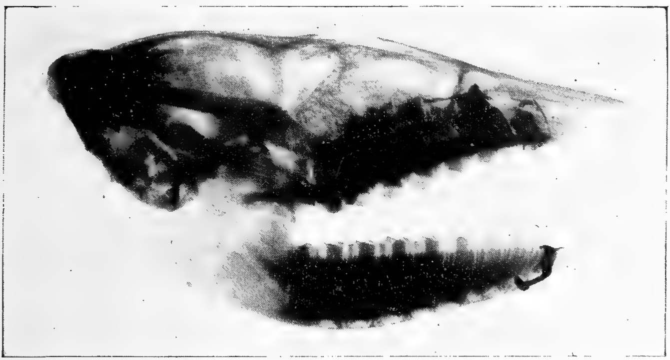


FIG. 39.—Roentgenogram of teeth of Armadillo *(Euphractus minutus)*.

lary bones only, the premaxillaries being destitute. In the Cape Ant-eater, the teeth are all molar-like in form, increasing in size from front to back. They are oval on section, and two facets are produced by wear as the teeth in the upper and lower series alternate on striking. The formula is m. $\frac{7-7}{6-6} = 26$. The Armadillos (Figs. 26 and 39) are peculiar for the shell-like covering in which the animals roll up, when attacked, for protection. They may have large numbers of teeth, —ninety-six to one-hundred being found in some species. These are of simple, molar-like form, increasing in size from front to back, and are compressed laterally, with oblique surfaces. Sometimes there are enamel germs in the embryo, but these are absorbed as the tooth develops, so that the tooth has no enamel. The teeth alternate, and are worn in distinct facets. Some species, perhaps all Armadillos, have a successive set. The Sloths are hairy mammals of arboreal habits, which suspend themselves beneath limbs by means of the powerful claws, which are formed for hanging down and moving about in trees. They have few teeth, the formula being mostly m. $\frac{5-5}{4-4} = 18$, implanted in the maxillary bones above and the mandible below. They are of molar-like form, and increase in size from front to back. The tooth is composed of a central axis of vascular dentin with an outside investment of harder dentin, and grows continuously. The grinding surface is usually cup-shaped, the hard rim presenting two or more points. These curious mammals are found in South America, and are probably descended from the great extinct Megatheroids of the Pampean formations. The gigantic *Megatherium* (an immense Sloth of earlier geological times) had the same formula and the same kind of teeth as the present sloths, but the wear of the crowns produced two transverse crests.

The orders of *Cetacea* and *Sirenia* include the aquatic mammalia which have been transformed for life in the water. The *Cetacea*—the Whales—have simple teeth, of blunt canine shape, or have mere horny substitutes for teeth. The Baleen Whales have a horny substance in the form of plates triangular in outline, arranged in rows on each side of the upper jaw. A row of smaller plates is internal to the outer row. Each plate is developed from a vascular pulp, and is of continuous growth. There are sometimes two hundred of these plates, and the width of the matrix is often two feet. The "whalebone" is fringed and frayed out at the ends, and this fringe is employed by the animal to strain the small sea animals, which are found in the Arctic regions, from the water. The whale gulps a quantity of water containing the animals, and then closing the mouth ejects the water through the fringe, thus straining the animals out. Tooth-pulps are found in the embryonic stage, but these are absorbed and disappear as the baleen is formed. The Sperm-whales (*Cachalot*) have often fifty-four teeth on the lower jaw, but the number varies, the upper jaw being edentulous. These are short and stout, of recurved form, and are worn obtuse by use. In the Narwhal the teeth are all suppressed except the tusk incisor in the left intermaxillary bone. This grows until it sometimes attains the length of eight or nine feet, and a basal diameter of four inches. The exterior of the tusk is marked by spiral ridges, which wind around the tooth from the left. The right side has a small suppressed tusk, but it is like the concealed tusk of the female, for the male only has the long tusk. The porpoise has eighty to ninety teeth of flattened cusped form, which alternate like the teeth of reptiles, with the largest teeth on the side of the jaws. The Dolphin has the most numerous teeth of any mammal, often reaching one hundred and ninety to two hundred, as in the common dolphin. These teeth are sharp, slender, conical, and recurved; diminishing in size each way from a long tooth on the side of each jaw. The teeth of the Cetacea exhibit an interesting degradation of form, as tooth germs are found in fetal life in the edentulous species. The gradual closing and obliteration of the dental groove in fossil forms has even been traced. The *Sirenia* comprise the herbivorous Cetaceans, of which there are but two genera now living,—the Dugongs and Manatees. In the Dugong (Fig. 40) the end of the upper jaw is bent downward, forming an angle with the body of the jaw, in the end of which two tusk-like incisors are implanted. These are thickly coated with enamel on one side, but absent on the other, so that wear produces a sharp edge. Dense, horny plates are placed farther back on the jaw, under which rudimentary teeth are found, and beyond these are molars of dentin and cementum. The Manatee has thirty-six teeth, with square crowns with transverse ridges. The upper molars have three roots and the lower two. There is a deciduous premaxillary tusk in the Manatee, but no incisor teeth in the

FIG. 40.—Teeth of Dugong.

adult, and horny plates are supplied instead. Stellar's Rytina was a sea-cow that has become extinct within historic times. The last of the species inhabited Behring's Island. The dentition consisted mainly of horny plates which were used in cutting soft sea-weed. Some extinct forms of this family are found which suggest relationship with the tapirs, and it is probable that the ancestors of the Sirenia were connected with the land herbivora.

The *Marsupialia* is an extensive order which is low in organization, although the dentition is much varied and rather advanced. It includes all the pouched mammals which carry their young (born in a very immature condition) in the marsupial pouch upon the front of the abdomen for the completion of the gestation period. It comprises the Kangaroos, Opossum, Bandicoots, etc.,

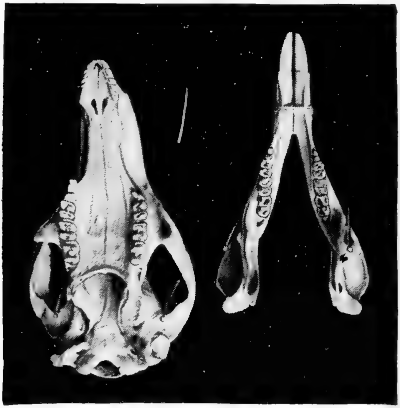


FIG. 41.—Teeth of Kangaroo (*Macropus giganteus*).

all of which are native to Australia and the adjacent islands, except the American Opossum. The Marsupials represent a very primitive type of mammalian life, and stop at a stage which other mammals have long since passed. Teeth are present in most of the Marsupials, but they are usually monophyodont, as only one set is developed as a rule. Incisors are well developed, but the canines are feeble in most species. The Kangaroos (Fig. 41) have the formula,—

$$\text{i.}\ \frac{3\text{–}3}{1\text{–}1}\ \ \text{c.}\ \frac{0\text{–}0}{0\text{–}0}\ \ \text{p.m.}\ \frac{1\text{–}1}{1\text{–}1}\ \ \text{m.}\ \frac{4\text{–}4}{4\text{–}4} = 28.$$

The upper central incisors are large cutting teeth; the lower centrals are large and chisel-shaped, and project forward horizontally with an interval between them (Fig. 41-A). The two halves of the

FIG. 41-A.—Roentgenogram of teeth of Kangaroo (*Macropus giganteus*). (By Dr. E. H. Skinner.)

lower jaw are separate and movable, for shearing grass with the horizontal lower incisors. The canines are absent, and the premolars are shaped for cutting and well developed. The molars have tubercular ridged crowns. The Bandicoots have canines and more incisors than the Kangaroos, with the molar series more cuspidate. The American Opossum has the formula,—

$$\text{i. } \frac{5-5}{5-5} \text{ c. } \frac{1-1}{1-1} \text{ p.m. } \frac{3-3}{3-3} \text{ m. } \frac{4-4}{4-4} = 52.$$

The incisors are small except the centrals, which are long and separated. The canines are long and sharp (Fig. 42). The premolars are sub-compressed. The upper molars are triangular in outline, and are an interesting survival of the primitive tritubercular type of the Eocene formations. The molar series have rather sharp cusps for the crushing of insect coverings. The

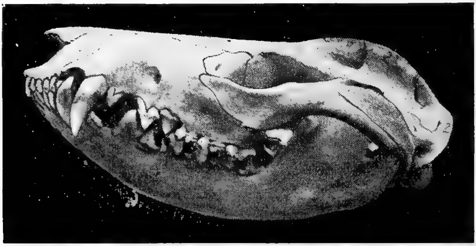


FIG. 42.—Teeth of Opossum (*Didelphis virginiana*).

Dasyure of Australia is more carnivorous than the Opossum, the canines being more developed and the molar series of more blade-like form. The Wombat is a heavy, clumsy Marsupial of Australia, with true rodent incisors. The insectivorous Marsupials have a dentition similar to the Insectivora. Other Marsupials are found, both fossils and recent, which are closely related to other orders as to dentition.

The *Insectivora* are so named on account of their peculiar diet,—the bodies of insects,—for which there is provided a peculiar dentition. The teeth are adapted to the crushing of the chitinous covering of insects, and for this purpose are armed with many long, sharp cusps. The best known members of the order are the Hedgehogs, Moles, and Shrews. The teeth are variable, but always bristle with cusps. The molars have a "W" pattern of the arrangement of the occluding ridges which is present in most of the order. The common English Hedgehog has the formula,—

$$\text{i. } \frac{3\text{–}3}{2\text{–}2} \text{ c. } \frac{0\text{–}0}{0\text{–}0} \text{ p.m. } \frac{4\text{–}4}{3\text{–}3} \text{ m. } \frac{3\text{–}3}{3\text{–}3} = 36.$$

In the upper jaw there is a wide interval between the first pair of incisors, which are very large and caniniform in shape. The second pair of incisors above are quite small and resemble premolars in form, the inner cingule being raised to a level with the edge. The third incisor has two roots, and is like a cusped premolar also. The canines are absent. In the lower jaw the first pair of incisors are large, but not separated widely. The second pair are smaller, and the third pair larger and caniniform in shape. The canine is absent, but the first premolar has an oblique crown with five sharp cusps, one at each corner and a fifth on the inner side. The molars are reduced from this size, the last below having but one cusp. The upper premolars are square with four cusps, and the molars gradually decrease to the back, but bristle with cusps. The teeth of the Hedgehog are fairly typical of the order. The Shrews have the formula,—

$$\text{i. } \frac{2-2}{2-2} \quad \text{c. } \frac{1-1}{0-0} \quad \text{p.m. } \frac{3-3}{3-3} \quad \text{m. } \frac{3-3}{3-3} = 34.$$

The incisors are remarkable in the Shrews. The centrals above are very large, are placed vertically, and are a little recurved or hooked. A cusp is developed behind the edge which makes a notch across the face, into which the tips of the lower incisors fit. The lower central is very large, lies horizontally, and has the point bent upward, with small tubercles raised to fit into the notch of the upper central. These teeth make very effective forceps for extracting insects from crevices in rocks or the bark of trees. The lower central extends backward and outward by a flange which overlaps the alveolar border of the jaw; it is one-third of the whole length of the jaw. The crushing teeth are rather small, but have the characteristic sharp cusps. The Moles have the formula,—

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

The first incisors above are small, but the third is large like the canines, and has two roots. The first two premolars are very small, then comes a very large one,—all being armed with pointed cusps.

The order *Cheiroptera* contains only the flying mammals,—the Bats. The modification of structure for flying—the long fingers with the membrane stretched between, the hooks for suspending, etc.—distinguishes these remarkable mammals from all others. They are closely related to the Insectivora in their dentition, as most of them subsist on insects. The formula of the common red bat is,—

$$\text{i. } \frac{2\text{–}2}{2\text{–}2} \quad \text{c. } \frac{1\text{–}1}{1\text{–}1} \quad \text{p.m. } \frac{3\text{–}3}{3\text{–}3} \quad \text{m. } \frac{3\text{–}3}{3\text{–}3} = 36.$$

The canines are round and sharp, and the molars have sharp cusps with the insectivorous "W" pattern. This dentition is of great constancy. The frugivorous bats vary from the insectivorous in having the incisors larger, the canines reduced, and the molar cusps rounded. The Vampire bat is a remarkable form that sucks the blood of larger mammals. For this purpose the two upper centrals are wide and scoop-shaped, with sharp edges for puncturing the skin to draw blood. There are no other incisors above, but the canines are of about the same shape and size as the centrals. The other teeth are much reduced in size and shape, as the diet requires no dental manipulation.

The *Rodentia* are a very numerous order, and include such animals as the Beavers, Squirrels, Rabbits, Rats, and Mice. It is so named on account of their principal peculiarity,—i.e., the two central incisors, one on each side of the median line, which are large, long, curved, in a circle, and grow out of the deep parts of each jaw from persistent pulps, so that they are of continuous growth. The tissues are so arranged that the enamel is thicker on the front than on the back of the tooth, so that a sharp edge is preserved on the front by the wearing away of the rear portion, producing a chisel-shaped crown; hence the name given to these teeth,—scalpriform. Continuous growth preserves the length of the tooth and the apposition of the edges. Wear and use are necessary to compensate for their growth, for if by accident an incisor becomes broken the opposite incisor continues to grow and curves around in a circle, piercing the soft parts of the head and producing death by starvation. Such accidents are not infrequent with rodents. The enamel of these teeth is usually of a light orange or reddish-brown color. Sometimes there are two longitudinal grooves on the anterior surface. There are usually no deciduous predecessors to those teeth in rodents, except in the Hares, so that their monophyodontism is nearly constant. There is an entire absence of lateral incisors, canines, and in some species of the premolars, in the order. The Hares have supplementary incisors behind the upper centrals. The molar teeth are few in number, obliquely implanted, and present many varieties of the pattern of the grinding surface. Sometimes they have long roots, again short (Fig. 43), or may be without roots, these differences being due to differences of diet. Those which subsist on a mixed diet or have a carnivorous tendency (as the true Rats), or eat only soft vegetable substances, as the oily kernels of nuts (as the squirrels), have the molar teeth less complicated in pattern and with small tubercles and less

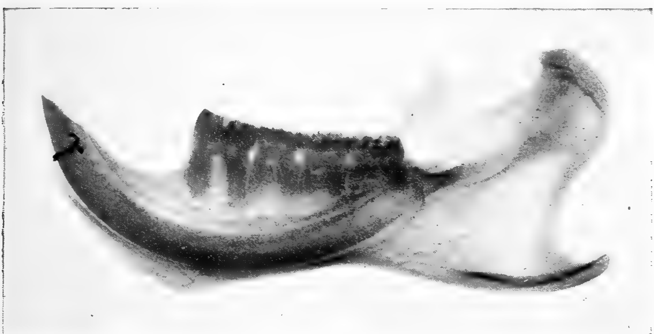


FIG. 43.—Roentgenogram of jaw of Woodchuck (*Arctomys monax*), showing long incisor and short-rooted molar. (By Dr. E. H. Skinner.)

firmly implanted. But those which subsist on hard substances, as the bark or branches or roots of trees, have molars with an arrangement of the tissues like the herbivorous Ungulata, in which hard wear produces a constantly rough surface. Such molars are of more or less continuous growth. In some rodents there are parallel plates of enamel placed transversely of the crown like the molars of the elephant, and like them there is a corresponding antero-posterior movement of the jaw. In some of the semi-carnivorous species, like the rats and mice, the molars are tuberculate, and much wear renders them cup-shaped like the much-worn molars of man. The American Beaver (Fig. 44) is one of the larg-

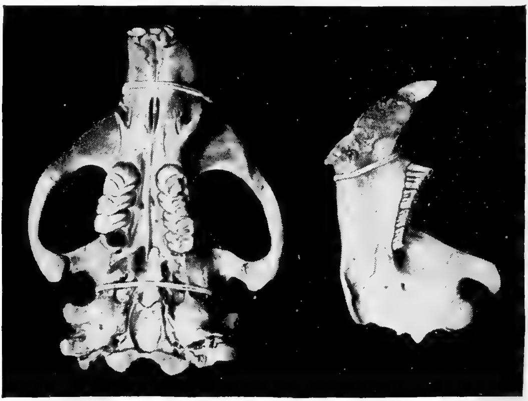


FIG. 44.—Teeth of Beaver (*Castor canadensis*). Occlusal view.

est living members of the order. It has the formula,—

$$i. \frac{1-1}{1-1} \quad c. \frac{0-0}{0-0} \quad p.m. \frac{0-0}{0-0} \quad m. \frac{4-4}{4-4} = 20.$$

It has exceedingly large, strong, scalpriform incisors, with which it cuts down small trees for the purpose of building the dams for which it is famous. The molars are strong, with the tissues arranged like those of the molars of the Ungulates for the purpose of reducing the resisting vege-

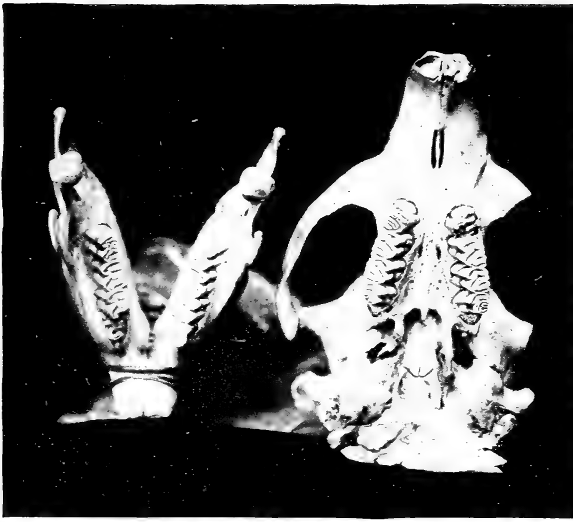


FIG. 44-A.—Teeth of Beaver (*Castor canadensis*). Occlusal view, showing condyles and glenoid fossa.

FIG. 44-B.—Teeth of Beaver (*Castor canadensis*). Side view.

FIG. 45.—Teeth of Rabbit (*Lepus campestris*). Front view.

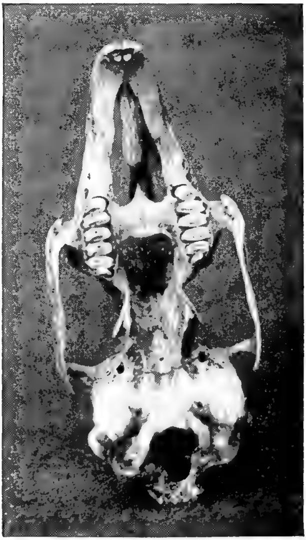


FIG. 45-A.—Occlusal view of teeth of Rabbit (*Lepus campestris*), showing four upper incisors.

FIG. 45-B.—Side view of teeth of Rabbit (*Lepus campestris*).

table fiber on which it feeds. The Hares and Rabbits have the formula,—

$$\text{i.}\ \frac{2-2}{2-2}\ \ \text{c.}\ \frac{0-0}{0-0}\ \ \text{p.m.}\ \frac{3-3}{2-2}\ \ \text{m.}\ \frac{3-3}{3-3} = 28.$$

FIG. 46.—Teeth of Squirrel (*Scurius niger*).

In most species of this family there is a second incisor posterior to the central (Fig. 45). The

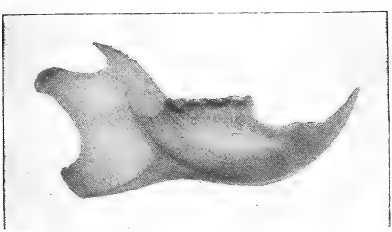
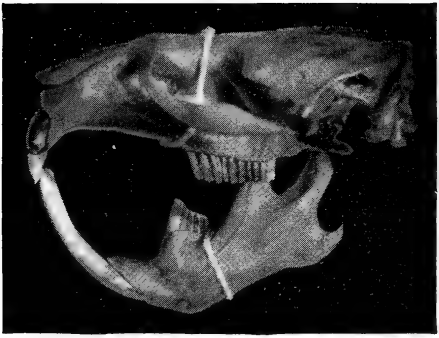


FIG. 47.—Mandible of Squirrel (*Scurius niger*), showing incisor, premolars, and molars.

upper centrals have vertical grooves upon the anterior face which are also characteristic. The molars are remarkable for their great length, and grow continuously. They are tuberculate when erupted, but soon wear into a characteristic pattern. They have deciduous molars which are

A.



B.

FIG. 48.—Skulls of Squirrels, showing excessive growth of incisors as a result of injury.

soon lost. The Squirrel family is very numerous. They usually have the formula,—

$$i.\ \frac{1-1}{1-1}\quad c.\ \frac{0-0}{0-0}\quad p.m,\ \frac{1-1}{1-1}\quad m.\ \frac{3-3}{3-3} = 20.$$

The incisors are medium in size, and are strongly colored on the anterior face (Figs. 46 and 47).

The premolars are small, of triangular form, and implanted by three roots. The upper true molars are large, and are marked by two transverse crests. The lower molars have a central depression with a marginal ridge and with cusps at each corner (Figs. 48 and 49). The Porcupine's teeth are similar to the Squirrel's, except that the molars have three transverse ridges inclosing two

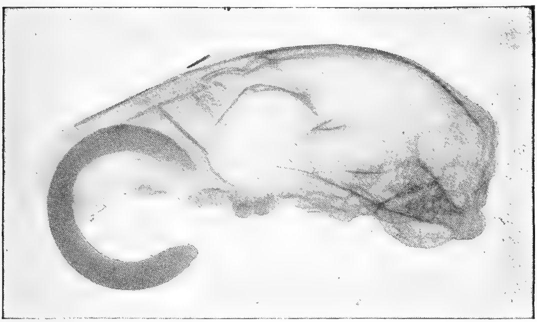


FIG. 49.—Roentgenogram of skull of Squirrel, showing growth of incisor. (By Dr. E. H. Skinner.)

valleys. In some of this family these crests and valleys are highly complicated. The common Rat has the formula,—

$$\text{i. } \frac{1\text{–}1}{1\text{–}1} \quad \text{c. } \frac{0\text{–}0}{0\text{–}0} \quad \text{p.m. } \frac{0\text{–}0}{0\text{–}0} \quad \text{m. } \frac{3\text{–}3}{3\text{–}3} = 16.$$

Deciduous teeth are entirely wanting in this family, so that it is monophyodont. The molars decrease in size from front to back, are simply tuberculate, and implanted by three roots. The tubercles are often worn away in aged individuals.

The common mice have the same formula. In some the incisors are grooved and the molars may be without roots. The field mice have a trefoil pattern of the molars, or are triangular. There are many other living members of this order, but all have similar dentitions to these well-known examples. The fossil progenitors of this order were often of gigantic size. Some were highly specialized, and others with composite features resembling those of their living descendants.

The *Carnivora* is the great order of the flesh-eaters, the destroyers of animal life. It comprises the true Cats, the *Felidæ,* the Lion, Tiger, Leopard, the common cat, etc.; the *Canidæ,* dogs, wolves, foxes, etc.; the *Ursidæ,* bears, raccoons, etc. They subsist upon flesh, and to obtain this must destroy animal life, and are well equipped for the purpose by a highly specialized dentition, by their sharp, strong claws, and by their strength, speed, and agility. They are simply organized and highly specialized. There is little or no mastication of food and little digestion required, so the intestines are short, and the whole organization indicates a simple diet which is easily appropriated. In dental organization, the Carnivora stand at one extreme end of high specialization, as the Herbivora do at the other,—the flesh-eaters as opposite to the plant-eaters. We notice first the special hinge-like structure of the temporo-mandibular articulation, which allows of but one motion,—i.e., the vertical,—the mere opening and closing, without any lateral movement, so as to cause the long-bladed teeth to pass close to each other, for the purpose of cutting the flesh fiber. The jaws are stout, to support the powerful muscles which are attached to them. The incisors are small and slightly tuberculate on the edge, the usual cutting function of these teeth being usurped by the long-bladed molars, as the

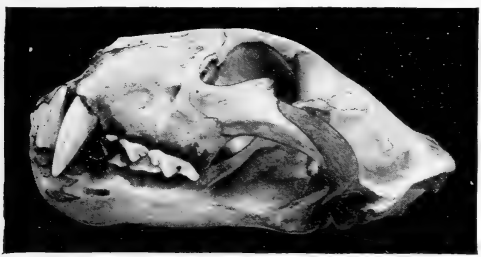


FIG. 50.—Teeth of Indian Tiger (*Felis tigris*).

incisors are now used only as scrapers for cleaning bones. The canines are long, conical or saber-shaped, curved, sharp, and piercing for seizing and tearing the prey. The premolars and molars are compressed and raised into effective cutting blades for the division of flesh. They perform the cutting function instead of the incisors, and exhibit a high degree of specialization (Fig. 50).

The *Felidæ* are the highest and most specialized as regards the teeth of the order. It includes the

Lion, Tiger, Leopard, Lynx, and other cats. The usual dental formula is,—

$$\text{i. } \frac{3\text{–}3}{3\text{–}3} \text{ c. } \frac{1\text{–}1}{1\text{–}1} \text{ p.m. } \frac{3\text{–}3}{2\text{–}2} \text{ m. } \frac{0\text{–}0}{1\text{–}1} = 28.$$

The incisors are small, rounded and tuberculate. The canines are highly developed, being very long, strong, and deeply implanted (Fig. 51). They are conical, or may be compressed and

FIG. 51.—Teeth of Mountain Lion. Side View.

saber-shaped with serrated edges as in the saber-toothed, extinct Cave-tiger or the Clouded Tiger of India. The lower canine is well developed (Fig. 52), and closes in front of the upper into a space between it and the lateral, called the diastema. The first premolar is usually small, of a blunt, conical or triconodont in form. The second is larger, with a sub-compressed conical crown and a posterior bilobed basal tubercle.

The third (and fourth, when present) are true sectorial teeth (Fig. 53), and have the tubercles developed still further and divided into two blades, with or without notches, and the other tubercles are round and blunt for crushing. The principal blade is more or less deeply cleft in different species, with the prominences variously modified. The principal sectorial blade below is

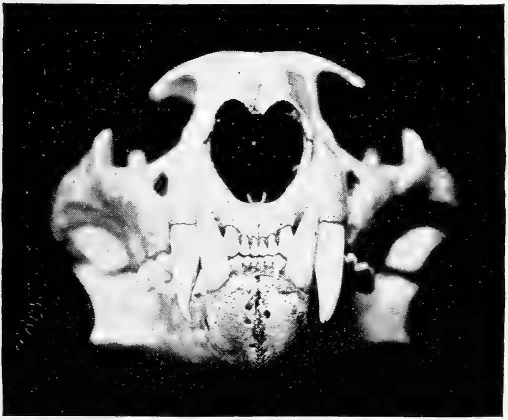


FIG. 52.—Teeth of Mountain Lion. Front view.

on the first true molar, which plays upon the inside and a little posterior of the body of the blade of the second or third upper premolar. There is usually no true molar above,—usually one below,—or there may be a small tuberculate molar in some species which are less carnivorous. The lower premolars are more tuberculate, and play against the inside of the tubercles or blades of the upper. The main characters of the *Felidæ* consist in a reduction of the number of the teeth, their high specialization, the vertical movement of the jaw and the raising of the tubercles to resist this movement, the great muscles of mastication (Fig. 54). The passage from the archetype

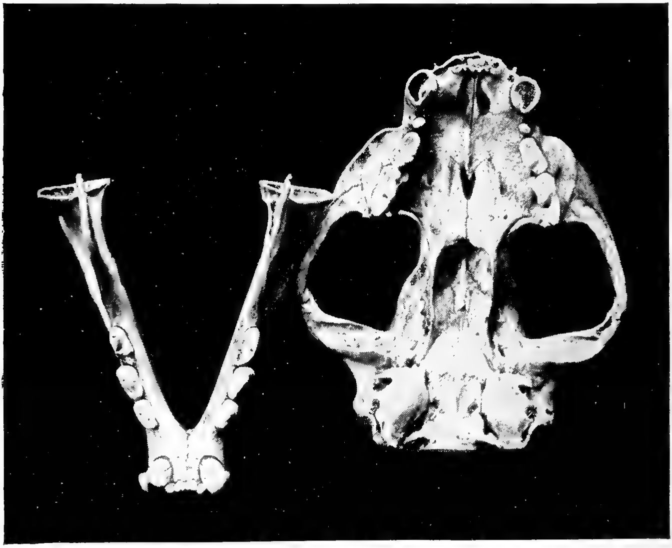


FIG. 53.—Teeth of Mountain Lion. Occlusal view, showing arrangement of cusps and condyle.

bunodont tooth to the scissor-like carnassial sectorial form is plainly exhibited by a series leading from the lowest type up to the *Felidæ*. This form is due to vertical strain and growth, to resist the stress of mastication. The extinct *Felidæ* had a formidable dentition, extravagant in its special-

FIG. 54.—Roentgenogram of skull of Mountain Lion. (By Dr. E. H. Skinner.)

ization. The Cave-lion and Cave-bear and tiger were large and fierce, with a massive dentition which armed them well for preying on the great pachyderms of that period. The canines were immense, and in some curious forms, as the *Smilodon,* reached far below the jaw even when the mouth was opened wide. The great saber-toothed cat (*Machærodus*) had great trenchant canines with denticulated edges, which caused the devel-

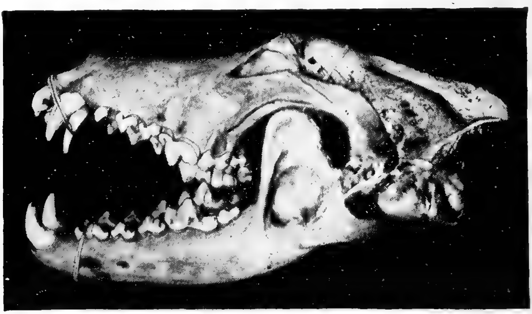


FIG. 55.—Teeth of Wolf (*Canis lupus*).

opment of a wide flange beneath the lower jaw where the canine passed, like a sheath for its protection.

The *Canidæ* includes the Dogs, Wolves, Jackals, Foxes, etc. The formula usually is,—

$$\text{i.}\ \frac{3\text{–}3}{3\text{–}3}\quad \text{c.}\ \frac{1\text{–}1}{1\text{–}1}\quad \text{p.m.}\ \frac{4\text{–}4}{4\text{–}4}\quad \text{m.}\ \frac{2\text{–}2}{2\text{–}2} = 40.$$

The teeth are reduced from the extreme carnivorous type of the cats, as the diet is mixed and the teeth respond to the changed conditions of food. The teeth are more tubercular, are reduced in specialization and increased in number to accommodate the increased demand for mastication (Fig. 55). The incisors are augmented in size, and often have a transverse groove on the edge into which the opposite tooth fits. The canines are reduced in length from those of the cats, and are more blunt, although the edges on both sides

FIG. 56.—Teeth of *Hyena crocuta.*

are still marked. The premolars are larger and stronger, the tubercles being rounded and reduced and more numerous than in the cats. The true molars are increased in number, are enlarged and more tubercular for crushing purposes and the general change in diet. In the short-muzzled dogs, as the Pugs, some of the molar series are absent on account of the contraction of the jaws

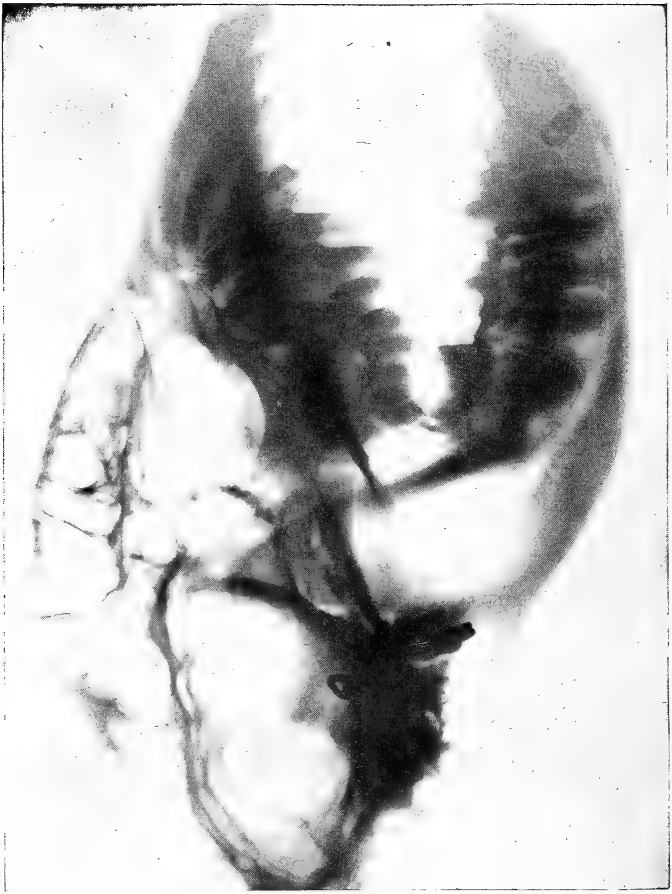


FIG. 57.—Roentgenogram of teeth of Hyena. (By Dr. E. H. Skinner.)

by breeding and the consequent lack of space for development. In the long-muzzled dogs, as the Hounds, on the contrary, there is increase of space, and additional molars are sometimes found.

The *Hyenas* are more carnivorous than the dogs, so that the tubercular teeth, the molars, are reduced, and the sectorial features increased (Fig. 56). The premolars are stout and heavy for crushing bones (Fig. 57).

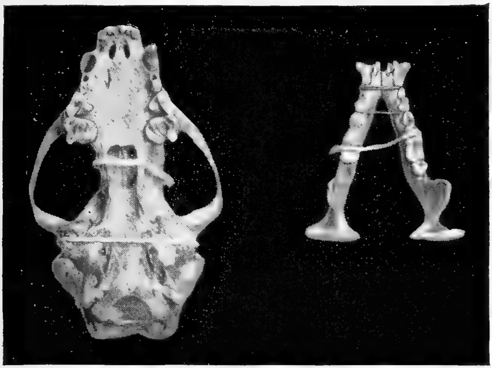


FIG. 58.—Teeth of Skunk (*Mephitis mephitica*).

The *Mustellidæ* includes the Ferrets, Weasels, Skunks (Fig. 58), Badgers (Fig. 59), etc. The formula is,—

$$\text{i. } \frac{3\text{–}3}{3\text{–}3} \text{ c. } \frac{1\text{–}1}{1\text{–}1} \text{ p.m. } \frac{4\text{–}4}{4\text{–}4} \text{ m. } \frac{1\text{–}1}{2\text{–}2} = 38,\text{—to } 36.$$

As these animals are predaceous or blood-sucking, their dentition is essentially carnivorous, though more sharp, long, and slender than that of the cats, but is modified for seizing and tearing the necks of animals for blood-sucking.

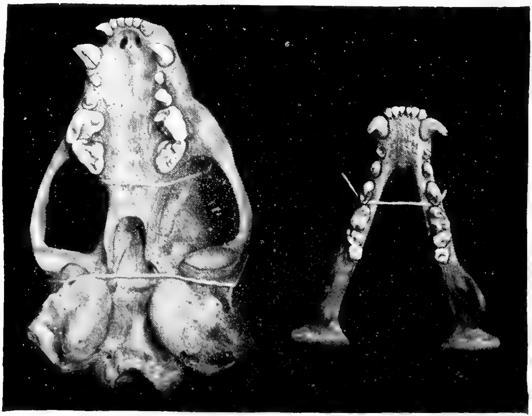


Fig. 59.—Teeth of Badger (*Taxidea americana*).

The *Ursidæ*—the Bears—have the formula,—

$$i.\ \frac{3\text{–}3}{3\text{–}3}\quad c.\ \frac{1\text{–}1}{1\text{–}1}\quad p.m.\ \frac{4\text{–}4}{4\text{–}4}\quad m.\ \frac{2\text{–}2}{3\text{–}3} = 42.$$

The teeth are still further modified from those of

Fig. 60.—Teeth of Bear (*Ursus americanus*).

the dog, to adapt them to a still more mixed diet (Fig. 60). The incisors are notched on the edge;

FIG. 61.—Roentgenogram of teeth of Bear. (By Dr. E. H. Skinner.)

the canines are much reduced, but are strong and are ridged both on the anterior and posterior surfaces. The premolars are dwarfed and are usually lost early,—seldom persisting through life. The molars are broad and tuberculate, and indicate a mixed diet (Fig. 61).

The *Procyonidæ* includes the Raccoon, Coatis, etc. The teeth are tuberculate and omnivorous in

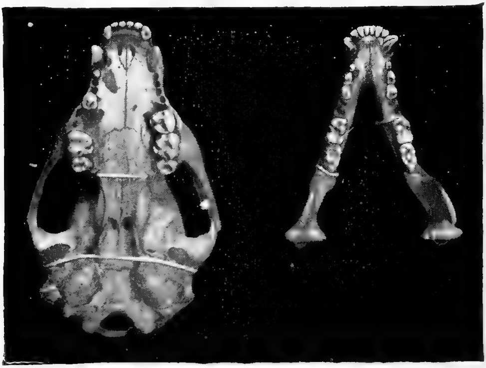


FIG. 62.—Teeth of Raccoon (*Procyon lotor*).

character (Fig. 62). The canines are sharp, with a posterior cutting edge. The premolars are reduced to flat crowns with sharp cusps and the molars have sharp cusps, thus showing an insectivorous character.

The *Phocidæ* are the Seals, which have the formula,—

$$\text{i. } \frac{3\text{–}3}{3\text{–}3} \text{ c. } \frac{1\text{–}1}{1\text{–}1} \text{ p.m. } \frac{4\text{–}4}{4\text{–}4} \text{ m. } \frac{1\text{–}1}{1\text{–}1} = 36.$$

The dentition is carnivorous, as they feed upon fish, and is simplified, and less highly specialized than in other Carnivora. The incisors are much reduced and often absent. The canine and even the molar series are simple and conical, being adapted to hold their struggling, slippery prey. The molar series are of typical triconodont form. In the Walrus the upper canines are elongated to form projecting tusks which reach far below the lower jaw. These are employed to assist in locomotion, to turn over rocks in seeking for food, and as formidable weapons of defense. In the Phocidæ the milk teeth are shed during fetal life in some species.

CHAPTER VIII

THE TEETH OF MAMMALS (*Continued*)

The *Ungulata* is that great division of hoofed quadrupeds which are herbivorous in food habits and form the other extreme as opposed to the carnivorous animals. There are two great divisions of the Ungulata,—first, the *Artiodactyla,* the even-toed Ungulates (the Ox, Deer, Sheep, Pig, etc.), and second, the *Perissodactyla,* the odd-toed Ungulates (the Horse, Rhinoceros, Tapir, etc.). The dental system of this great branch presents extreme modification for adaptation to an exclusively vegetable diet, and is highly elaborated and complex. It is the extreme of specialization in the herbivorous direction. The molar teeth are of the folded or lophodont type, the tissues being folded on the sides of the crown and the valleys dipping down into the crown so as to form high, sharp crests which, when worn away, present curious patterns of the arrangement of the dental tissues (Fig. 63). As opposed to the vertical direction of the movement of the jaw in the Carnivora, in this order the jaw movement is horizontal, the articulation being wide and loose, so that the grinding teeth are spread out and developed laterally to resist the transverse movement so necessary to the grinding of refractory vegetable fiber. The lophodont type of molars has, of course, been gradually developed from the

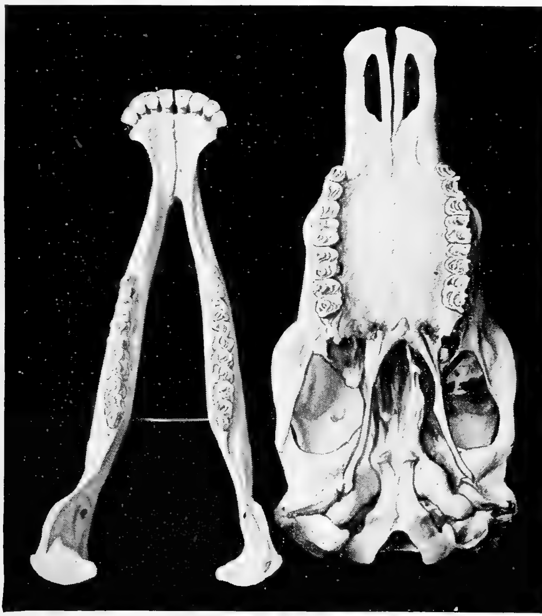


FIG. 63.—Teeth of Cow (*Bos taurus*).

simple bunodont or tubercular type, by increasing the number of tubercles and ridges and their erection into sharp crests and ridges. The lateral excursion of the jaw is more extensive in some forms,—as the ox, deer, etc.,—and in these the molars present a lateral extension of the grinding surface (Fig. 64). There is always a corresponding modification of the condyle and the glenoid cavity to accommodate the movement, and the corresponding development of the teeth due to lateral motion is most remarkably shown. There are deep transverse valleys and high crests, and the duplication is greatest in the direction trans-

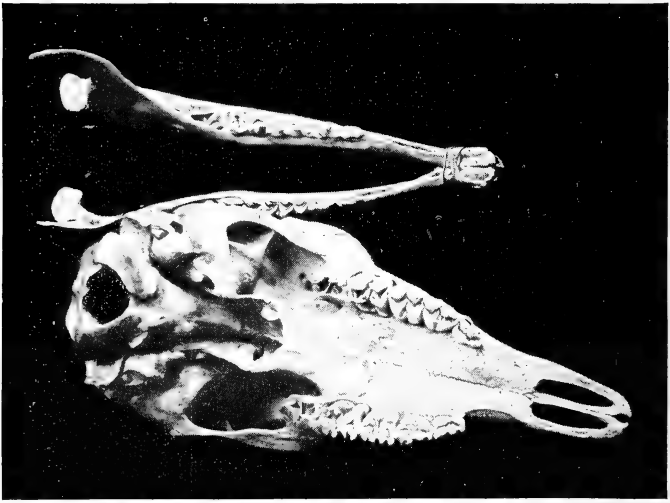


FIG. 64.—Occlusal view of teeth of Antelope (species unknown).

verse to the jaw movement. The crests have been flattened and bent oblique, or folded about in various directions, which have produced a variety of patterns of grinding surface where the teeth are much worn. This gives a peculiar arrangement of the dental tissue, and looks as if the enamel, dentin, and cementum had been laid together and rolled and crushed and the ends of the roll presented for mastication. The different densities of the three tissues produce different degrees of wear, so that the grinding surface is always rough to be more effective for the reduction of vegetable fiber. The enamel being hardest stands highest, and traces the pattern of the surface; the dentin being next in density stands lower, and the ce-

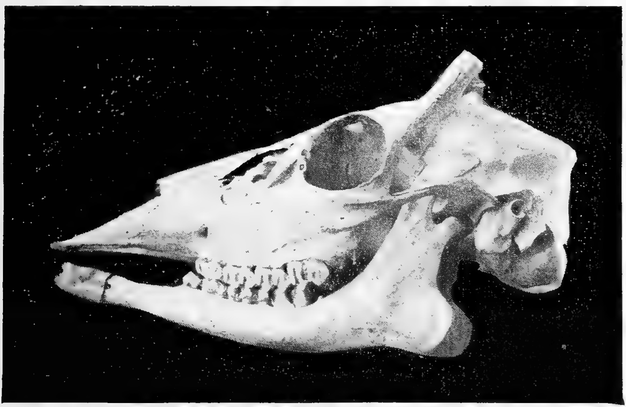


FIG. 64-A.—Side view of teeth of Antelope.

mentum being softest is most worn out. The patterns of the arrangement of the folds of enamel thus presented are very various throughout the order, but each family have the same type of pattern, and this is so constant as to have a distinct diagnostic value for the distinguishing of species, especially in fossil remains. Different groups of the Ungulata are characterized by a distinct pat-

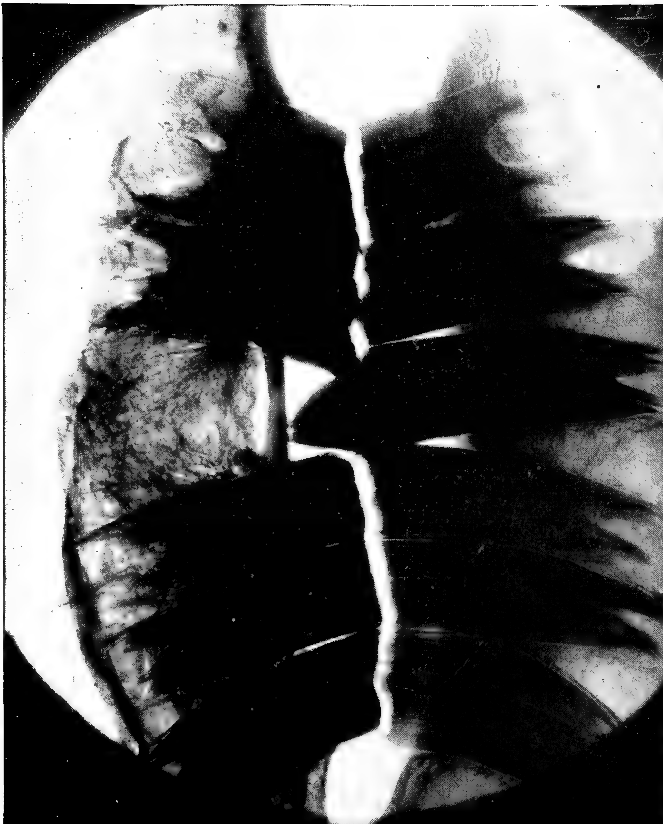


Fig. 65.—Roentenogram of jaws of Buffalo (*Bison americanus*), showing missing molar. (By Dr. E. H. Skinner.)

tern of the arrangement of the tissues of the molars that is exact and constant.

In the *Artiodactyla,*—the even-toed Ungulates,—the first and most important group is that of the *Ruminants,*—those herbivora which regurgitate the bolus of food from the stomach to subject it to a second chewing or rumination. This division includes the Ox, Sheep, Deer, Antelope, Giraffe, and indeed the greater part of the Artiodactyla, which have no incisors in the upper jaw. The formula is usually,—

$$\text{i. } \frac{0\text{–}0}{3\text{–}3} \quad \text{c. } \frac{0\text{–}0}{0\text{–}0} \quad \text{p.m. } \frac{3\text{–}3}{3\text{–}3} \quad \text{m. } \frac{3\text{–}3}{3\text{–}3} = 30.$$

There are no incisors nor canines in the upper jaw, but instead a hard pad of cartilage covered with dense gum-tissue, against which the lower incisors and incisor-like canines close in cutting off grass. Rudimentary incisors are met with in the Red-deer, and the Musk-deer, Water-deer, and Muntjac have formidable upper canines projecting downward below the lower jaw for weapons and digging roots. The canines bear a more or less distinct inverse relationship to the presence or absence of horns,—i.e., when the upper canines are present the horns are absent, or *vice versa.* The molar teeth of this group present great variety as to the pattern of the grinding surface, but within families are much alike. Thus the molars of the ox family, the deer family, etc., have each a distinct and characteristic pattern which is unmistakable. The *Camelidæ* includes the camels

FIG. 66.—Teeth of Hog (*Sus scrofa*).

and dromedaries. The two first pairs of incisors above are absent, but the third pair are canine-

FIG. 66-A.—Teeth of Domestic Hog.

like in shape, and the canines are large and formidable. The first premolar above is like a canine, and the presence or absence of the other two varies much. The type of the molar is selenodont. The non-ruminant, even-toed Ungulates include the Pig (Fig. 66), Hippopotamus, etc. The formula of the Pig is,—

$$\text{i.}\ \frac{3\text{–}3}{3\text{–}3}\quad \text{c.}\ \frac{1\text{–}1}{1\text{–}1}\quad \text{p.m.}\ \frac{4\text{–}4}{4\text{–}4}\quad \text{m.}\ \frac{3\text{–}3}{3\text{–}3} = 44.$$

The Wart Hog has but thirty-four and Dicotyles thirty-eight. The incisors are well developed, and increase in size from center to sides. The canines are sometimes enormously developed, as in the Wild Boar. This development is arrested in the domestic hog by castration, showing that the excessive growth is due to sexual influence. The canines are small in the female. In the Wild Boar they curve outward and upward into hooks to make formidable weapons for ripping up an adversary. They sometimes pierce the upper lip, are triangular in section, and are deeply ridged on the anterior surface, the enamel being rough and irregular. The lower canines are much smaller. The molar series increase in size from front to back, and present sharp, high crests which usually remain unworn in the domestic hog. When worn the crests present a characteristic triangular form. The Wild Hog of Mexico (Fig. 67) has long, sharp canines for warfare (Fig. 68). The Hippopotamus is much like the pig as regards its dentition, but has four incisors less.

There is a monstrous development of the ill-shaped incisors and canines, which are large, blunt, and variously directed, so that their edges, ends, or sides may be worn on different surfaces. They are coarse and tusk-like, and nearly cylindrical in form. The upper incisors are implanted vertically and the lowers horizontally. The canines are enormous, trihedral in shape, and are

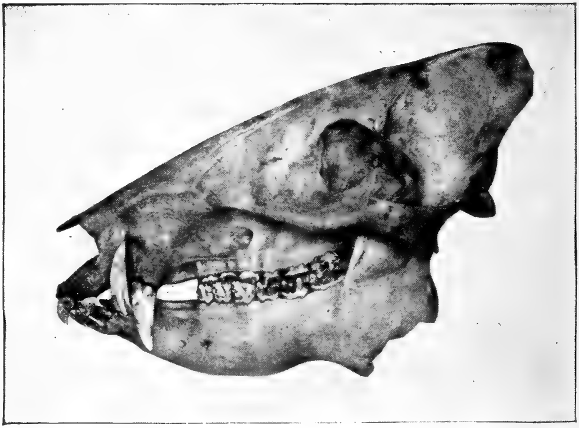


FIG. 67.—Teeth of Wild Hog (*Peccary*).

of persistent growth. The molars have sub-compressed conical crowns which have two lobes, each divided into two half crowns, with a crucial depression separating the four cusps. Each cusp is formed in a definite trilobed shape which wears into a characteristic trefoil pattern, like the pig. Sometimes the molars are quadrilobate when much worn.

FIG. 68.—Roentgenogram of teeth of Wild Hog. (By Dr. E. H. Skinner.)

The *Perissodactyla* are much less numerous as regards their living representatives, although great numbers have lived on the earth in past geological times. It includes the Horse, Rhinoceros, Tapir, and their allies. The Horse family has the formula,—

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

The incisors are broad, thick, and slightly curved, with a valley dipping down into the crown which

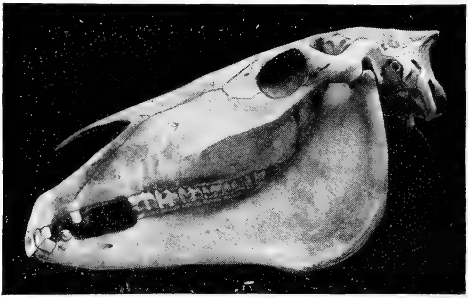


FIG. 69.—Teeth of Horse (*Equus caballus*).

when worn produces the well-known mark by which the age of a horse is estimated (Fig. 69). The canines are long and cubical in the male, but smaller in the female. A considerable space exists between the canine and the premolars. The first premolar is rudimentary, and often becomes a source of irritation. It is popularly called the "wolf-tooth," and is soon shed. The other premolars are often as large and complex in pattern as the true molars. The upper molar crowns are cubical and large. The grinding face presents a peculiar pattern which is distinctive of all varieties of the genus *Equus*, both living and extinct. The molars are rather of an archaic pattern, and not so complicated as in the Ruminants. The characteristic crescents of the lower molar ridges are much like those of the Rhinoceros. The phylogeny of the horse has been well made out, and the pattern of the teeth has played an impor-

FIG. 70.—Roentgenogram of mandible of a young horse. (By Dr. E. H. Skinner.)

tant part in this most interesting scientific triumph. The teeth are hypsodont as the crown exceeds the length of the root and the teeth erupt farther as the crown is worn off (Figs. 70 and 71).

Fig. 71.—Roentgenogram of mandible of an old horse. (By Dr. E. H. Skinner.)

The Rhinoceros has the formula,—

$$\text{i. } \frac{3-3}{3-3} \text{ c. } \frac{0-0}{0-0} \text{ p.m. } \frac{4-4}{4-4} \text{ m. } \frac{3-3}{3-3} = 40,$$

when the full quota is present. The incisors of the Rhinoceros (Fig. 72) bear an inverse relationship to the development of horns,—i.e., when the horns are present the incisors are reduced or absent, and when the horns are absent these teeth

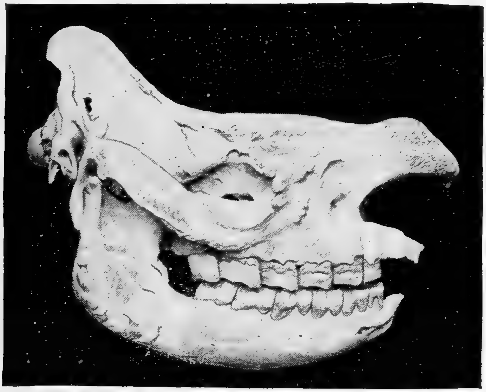


FIG. 72.—Teeth of Rhinoceros (species unknown).

are augmented. The two-horned species have no incisors in the adult individual. The incisors vary from four to eight,—some having the centrals missing and others the laterals. The canines are absent in all species. The grinding teeth increase in size from before backward, and differ from those of the horse by being implanted by distinct roots. They present a characteristic pattern which is found in both extinct and recent species. The little Biblical Coney (Hyrax) is unique in that it is closely allied to the Rhinoceros in the pattern of its molars. The central incisors are very large, and similar to the rodents. The laterals are smaller, and are soon lost. The lower incisors have denticulated edges which bite upon a callous part behind the upper incisors. It has the formula,—

$$\text{i.}\ \frac{2\text{–}2}{2\text{–}2}\ \text{c.}\ \frac{0\text{–}0}{0\text{–}0}\ \text{p.m.}\ \frac{4\text{–}4}{4\text{–}4}\ \text{m.}\ \frac{3\text{–}3}{3\text{–}3} = 36.$$

The Tapir has the formula,—

$$\text{i.}\ \frac{3\text{–}3}{3\text{–}3}\ \text{c.}\ \frac{1\text{–}1}{1\text{–}1}\ \text{p.m.}\ \frac{4\text{–}4}{3\text{–}3}\ \text{m.}\ \frac{3\text{–}3}{3\text{–}3} = 42.$$

The incisors are round, and with a transverse groove between the edge and the basal ridge into which the lower incisors fit. The outer incisors are long and caniniform. The canines are rather small and pointed. The lower incisors are smaller than the upper. The molar series are partly tuberculate and partly triturating on the surface; the lowers are of the double transverse ridge type. There were many extinct forms of the Rhinoceros and Tapir which had similar dentitions, and by which the remains are readily recognized.

The *Proboscidæ* are the large mammals which have a long proboscis,—the living Elephant, the extinct Elephants, Mammoths, Mastodons, etc.

Only two species are now living,—the African and Indian Elephants. The Mastodons, Dinotherium, Mammoth, and several Elephants are now extinct on the earth, and can only be studied in fossil remains. The order is almost entirely extinct, and the living species of Elephants can only be preserved by domestication and care, as they have been remorselessly destroyed for the ivory furnished by the long tusks. The order is distinguished by the long incisor tusks, which are implanted in deep sockets in the premaxillary bones, and grow continuously from persistent pulps. The bulk of the tusk consists of finely-tubed dentin which constitutes the ivory of commerce. The tubules bend and curve, which makes the fine ivory lines and causes the refraction of light which is one of the beauties of fine ivory. The present trade in ivory is enormous, and comes from Africa, where the elephants have been destroyed by thousands, so that the wild species will soon become extinct. Formerly the fossil beds and Arctic shores and islands of Siberia yielded great quantities of the tusks of the extinct Mammoth, and they are yet washed up by the waves. Of the two living species of the Elephant the formula is,—

$$\text{i. } \frac{1\text{–}1}{0\text{–}0} \text{ m. } \frac{6\text{–}6}{6\text{–}6} = 26.$$

The two upper central incisors are greatly prolonged into the form of round, curved tusks, which sweep outward and upward to the length of several feet. The African Elephant has larger tusks than the Indian species, and they sometimes reach the length of eight feet and weigh one hundred and fifty pounds. The tusks are incisors and not canines, which is shown by the fact that they are inserted in and supported by the premaxillary bones, which are enlarged and prolonged to support them. These tusks grow from persistent pulps, and are subject to disease and injuries. Gunshot and spear wounds sometimes reach the pulp in the immature portion of the tooth, and give rise to abscesses which affect the development of the dentin. Sometimes resorption of the root is caused by the larva of a dipterous insect in India, and the tusk is so weakened that it breaks off. There are no lateral incisors or canines in the Elephant, and probably no premolars, although from the peculiar mode of succession of the molars the premolars and true molars cannot be distinguished. Six molar teeth (Fig. 73) are developed on each side of each jaw which succeed each other from behind forward, moving in a groove. One molar, or parts of two only, are in use at one time, and when one is worn out it has been pushed up to the anterior end of the groove, where it is partially absorbed and shed. Its successor then advances slowly to take its place, and is shed in turn. The series are in continual process of formation and destruction, of shedding and replacement, until the last molar comes into place when the animal is old and remains through the

FIG. 73.—Teeth of Elephant (species unknown).

rest of life. The first of the molars is in place at three months, and has but four plates of enamel. The second follows at two years, and has eight or nine plates. The third follows about the fifth year, and has eleven to thirteen plates, and is four by two inches in size. The fourth follows in the ninth or tenth year, has fifteen to sixteen plates, and is eight by three inches in size. The fifth molar appears at the twentieth year, has seventeen to twenty plates, and is ten by three inches in size. The sixth molar appears ten to twenty years later, has twenty to twenty-seven plates, and is twelve to fifteen inches in length. This lasts until the close of the animal's life, which may be a century. These molars are very complex and remarkable in structure. Each consists of a series of transverse, oval plates like flattened circles of enamel, the central space being filled with dentin, the bulk of the crown between and around the plates being made of cementum,—the unequal density of the tissue producing a rough surface for grinding, as in all Herbivora. The occluding surfaces are originally tuberculate with crown crests, like the molars of the Mastodon, but these soon wear down and expose the plates, which are arranged transversely to resist the antero-posterior movement of the mandible. These plates present different patterns in the Indian and African species; in the former they are of parallelogram or diamond shape with zig-zag foldings of the enamel rim, and in the African species the plates are lozenge-shaped, or flattened circles, and the rim of enamel is smooth and even. The molars are composed of separate enamel plates.

Each enamel plate is developed from a separate tooth-pulp.

The majority of the members of this order of gigantic mammals are now extinct, though some of them have survived to recent geological times. The Mammoth of Siberia and glacial Europe was a great hairy elephant, with enormous tusks sweeping upward and backward in a circle. His remains have been found in the flesh frozen in the ice of Northern Siberia, and his image has been discovered carved on his own ivory and upon reindeer horns by his contemporary, primeval man, in the glacial caves of Europe.

The bones of Mastodons are found all over the United States in recent formations, and are sometimes associated with the bones and implements of prehistoric man. The Mastodon had the formula,—

$$\text{i. } \frac{1\text{–}1}{1\text{–}1} \quad \text{p.m. } \frac{3\text{–}3}{3\text{–}3} \quad \text{m. } \frac{3\text{–}3}{3\text{–}3} = 28.$$

It had four incisor tusks,—two above and two below in the center of the jaws. The upper tusks were large, thick and strong, and sometimes attained the length of twenty feet, describing a sweeping curve outward. The two lower tusks were small, straight, and projected horizontally forward. The molars of the Mastodon differ from those of the Elephant, but are plainly the type of the forerunners of the latter. The latter have similar cusps to the former, when erupted, but soon wear down to the characteristic plates, the separate denticles taking the form of dentinal plates. The grinding face of the molar of the Mastodon had transverse ridges which supported two teat-like tubercles. The first molar had two such ridges and four tubercles. The second had three bifid, transverse eminences and a tuberculate ridge on the rear of the crown. The third molar had four ridges and occasionally five and a posterior talon. The intervening valleys were at first filled with cementum, but this wore out with use. The extinct *Dinotherium* had the upper tusks absent and the lower prolonged into downward-curving tusks. It was aquatic in its habits, and employed the anomalous tusks for digging aquatic plants. Its molars were similar to those of the Tapir.

The *Primates* (or *Quadrumana*) comprise those mammals having four hands,—the Lemurs, Monkeys, and Apes. They are distinguished from all other mammals by having opposable thumbs on both hands and feet which enable them to grasp objects. The Primates include also those members of the animal kingdom, the Apes, which stand next to man in structure and whose dentition is exactly like that of man. Although thus approaching man, the teeth are still like the lower mammals, arranged in a parallelogram instead of the rounded arch of man. The skull is small, and the teeth and jaws are still prominent and prognathous. The *Lemurs* are the lowest of the Quadrumana, and connect that order with the lower mammals in many features of structure. They have the formula,—

$$\text{i. } \frac{2\text{–}2}{2\text{–}2} \quad \text{c. } \frac{1\text{–}1}{1\text{–}1} \quad \text{p,m. } \frac{3\text{–}3}{3\text{–}3} \quad \text{m. } \frac{3\text{–}3}{3\text{–}3} = 36.$$

The upper incisors are small (Fig. 74), and are separated from each other by wide spaces. The

FIG. 74.—Teeth of Ruffed Lemur (*Lemur varia*).

lower incisors project straight forward and interdigitate with the upper, passing into the interdental spaces. This enables them to cut up the tender shoots of bamboo, twigs, grass, etc., on which they feed, with facility. The upper canine is large and pointed, with sharp edges. The lower canine is like the incisors in form and ranges forward with them. The premolars are sub-compressed, and have long, sharp cusps. The first upper premolar is large and caniniform.

The others are lobed and have a small internal cusp. The fourth is like the true molars, which are made quadrangular by the internal cingulum rising up into a cusp at the posterior angle of the crown. In some forms, as the Spectre-lemur, the teeth are of insectivorous type for the peculiar diet. There is often a basal ridge on the incisor, which is well defined even on the anterior face. The inner cingule on the incisors is like those of Moles. The molar series are inclined to be trihedral. The *Galeopithecus* is remarkable for having the lower incisors, which are broad and flat, cleft to the base by deep vertical fissures, so that they resemble the teeth of a comb and are used in dressing the coat of the animal. There are seven such fissures, making eight columns in the central and nine in the lateral incisors. The upper centrals are broad, flat, and notched, as are also the third incisors and canines. The molar series are simple and tuberculate. The *Aye-Aye* (Cheiromys) has a dentition of the rodent type, with similar continuously-growing, scalpriform incisors. The lateral incisors, canines, and most of the premolars are absent, the molars having an elliptical grinding surface. Other forms of Lemurs present different varieties of dentition. They are survivors of that primitive type of Quadrumana which were the progenitors of the *Anthropomorpha* of today,—including man,—

which are found in the Eocene formations of the West. One genus—*Anaptomorphus*—had the generalized characteristics of the progenitors of the Primates. It had the tritubercular upper molar, and a monkey of the later Eocene had the quadritubercular form such as is found in the later Primates and man today.

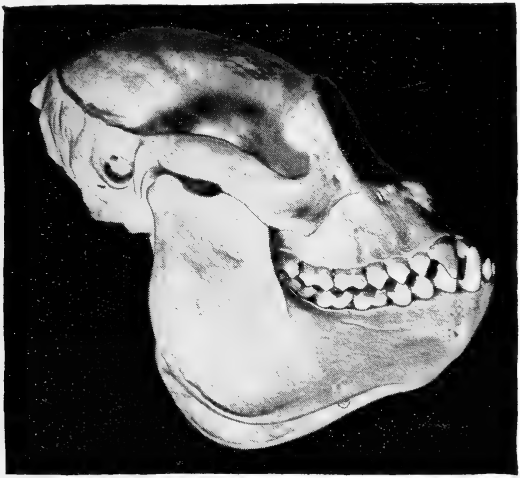


FIG. 75.—Teeth of New-world Monkey (species unknown).

The true monkeys are divided into two great classes,—first the *Platyrrhine* (wide-nosed), or New World Monkeys (Fig. 75), and second the *Catyrrhine* (narrow-nosed), or Old World Monkeys. The Platyrrhine, or American Monkeys, have prehensile tails, wide nostrils, and the dental formula, usually, of the Cebidæ,—

$$i. \frac{2-2}{2-2} \quad c. \frac{1-1}{1-1} \quad p.m. \frac{3-3}{3-3} \quad m. \frac{3-3}{3-3} = 36.$$

The Halpiadæ have but thirty-two teeth. The presence of the third premolar in this branch, along with other peculiarities, indicates that they are nearer the Lemurs than the Old World Primates, and are therefore lower in structure. They have stopped at a lower stage of development, and the Old World branch has progressed. The Catyrrhine, the Old World Monkeys, and Apes have the formula,—

$$i. \frac{2-2}{2-2} \quad c. \frac{1-1}{1-1} \quad p.m. \frac{2-2}{2-2} \quad m. \frac{3-3}{3-3} = 32,$$

which is exactly that of man. There is one less premolar on each side of each jaw than in the New World Monkeys. However, of the latter, the little Marmoset has only thirty-two teeth, owing to the absence of the third molar on each side, although they still have the third premolar. The Platyrrhines have the third molar in the deciduous set also. Some of the species have nearly horizontal incisors,—another lingering lemurine characteristic,—but the teeth as a rule begin to approach the erect position. The incisors are thick and strong, and of nearly the same width. The canines are strong and prominent, and appear before the last molars. The diastemas in front are well marked, into which the lower canines close, as in the carnivora. The molars usually have two transverse ridges with four cusps. In some forms the oblique ridge, a remnant of the tritubercular stage, is retained. The disto-lingual cusp is added to complete the quadritubercular form. Some of the American monkeys —as the Marmosets—have sharp cusps, showing an insectivorous diet. The *Howlers* have large, strong canines projecting from both jaws. The upper have the deep anterior grooves. The premolars are trihedral, with three pointed cusps on the buccal line, being triconodont. The true molars are quadritubercular except the last, which is tricuspid. The dentition of the American monkey is, on the whole, rather low and lemuroid. The Capuchins have lower incisors with broad, thick, wedge-shaped trenchant crowns, which is the characteristic form of these teeth throughout the Quadrumana. The canines are strong and pointed. The upper premolars have two cusps on a transverse line, the outer one being longest and largest. The first premolar below has the trenchant ridge continued forward from the outer cusp, like the Baboons of the Old World. The true molars decrease in size from first to last, and are all quadricuspid except the third below, which is tricuspid. The dentition in general of the Platyrrhines is thus rather uniform.

The *Catyrrhine,* or Old World Monkeys, have the same dentition as man, as to number, and the human forms of the teeth are gradually approached in advancing from the lower to the highest species. The upper central incisors gradually become wider and the laterals narrower. The lower incisors become narrower, and are less thick and heavy. The canines remain strong and powerful, but are reduced in some species. The

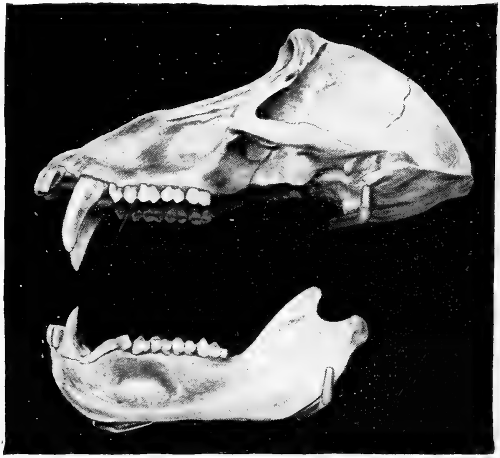


FIG. 76.—Teeth of Old-world Baboon (*Cynocephalus porcarius*).

Mandrills have these dental weapons most formidable for their size and shape, and the uppers descend behind the lower canines against the edge of the lower first premolar, which is raised to meet them. This is a marked peculiarity of the Baboons (Fig. 76). A large diastema separates the upper canine from the incisors, into which the sharp lower canine closes. The premolars gradually assume the bicuspid form, but the cusps are large, long, and sharp. The true molars have four prominent sharp-pointed cusps with an anterior and posterior basal ridge. They progressively increase in size from the first to the third in all Baboons. The crowns of the lower molars are narrower and longer than the upper, and the last has a fifth lobe or tubercle. The first lower premolar is bicuspid or unicuspid, but the second is quadricuspid. In the long-tailed monkeys, the upper molars have four tubercles, and the lowers five. In some Catyrrhine monkeys the curved form of the arch begins to appear. In some the teeth have long, sharp cusps, indicating an insectivorous diet. In most of the higher species they are tuberculate, as in man, indicating a mixed diet. The deciduous set are the same as those of man and succeed each other similarly, but with some variation as to the time of the eruption of the teeth.

CHAPTER IX

THE TEETH OF THE HIGHER APES AND MAN

The higher Apes (the *Anthropomorpha*) include the Gibbon, the Orang, Chimpanzee, and Gorilla. They differ markedly from the lower Primates in many respects, i.e., in having no tails and no callosities; in habitually assuming a semi-erect attitude; the broader thorax; the elongation of the forearm so as to support the body on the fingers or knuckles, etc. They are largely arboreal in their habits.

The jaws are of a more or less parallelogram shape, the rounder arch of man being but little approached in the Apes. The skull is small and depressed, and the jaws large and prominent, so that the prognathism is very marked.

The teeth are similar in number and form to those of man, and approach his in all the essential features of their structure, although there are some differences as to arrangement, texture, squareness of form, etc. The central incisors are wider than the laterals, as in man; the lower

Primates, especially the Lemurs and Platyrrhines, having the incisors of nearly the same width, and the difference becomes apparent as the advance is made from the lowest to the highest forms.

The great canines stand out at the corners, and are large and trenchant like those of the Baboons, and there is still a large diastema in front of the upper canine into which the lower one closes.

The premolars are of the bicuspid type, but are coarse and large, with strong, high, sharp cusps. They are implanted by three roots above and two below, just like the true molars and like the lower Primates. The molar teeth are large, square, and coarse, and increase in size from front to back, the reverse being the rule in man. They are of the distinctly human pattern,—quadritubercular above, quinquitubercular below.

The teeth of the Apes resemble those of man in various degrees, but there are conspicuous differences which can best be tabulated as follows:

(a) Relatively to the size of the cranium, the jaws and the teeth are very large and prominent in the Apes. Hence they are very prognathous, and the facial angle is low. In man, on the contrary, the jaws are much reduced, the cranium is enlarged and brought forward, and the facial angle is nearly vertical.

(b) The dental arch is a long parallelogram in the Apes, like the lower mammals. In man the arch is shortened and rounded to form a graceful curve.

(c) The teeth of the Apes are of irregular height, the canines standing above the level of the rest. In man no one tooth surpasses another in height, but all are on the same level.

(d) In the Apes there is a diastema in front of the canine above into which the lower canine closes. In man there are no spaces between the teeth, but they are in regular continuity in the series in both jaws.

(e) The incisors in the Apes incline forward more or less, and by their projection increase the prognathism. In man the incisors in both jaws are vertical, except in some of the low races with distinct prognathism.

(f) In the Apes the canines are very large and long, with sharp edges behind like the Carnivora, and are larger in the male than in the female. In man they are reduced to a level with the other teeth, the animal features obliterated, and there are no sexual differences in these teeth.

(g) In the Apes the molar series increase in size from front to back, and follow a straight line. In man they decrease in size from first to last, and follow a curved line.

(h) The third molar is the largest of the series in the Apes, and has ample room in the jaw. In man it is the smallest of the molar series, and is often crowded for space on account of the shortening of the jaws.

(i) The teeth in general are larger, thicker, and coarser in the Apes, are more square and angular, and the cusps and edges are more prominent and sharp. In man the teeth are smaller and finer in texture, the crown is narrower and rounder, the angles are reduced, and the cusps and edges are short and blunt.

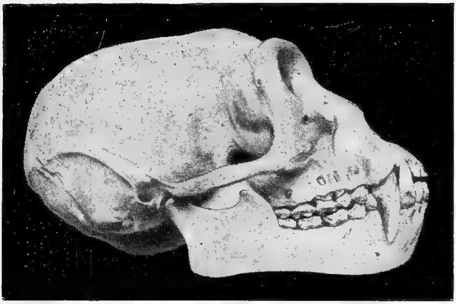


FIG. 77.—Teeth of Gibbon.

The resemblances are also marked in the exact formula and number, but all the resemblances are not found in the Apes. Thus in the little Celebes monkey the teeth are in close contiguity as in man. The oblique ridge of the upper molars is found in the higher Apes, also in some of the American monkeys. In man the canines erupt before the third molars, but in the Apes not until afterward.

Descriptive. The Gibbons (Fig. 77) are the lowest of the tailless Apes, and are found in the

Malay archipelago. The incisors are of the human type, but the difference between the centrals and laterals is not so marked as in the higher Apes; they being more nearly of one width, like the lower Quadrumana. The canines appear simultaneously with the third molars, and are of a smaller, conical type than the other Apes. The

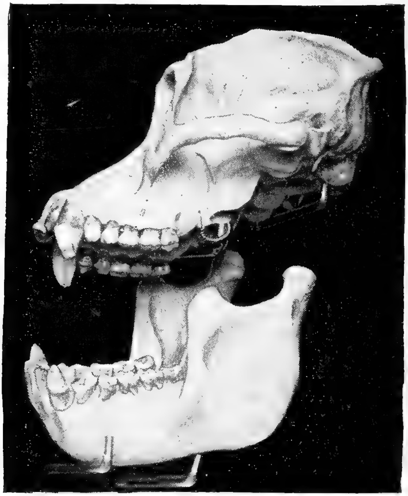


FIG. 78.—Teeth of Orang-Outang.

premolars are large and heavy, but of the low, Simian type.

The true molars are sub-equal in width, but more reduced than those of the other Apes, and more human.

The *Orang-Outang* (Fig. 78) also inhabits the Malay archipelago. It is quite human in its dentition, but the Chimpanzee and Gorilla are nearer man in many other respects.

The upper centrals are of great size, and are twice as wide as the laterals. They have basal ridges on the lingual surface.

The laterals are pointed, the distal edge being obliquely truncated and the mesial edge rounded so that but a point appears. A diastema as wide as the laterals separates them from the canines. The lower incisors are of nearly equal width, and long and stout.

The canines in the males are long, strong, and slightly curved without the anterior groove of the Baboons. They are much larger than the other teeth, and imperfectly trihedral, with a trenchant edge behind and a ridge running from the lingual cingulum to the point. These teeth are smaller in the female. They do not appear until after the third molars are in place. The lower canines are sharp-pointed, with a marked lingual ridge.

The upper premolars are smaller than in the Baboons, the cusps of the first being more pronounced than those of the second. The outer cusp is the larger. The lower first premolar has a subacute point with three ridges descending internally. The second is bicuspid in form.

The first and second true molars above are larger than the third. There are four tubercles, but these are rather reduced. The enamel of the grinding surface is finely wrinkled. The lower molars have five tubercles, three externally and two internally. The third is five-lobed, with a wrinkled face.

The *Chimpanzee* is a medium-sized man-ape found in West Africa. The dentition is strictly quadrumanous, but approaches the human type in many particulars.

The central incisors are reduced from those of the Orang, so that they are smaller and the laterals larger than in the latter ape, which is a lower form. Each incisor has a prominent basal ridge. The laterals are larger, but still have the distal corners rounded off. The lower incisors are large, and project forward.

The diastema between the incisors and canines is narrower than in the Orang.

The canine is much smaller than in the Orang, is conical, and with a sharp posterior edge. It does not erupt until after the third molar is in place. In the female, it follows the second molar, and is much smaller. As in the Orang, it is so long as to extend below the lower alveolar border when the mouth is closed. The lower canines are smaller, conical, and trihedral, and with a sharp inner edge.

Both upper premolars are biscuspid, the exterior cusp being most pronounced. The lower first premolar is larger than the second, and is twice the size of the human tooth. It is shaped like the Baboon's, with a sharp anterior edge with two sharp trihedral cusps. The second lower premolar is subquadrate, with three tubercles.

The true molars above are quadricuspid, and are relatively larger than the premolars; in the Orang they are relatively smaller. There are five

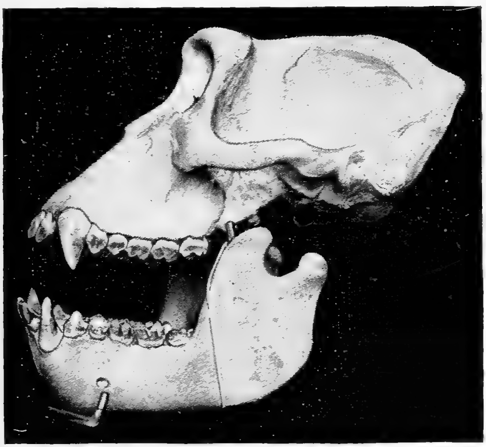


Fig. 79.—Teeth of Gorilla.

cusps on the lower molars, the two inner ones being sharpest. The tubercles are rounded and more prominent than in man.

The *Gorilla* (Fig. 79) is the largest of the Primates and Apes, and approaches nearest to man in general organization. The Gorilla, with the Chimpanzee, is found in the Gaboon region of West Africa. Although close to man in many details of organization, the dentition of the Gorilla is not so human as that of some of the lower Primates. That of the Chimpanzee is more close. The diastema is still wide, and the canines are large and baboon-like. The jaws are large and square, the arch is a mere parallelogram, and the brain-case is much smaller. The great ridges erected to support the muscles of mastication are very conspicuous. The incisors are of similar shape to those of man, and relative sizes of the central and lateral are nearly the same as that of man. The crowns are coarses, square, heavy, and roughly ridged. The canines are of great size and strength, quite like those of the Baboons. The crown is trihedral in section, with a groove on the labial face and a cutting edge behind. It stands out in such prominence as to give a ferocious look to the face, and adds to the squareness of the jaws. It is not as large in the female as in the male. They erupt after the third molar, which is the reverse in man. The upper premolars are of bicuspid form, as in man, but the cusps are more high and pointed, and are united by a strong cross ridge. The uppers are implanted by three roots. The lower first premolar is strong, pointed, and caniniform. The second is tricuspid. Both are implanted by two roots, like the true molars. The upper molars are more strong and square, the cusps sharper and longer, than in man, but have the oblique ridge. These teeth are not so human as those of the Chimpanzee and Orang. The lower molars are similar and have the same pattern as in man, but the second has the fifth cusp, which is wanting in man. The third molars are larger than the others, as the molar series increase in size from first to last; in man the reverse is true. They have ample room in the jaws, and are useful grinders. The grinding teeth are very strong, as the massive muscles of this great Ape are used for biting and crushing with tremendous force.

The Teeth of Man. The teeth of Man are closely related in form and structure to those of the apes below him, and remotely to various members of the Quadrumana. Indeed, like other organs, they bear in their structure the history of a long line of descent, and many of the indications of their history can be read with some certainty. Some of his teeth are quite primitive in type, as the quadritubercular molar, which is found far back in the Eocene; and occasionally this lapses into the still more primitive form of the tritubercular molar. The teeth of Man in general are degraded in form and structure and much reduced in specialization as compared with, for instance, the highly specialized teeth of the Carnivora and Herbivora. The structural integrity of the teeth is much more deficient in civilized man than among savage races, of course, although dental diseases are not unknown among the latter. There is not so much of a gap between the higher species of the Apes and the lower races of Man as might be supposed, scarcely more than between the lower and higher races of Man. As the teeth of Man are strong and well made, they approach the Simian form and integrity; as they are defective and ill-formed they depart from it. The best dentures are those which have animal perfection of organization. The reversions to lower forms often presented by the teeth of Man are of peculiar interest, and exhibit their descent and animal relationship in a remarkable degree. The teeth of Man being rudimentary as compared with the lower Primates, these reversions are not unexpected. Some of the instances of reversion may be noted as follows: Man has but thirty-two teeth, while the typical mammalian formula is forty-four. He has thus lost twelve teeth, some of which sometimes reappear as so-called "supernumerary teeth," but are in reality due to atavism, and are reversions. Thus a third incisor, or third premolar, or fourth molar are sometimes seen. The upper incisors may be scoop-shaped (like the Shrews or some Lemurs), or may have a cingulum on the base, like the Quadrumana; or may be deeply ridged or notched (as it always is at birth), recalling the cleft incisors of the

Galeopithecus, etc. The upper lateral is very erratic, and, like the third molar, seems to be on the road to extinction. It is sometimes absent, or may be reduced to a mere peg-shape; or it may be bicuspid by the raising of the lingual cingule, like the incisors of the Insectivora. The canine is sometimes strongly marked by the ridges or a cingule, which it shows in lower forms; the upper premolars sometimes have three roots, as in the Quadrumana; the upper molar is sometimes tricuspid, which is a lemurine form and reaches far back into Eocene times. The second lower molar occasionally has the fifth cusp, which is the anthropoid type; but this cusp is wanting in the higher races, though often present in the lower. The lower third molar is sometimes wrinkled on the face, like the molars of the Orang, etc.

The prehistoric and other low races of mankind stand nearer to the Apes in many essential points of structure than the highly developed and advanced races. This is illustrated by many parts of their anatomy, and markedly so in regard to some features of the dental organization, in which they differ from the higher races in many points and approach the Apes below them. The arch is not so rounded as in modern man but it is more square in front; the third molars have ample space, and are as large as the other molars; the jaws are prominent and prognathous; the teeth are well arranged, and irregularity is uncommon; the roots of the third molar are separate, like the other molars,—in the higher races they are fused together; the second lower molar has the fifth tubercle.

As the higher races vary from savage strength and perfection of the teeth, it is in the direction of incompleteness and imperfection. The best dentures among European races are those which have the animal perfection of form and organization, so that the differences that distinguish the teeth of the lowest savage from those of the European are much the same as mark the change from the anthropoid to the human type, though the latter are far greater. The large size of the jaws of the savage is due to the harder work to which the teeth are put, owing to the hard and often gritty nature of the food used by savages. For the same reason the teeth of low races are much worn with age, which does not always occur among civilized races. In a general way the savage has what we would call a good set of teeth, if it were found in the mouth of a European; but the massive jaws are among the most marked of structural traits of low races. The use of the teeth as tools, until superseded by tools made by hands, also caused the greater development of the parts.

The fossil remains of Man found in Europe show the ape-like features of the teeth and jaws very strongly. The prominent superciliary ridges and glabella were accompanied by massive zygomatic arches, jaws, and mandible, and a receding chin like the Apes. The posterior molars were as large or larger than the other molars, which increase from front to back; the lower molars were often elongated like the Apes; the lower molars all have the fifth tubercle, which is missing in the second molar in later Man; the bicuspids were large and thick, and of large size in proportion to the molars; the cusps were high and sharp, but, like the tubercles of the molars, became much worn in adult age with rough usage; the canines were heavy, long, and sharp, being more of the baboon type; the incisors were long and thick; the centrals and laterals were more nearly of the same width, like the teeth of the anthropoid Apes.

The teeth are very degenerate in tissual organization among the higher, i.e., European races, but this is due not to the mere fact of civilization, but to the enervating effects of the luxuries and vices of civilization, to which they succumb. The higher races do not live near enough to the energizing influences of nature, but by surrounding their lives with enervating luxuries and degrading vices induce weaknesses which transmit degenerate organization. From this cause the teeth of the higher races have suffered much. Savages as a rule have good, strong teeth, but their physical organization is also sometimes degenerated by lack of nourishment or by disease. Their teeth also then partake of the general deficiency, and become deteriorated in structural integrity also. This fact shows that dental degeneracy and disease is due to deficiency of general structure, strength, and integrity, for the teeth are among the first of the tissues to be affected by disturbance of the nutritive supply.

The teeth of civilized man are much reduced in size as well as structure, and also the strength of their supporting environments, by disuse. The gradual lessening of the function of mastication, and the reduction of the force and variety of jaw movements has led to a marked weakening and degradation of the dental mechanism in Man. Growth force has been reduced by disuse, and the whole apparatus has become more or less rudimentary, in accordance with the law of economy of growth in the unused parts. The jaws are much contracted through disuse,—so much so that there is often lack of space for the teeth to erupt in proper position. This produces irregularity of the arrangement of the teeth, and, in the case of the third molars, leads to serious disturbances, owing to the shortening of the jaws and lack of room for them to come into place. The teeth are also disappearing through economy of growth due to disuse, as evidenced by the degraded third molar, which is often stunted in form and frequently absent entirely. The upper lateral incisor also is occasionally stunted and sometimes absent, and seems to be following the path of those teeth of man which have passed into oblivion, only to be recalled by their occasional reappearance as supernumeraries.

In regard to the *racial differences* of the teeth, it is well known that the lower races approach the Simian type and mark the transition to the human form. They belong to what are called the *Macrodont,* or large-toothed races. The most prominent of the latter are the *Australians,* who are the lowest of living races and most ape-like. Their teeth are large, white, and well formed. The molars do not decrease in size from front to back, but tend to increase or are of nearly the same size. The second lower molar has the fifth cusp, just like the Apes. The canines are large and conical. Supernumerary teeth—especially fourth molars—are not uncommon. The jaws are massive, with a monkey-like squareness in front, and are very prognathous. In the New Caledonians and some other Australoid people the central incisors are so large and insectivorous-like as to show their form through the lips.

The *Negroid* races have teeth that are large, thick, dark-colored, coarse, and ape-like, and project forward (Fig. 80). The molars are large (macrodont); the roots of the third molar are distinct, and the molars are of the same size, or increase from front to back. The second molar below usually has the fifth cusp. The third molars are usually of good size, as large or larger than the other molars, and fourth molars are not uncommon in the black races. The canines are large and conical, the teeth are well set and reg-

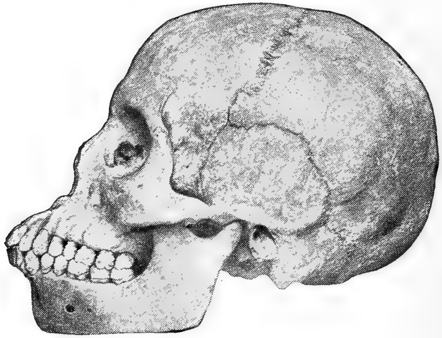


FIG. 80.—Skull of Fan Tribe, West Africa.

ular, and the anterior teeth stand apart. The arch is parallelogram in form, with square corners, and the prognathism is well marked. The facial bones partake of the general dolichocephaly of the cranium (Figs. 81 and 82). The prominence and massiveness of the mandible is such that the wear of the lower incisors is ofttimes toward the inside, and of the upper incisors toward the labial surface. The alveolar process is thickened about the roots of the teeth to form prominent ridges just beyond the necks. The gums

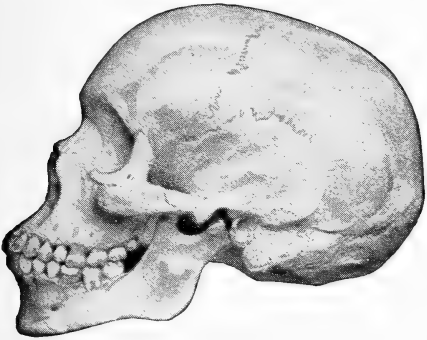


FIG. 81.—Teeth of African Negro.

are dark or mottled, the pigmentation of the skin extending even to the mucous surfaces. Some of

FIG. 82.—Occlusal view of teeth of African Negro.

the Polynesian negroes have small arches, with small, finely-formed teeth.

The *Mongoloid* races have the jaws rounded in relation to the brachycephalic skull, although still prognathous. The teeth are macrodont, with rather heavy prominent tubercles and cusps. The biscuspids are large as compared with the molars, —a Simian feature. In the Chinese the teeth are large and white, the anterior teeth being obliquely placed. The teeth of the Japanese are similar to the Chinese, but smaller, as the race is small-boned. The Eskimos have rather small teeth, with a round arch, the third molars being often reduced in size and sometimes wanting. The upper molars are often tritubercular. The Malays have teeth like the Mongolians, but are much disfigured by betel-nut chewing and mutilating customs.

The *Indians* of America are generally macrodonts, the teeth being large, strong, and well set in a round arch. There is considerable variety exhibited among the divers races of North and South America, large, medium, and small teeth being all found. Deformities are not infrequent, and fourth molars and third incisors sometimes occur. The teeth are much worn with age, like the teeth of all savage people who live on a coarse diet. The Mound-builders had fine teeth, in a round arch, which when not worn were large, yellow, and squarely set and coarsely made. The ancient Aztecs had small arches and small, fine teeth, but the Mexican peon of to-day has defective teeth owing to deficient nourishment and disease. Deformities and dental diseases are not uncommon among them. The Indians of the United States of later times had large fine teeth, but, with the degeneracy and disease incident to the vices acquired from the white man, they became degenerate and defective.

The *European* (Figs. 83, 84 and 85) races of

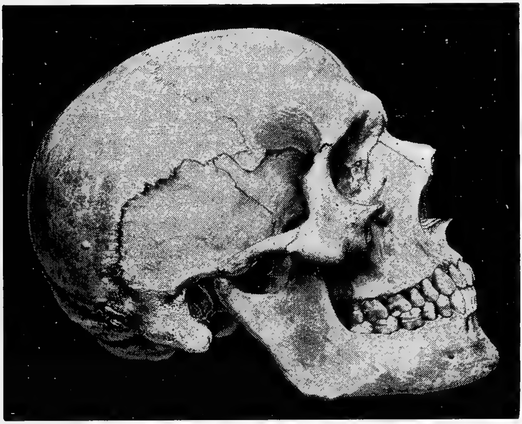


FIG. 83.—European (Caucasian) teeth.

today are descended from two distinct types,—the light and dark,—which are named *Xanthochroid* and *Melanochroid* types respectively. The Xanthochroid sub-races are the light-complexioned people of Scandinavia, Germany, the British Isles, the Libyans, the ancient Etruscans, and others. The teeth of the light races are rather large, square, light in color, and with square jaws and prominent canines. The skull being usually dolichocephalic, the jaws are narrowed also, but are not often prognathous. With highly civilized and luxurious, or poorly nourished lower peoples, the teeth are rather deteriorated in structure and prone to caries. This is noted even in the skulls of ancient Britons, Etruscans, and others, who were more or less civilized and luxurious. The

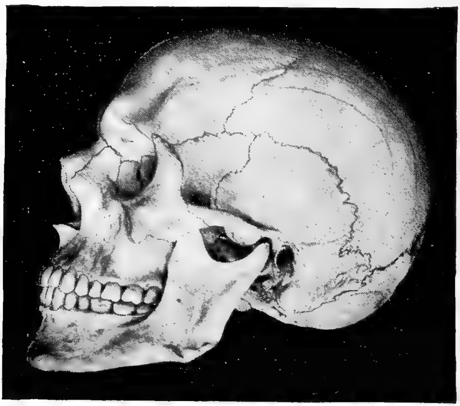


FIG. 84.—European (Caucasian) teeth.

prehistoric ancestors of these people had teeth of better structure than their descendants. The Melanochroid, or dark races, include the dark types of Europe, the Mediterranean people, the Slavs, the Semitic branches, the ancient Egyptians, the Persians, Hindoos, and other dark Aryan races. They are usually brachycephalic, with a round dental arch, and are microdonts,—

i.e., small-toothed,—as are also the Xanthocroids, but the latter are more properly mesodonts,—i.e., of intermediate size. The teeth are small, of fine shape, closely set in a round and graceful arch, of medium color, and rather better organized than those of the light races. The deleterious influence of the luxuries and vices of civilization of course affects them, but among the wilder and stronger branches of the dark race the teeth are

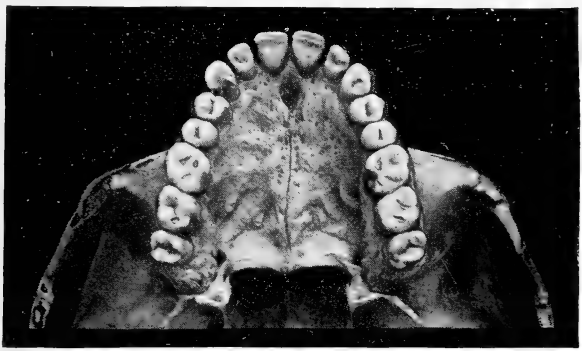


FIG. 85.—Occlusal view of Eurcpean (Caucasian) teeth.

strong and fine. One peculiarity of this type is the tritubercular upper molar which is prone to appear in the Latin races.

The light and dark races of Europe are so interminably intermixed that the ethnic features of all kinds are much confused. In this confusion, the racial characteristics of the teeth have been practically lost beyond identification. The intermarriage of races has resulted in the teeth partaking the characteristics of both types, but in some instances may resemble one or the other or be a blending of both.

Owing to the effects of civilization, the teeth of the higher classes of both the American and European people are often decayed, which is not so much the effect of a weakness of the structure of the teeth as it is the result of unnatural foods and habits.

The teeth are often uneven and crowded in the arches, because of disuse and other constitutional diseases, including diseases of the nose and throat.

The closer the human family approaches the natural methods of life, and the teeth are made to perform their normal functions, the more often do we find a better structure and arrangement of the dental organs. The effect of irregular habits and the feverish pursuit of the elusive so-called pleasures of civilization, and the consequent physical degeneracy have an extraordinary effect on the teeth of all the higher races.

GLOSSARY

Acrodont. Having teeth ankylosed on parapets of bone on the edges of the jaw (as found in some lizards).

Alveolar. Pertaining to the alveoli or sockets of the teeth; as alveolar arch, alveolar border.

Alveolus (Pl. *Alveoli*). The socket of a tooth.

Anisognathous. Having the upper molars unlike the lower in size and pattern.

Ankylosis. The growing together of two bones or parts of bones. Applied to the union of teeth to the jaw-bone.

Arch. The curve made by the upper and lower teeth.

"Aristotle's Lantern." The dental apparatus of Echinus.

Asymmetry. Absence of symmetry.

Axial. Term applied to all surfaces, walls, and lines parallel to the long axis of a tooth.

Basal. Of, pertaining to, situated at, or forming the base.

Bell-crowned. Applied to a tooth crown which is largest at the occlusal surface and tapers toward the cervix.

Biscuspid. The premolar of man (a tooth with two cusps).

Bifurcated. Divided in two in fork form, as the roots of the inferior first and second molars, or in many cases of the superior first biscuspid of man.

Brachycephalic. Having a skull the transverse diameter of which is more than eight-tenths of its long diameter.

Buccal. Toward the cheek.

Bunodont. Tooth crown supporting tubercles.

Calcareous. Composed of or containing lime.

Canine. The first tooth posterior to the intermaxillary suture above and its opponent below.

Canine Cusp. The buccal cusp of the bicuspid.

Caniniform. Formed like a canine,—long, slender and pointed.

Cementum. A tissue resembling bone which covers the outer surface of roots of the teeth.

Cervical. Of, or pertaining to, a neck. Applied to that portion of the tooth where the enamel and cementum unite.

Cervix. The neck of the tooth, the portion grasped by the gum,—between the crown and root.

Chitin. The horny covering of insects and Arthropoda, of which the masticating apparatus of the invertebrates is often composed.

Cingule. A small cusp or tubercle on the lingual face of a tooth.

Cingulum. The ridge or tubercle on the lingual face of a tooth near the gum.

Coalescence. The structural union of like parts, as the coalescence of the roots of a tooth.

Complex Crown. A tooth crown composed of two cones (as the bicuspids) or of three or more cones (as the molars).

Cone. The mechanical element of the tooth crown.

Cone-shape. Teeth formed of one cone only,—as the teeth of fishes and reptiles and the canines of mammals.

Coronal. Of or pertaining to a crown. Applied by some to the occlusal surfaces of teeth.

Coronoid. Having a crown-like form.

Crests. The sinuous cusps or enamel ridges on the grinding faces of the molars of herbivora.

Crown. That portion of the tooth which is exposed above the gum.

Crucial. Having the form of a cross.

Cusp. A sharp eminence on the occlusal surface of a tooth crown.

Cuspid. A tooth with one point or cusp,—the canine.

Cuspidate. Formed of or like one or more cusps.

Deciduous. Liable to be shed at periodical or certain stages of growth; as antlers, hair, teeth. Applied to the first series of teeth of young mammals, which are replaced by the permanent set.

Dens Sapientiæ. The third molar, the wisdom tooth of man.

Dental. Referring or pertaining to the teeth.

Denticles. Shapeless calcareous bodies which serve the purposes of teeth.

Denticulate. Furnished with small teeth.

Dentigerous. Bearing or supporting teeth,—supplied with teeth; also containing teeth, as a dentigerous cyst.

Dentin. The calcified tissue that forms the main portion of the teeth.

Dentinal. Referring to the dentin.

Dentinoid. Having the form of a tooth.

Dentition. The eruption of the teeth.

Deuterocone. The mesio-buccal cone of the upper premolar.

Deuteroconid. The mesio-buccal cone of the lower premolar.

Diastema. A space between the teeth,—especially the space between the upper lateral and canine into which the lower canine closes in the carnivora, quadrumana, etc.

Diphyodont. An animal having two sets of teeth, both the deciduous and the permanent.

Distal. Away from the median line of the face (following the curves of the dental arch).

Docoglossa. Plate or chevron formed teeth of mollusks.

Dolichocephalic. Having a long skull, the breadth being less than 75 per cent. of its length.

Ecderonic. Applied to structures derived from the upper epithelial layers of the derm, as hair, chitin, enamel, etc.

Elastic Hinge. A device found in fishes and reptiles, by which the teeth can be pushed over and then sprung back to hold prey.

Enamel. The calcified epithelial tissue covering the crowns of teeth.

Enderonic. Applied to structures derived from the lower layers of the derm, as dentin.

Entoconid. The linguo-distal cone or cusp of the posterior heel or talon of the lower molars.

Epithelium. The superficial layer of cells of mucous membranes. A very delicate membrane forming the outer covering of the corium or true mucous membrane, and which enters into the structure of glandular organs.

Fang. The root of a tooth.

Fibrous Membrane. The membrane which carries the teeth of sharks and rays.

Foramen. A passage perforating tissues (usually bone) and transmitting vessels or nerves; e.g., the apical foramen of the root of a tooth.

Fossa. A round or angular shallow depression in the occlusal surface of bicuspids and molars, and the lingual surface of incisors and canines.

Ginglymoid. Hinged, as the jaw articulation of the carnivora.

Gluten. The organic basis of bone, dentin, etc.

Gomphosis. Attachment of the teeth by implantation in a bony socket or alveolus.

Gothic (arch). Of or pertaining to the pointed types of mediæval architecture, as Gothic arch. Applied to teeth arranged in a Gothic arch.

Haplodont. Having undivided or simple tooth crowns.

Heterodont. The teeth being heterogeneous or unlike forms in the same jaw.

Homodont. The teeth being homogeneous or similar forms throughout the same jaw.

Hypocone. The disto-lingual cone of the upper molars.

Hypoconid. The disto-buccal cone (or cusp) of the lower molars.

Hypoconulid. The distal cusp—the fifth tubercle—of the lower molar.

Incisor. A tooth with a cutting edge,—from incise, to *cut.* The anterior teeth above located in the intermaxillary bones (whatever their shape), and their opponents below in the anterior portion of the lower jaw.

Isognathous. Having upper and lower molars of same size and pattern.

Kreatin (or Creatin). The organic, epithelial basis of horn, hair, enamel, etc.

Labial. Pertaining to or toward the lips.

Lateral (incisor). The second incisor from the median line.

Lenticular Jaws. The serrated maxillæ of the leech and other worms.

Lingual. Situated near or toward the tongue, as the lingual surface of a tooth.

Lobe. A division of a tooth crown formed from a distinct point of calcification.

Lophodont. Summit of a tooth crown thrown into transverse or longitudinal folds.

Macrodont. Having large teeth.

Mandible. The lower jaw.

Mastax. The muscular pharynx of a rotifer, containing the jaw parts.

Mastication. The process of comminuting the food with the teeth—synchronous with insalivation.

Maxilla (Pl. *Maxillæ.*) The upper jaw or jaw-bone.

Maxillary. Of or pertaining to a jaw or jaw-bone.

Median. Middle, as the median line of the body.

Mesial. Toward the median line of the face (following the curve of the dental arch).

Mesocephalic. A term applied to a skull having a capacity between 135 and 145 c.c.

Mesodont. Having medium sized teeth.

Mesognathous. Having a moderate or intermediate gnathic index of from 98 to 103—as a skull.

Metacone. The disto-buccal cone (or cusp) of the upper molars.

Metaconid. The mesio-lingual cone (or cusp) of the lower molars.

Microdont. Applied to small-toothed races.

Molar. A grinding tooth with multi-cusped crowns.

Monophyodont. An animal having but one set of teeth, i.e., the first set not being shed, but remaining permanently.

Multitubercular. A tooth crown having many tubercles.

Neck. The narrowest part of an object; the junction of crown and root of a tooth.

Oblique Ridge. The ridge running obliquely across the occlusal surface of upper molars, from the mesio-lingual tubercle to the disto-buccal. (It is the marginal ridge of the primitive tritubercular molar.)

Occlude. To strike against, as the striking of the upper with the lower teeth.

Occlusal. Applied to the grinding surface of the teeth.

Odontogeny. The generation or origin and development of the teeth.

Odontography. A description of the teeth.

Odontophore. The strap-like organ of mollusks which carries the teeth.

Orthognathism. Having perpendicular facial lines, i.e., near 90°; as the European races.

Paracone. The mesio-buccal cone (or cusp) of the upper molars.

Paraconid. The mesio-lingual cone (or tubercle) of the lower molars, which has been lost in man and some other mammals.

Permanent Teeth. Those teeth which appear in childhood and are retained as the teeth of adult age.

Placoid. Plate-like, as the scales and some kinds of teeth of sharks and rays.

Pleural. Pertaining to a pleuron or lateral part. Applied to the lateral rows of teeth on the odontophore.

Pleurodont. Having teeth attached by ankylosis to the sides of the dental groove, as in some reptiles.

Premolars. The succedaneous grinders between the canines and true molars in mammals (called bicuspids in man).

Prognathism. A projecting lower jaw, and a facial angle below 75°.

Protocone. The primitive reptilian cone of an upper molar, i.e., mesio-lingual cusp; also the buccal cusp or cone of an upper bicuspid or premolar, etc.

Protoconid. The mesio-buccal cone (or cusp) of a lower molar; also the mesio-buccal cone of a lower premolar.

Ptenoglossa. A group of gasteropods having teeth only on the sides of the odontophore, but no middle row.

Ptychodont. Tooth crowns folded on the sides, sometimes across the crown.

Pulp. The soft tissue of vessels and nerves which fills the pulp-chambers and root-canals of a tooth; the remnant of the formative pulp.

Pulp-canal. That portion of the pulp-cavity traversing the roots of teeth from the apical foramina to the bottom of the pulp-chambers.

Quadritubercular. Teeth having four tubercles.

Quinquetubercular. Teeth having five tubercles.

Rachidian. Pertaining to the rachis or axis. Applied to the central rows of teeth on the odontophore.

Radula. The dentary organ of mollusks.

Raphidio-glossa. Needle-shaped teeth on the odontophore.

Ridge. A long elevation on the surface of a tooth crown.

Root. That portion of the tooth which is inserted in the alevolar process.

Root-canal. A canal in the center of the long axis of the root which contains the branches of the pulp.

Rugæ. Folds or creases. Applied to the irregular ridges of the membrane of the roof of the mouth.

Scalpriform Incisors. The cutting incisors of the rodents and other mammals.

Sectorial Teeth. The cutting teeth of the Carnivora, the long-bladed premolars and molars.

Selenodont. Having longitudinal crescent-shaped ridges, as a molar tooth.

Septum. A partition of the alveolar process which separates the alveoli.

Stomacholiths. The calcareous plates found in the stomach or gizzard of crustaceans, which carry cusped or molar-like eminences.

Succedaneous. Those teeth of the permanent set which succeed or take the places of the temporary teeth.

Sulcus (Pl. *Sulci*). A long, narrow channel, or furrow; a groove. Applied to narrow depressions and grooves on the surfaces of teeth.

Supernumerary. Having more than the usual or normal number.

Symphysis. The coalescence or junction of bones, usually of symmetrical bones in the median line.

Tœnio-glossa. A kind of gastropod having bent teeth on the odontophore.

Talon. The linguo-posterior prominence or heel of an upper molar crown, bearing the hypocone.

Talonid. The heel, or disto-buccal portion, of a lower molar crown, bearing the entoconid, hypoconid, and hypoconulid.

Tetartocone. The linguo-internal cone; the fourth cusp of the upper premolar.

Tetartoconid. The linguo-internal cone of the lower premolar.

Theca. Pertaining to a sheath or case.

Thecodont. Having fangless teeth, as a lizard.

Tooth (Pl. *Teeth*). A specialized dermal structure, situated in the oral cavity, containing a calcified osseous tissue called dentin.

Toxoglossa. Mollusks having arrow-shaped teeth.

Transverse Ridge. A ridge extending across the crown of a molar.

Triangular Ridge. The ridge running down from the point of a cusp or tubercle toward the center of the crown.

Triconodont. Having three cones in a line.

Trigon. A triangle. Applied to the first three cones of an upper molar.

Trigonid. The first three cones of a lower molar.

Trigonodont. A tooth having three cones in a triangle.

Tritocone. The mesio-buccal cone of the upper premolars.

Tritubercular. Having three tubercles upon the occlusal surface.

Truncate. Cut off or terminated abruptly.

Tubercle. A small rounded eminence on the occlusal surface of a molar; a cusp.

Tusk. A prominent incisor or canine which protrudes some distance beyond the lips.

Ulcini. The external teeth on the odontophore.

INDEX

INDEX

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