Comparative Dental Anatomy of Mammalians

CONTENT

INTRODUCTION

Types of Dentition

Rodentia

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Carnivora

Primates

- Importance of dentition
    - Helps in tracing evolution
    - Helps in classification
    - Gives an idea of approximate age of the mammal
    - Provides clue to the diet of mammal

Structure of tooth

- In mammals – tooth is firmly fixed in a socket in the jaw-bone, hence called **thecodont**
- Some portion lie within jaw-bone & some portion lies outside it.
- Typical mammalian tooth has 3 regions – a **crown**, a **root** & a short **neck** between them
- Tooth is made up of **dentine**, & coated with **enamel** on the crown & with **cement** in the root.

Structure of tooth

- Gum covers neck region
- Pulp cavity inside tooth with gelatinous connective tissue or pulp containing blood vessels and nerves
- In incisors of **elephants and rodents**, pulp cavity remains open basally so that teeth continue growing throughout life and termed **open rooted**
- In **other mammals**, pulp cavity becomes closed at a certain age so that nourishment stops and further growth stops : **close- rooted**

Types of mammalian teeth

- Heterodont
  - Dissimilar in shape and size (all other vertebrates-homodont)
  - Incisors, canines, premolars & molars

- Diphyodont (most mammals)
  - Two sets of teeth in life history
  - 1^{st} set – deciduous/lacteal/milk teeth
    - They erupt usually after birth (in guinea pigs & bat, they form and shed even before birth)
    - Deciduous dentition has no premolars
    - If lost they are not replaced
  - In platypus, whales, moles, etc there is only one set of teeth throughout life - **monophyodont**

- The *reptilian or haplodont* stage - the simplest form of tooth, i.e. the single cone.

1. This type of dentition includes many teeth in both jaws that limit jaw movement.
2. There was no occlusion of the teeth in this class, the teeth being used mainly for prehension or combat.
3. The limitation of jaw relation was confined to that of a simple hinge movement.

- The *mammalian or triconodont* stage - three cusps in line with the development of posterior teeth.

1. The largest and the original cusp, were centred with a smaller cusp located anteriorly and other cusp centred posteriorly.
2. Some teeth in some breeds of dogs and other carnivores had some teeth that indicate a triconodont background.

- The dog and the other animals carnivorous by nature are considered to be in the third category, namely the, *tritubercular class*

- The multiplication and fusion of lobes during tooth development were demonstrated when human teeth are viewed from the mesial or distal aspect.
- Anterior teeth which are used for incising or apprehensing food, reflect the single cone; whereas, the posterior or multicusp teeth, which are used for grinding food in addition to the shearing action, appear to be a fusion of two or more cones.
- Each “lobe” represents a primary centre of formation.
- The anatomical and anthropological crown is conical in shape, and is composed of a single cone or lobe. This type of tooth was common in primitive vertebrates, and today is exhibited by many of the lower vertebrates, including the reptiles.
- These animals are homodonts, with similarly shaped teeth differing only in size. Since jaw movement is directly related to tooth form, these animals possess only up and down (or hinge action) jaw movements, because the single conical cusps lock together on closure, not allowing lateral movements.
- Unlike the lower vertebrates, which are generally homodont, mammals exhibit different tooth forms, and thus are heterodont in nature

- Teeth present in all mammals except the following
- Platypus
    - Embryonic teeth are replaced in adult by horny epidermal plates for crushing molluscs
- Whale –bone whales
    - Foetal teeth are replaced in adult by baleen plates for straining the planktonic food
- Ant-eaters
    - Teeth not present even in early stages

Incisors

- Front teeth borne by the premaxilla in upper jaw & by the tips of dentaries in lower jaw
- Single rooted & monocuspid
- Used for seizing and cutting
- In rodents (rabbit) incisors are open rooted – continue to grow- have a sharp edge & chisel like form – for cutting and gnawing
- In lemurs – incisors are denticulate like a comb- for cleaning fur
- In elephants – upper incisors are greatly elongated to form two large tusks – contains entirely of dentine, there being no enamel coating
- In sloths, incisors are totally absent
- In ox they are lacking on upper jaw

long open-rooted orangish maxillary incisors of a guinea pig (Cavidae)

- Canines
  - Simple conical tooth with single root
  - Occurs outside the incisors
  - Well developed in carnivores
  - Absent in herbivores (diastema – space)
  - Monocuspid crown – for tearing body of prey
  - Long and sharp in cats and dogs
  - Upper canine form tusks in Walrus for digging molluscs and for locomotion in ice

- Cheek teeth
  - Premolars and molars
  - Have more than one cusp and more than one root
  - Premolars have two roots and two cusps
  - Molars have more than two roots and several cusps
  - Cheek teeth – for crushing, grinding and chewing
  - In man – last molar is called wisdom tooth – erruption may be delayed (18 yrs age to 22 yrs)
  - In carnivores – last premolars in upper jaw and first molar in lower jaw are called carnassial teeth – have very sharp cusps for cracking bones and shearing tendons

Various types of cheek teeth

- Triconodont
  - Have 3 cones in a straight line – fossil mammals
- Trituberculate
  - 3 cusps in the form of a triangle – primitive type in fossil mammals
- Bunodont
  - Low conical cusps meant for crushing in mammals with a mixed diet– monkey, man, pigs
- Lophodont
  - Cusps are connected by several transverse ridges called lophos – adapted to grind all sorts of plants – in elephants
- Selenodont
  - Molar teeth with vertical crescent-shaped ridges – camel
- Brachyodont
  - Molar teeth with low crowns and short roots – cow
- Hypsodont
  - Molar teeth with high crowns and short roots – horse
- Secodont- Cusps having sharp cutting edges for tearing and cutting fleshes - carnivores

Modifications of teeth according to the diet

- Herbivorous mammals
  - Canines are reduced/absent leaving a gap called diastema
  - Cheek teeth are broad with transverse ridges – elephant
- Insectivorous mammals
  - Upper & lower incisors are elongated & form a pair of forceps to catch insects (hedgehogs & moles)
- Plankton feeding mammals
  - Teeth are lost and replaced by numerous horny plates called baleen plates (whale-bone whales)
- Piscivorous
  - Teeth are similar, recurved and conical – to hold the slippery fish-dolphin
- Carnivorous
  - Incisors are small and canines elongated and pointed – dogs, bears, cats, etc

Dental formula

- I, C, PM and M
- Teeth on each half of upper & lower jaws are expressed in dental formula

Cat – $\frac{3.1.3.1}{3.1.2.1}$

Rabbit – $\frac{2.0.3.3}{1.0.2.3}$

Elephant – $\frac{1.0.0.3}{0.0.0.3}$

Cat

Dental Formula: I=3/3 C=1/1 P=3/2 M=1/1

Dog – 3.1.4.2

3.1.4.3

Rat – 1.0.0.3

1.0.0.3

Squirrel

Fox

Dental Formula: I=3/3 C=1/1 P=4/4 M=2/3

Evolution of teeth

- Trituberculate theory of Cope & Osborn
  - A trituberculate molar tooth evolved from a simple conical reptilian type tooth by the development of two more cusps
  - In the process of development of this condition, at first three cusps arouse in a line, (triconodont pattern) and then became arranged in a triangular form by a rotation of these cusps
  - This tooth might have given rise to several other patterns
- Concrescence theory of Rose
  - Molar tooth has evolved by the fusion of a number of simple conical teeth like of reptiles
  - This theory has only theoretical value and hence discarded

Subtitle

1. Single cone (haplodont)

2. Three cusps in line (triconodont)

3. Three cusps in a triangle (tritubercular molar)

4. Four cusps in a quadrangle (quadritubercular molar)

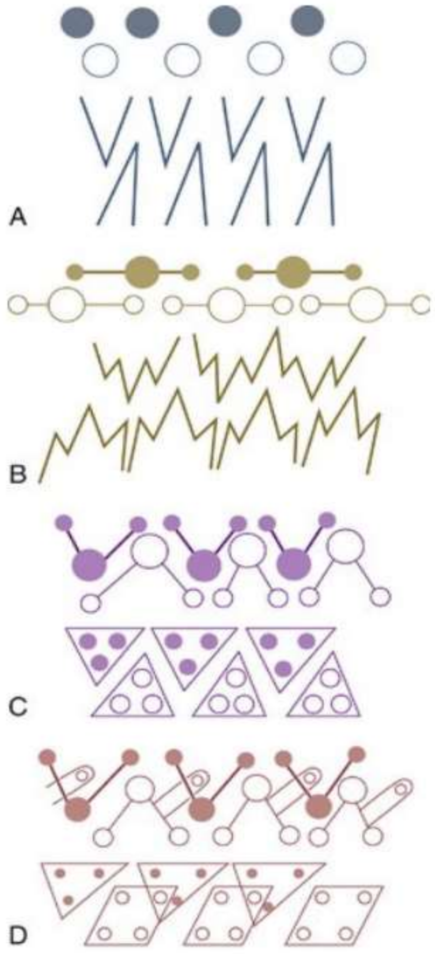


Figure 4-2 Classification of cusp forms. **A,** Haplodont. **B,** Triconodont. **C,** Tritubercular molar. **D,** Quadritubercular molar. The solid black dots represent upper molar cusps. The circles represent lower molar cusps.


HOMODONT


POLYPHYODONT

The haplodont class is represented schematically by the simplest form of tooth, the single cone (Figure 4-2, *A*). This type of dentition usually includes many teeth in both jaws and is seen where jaw movements are limited to simple open and close (hinge) movements (Figure 4-3). No occlusion of the teeth occurs in this class, since the teeth are used mainly for prehension or combat.26,27 Their main function is the procurement of food. Jaw movements are related to and governed by tooth form in all cases.

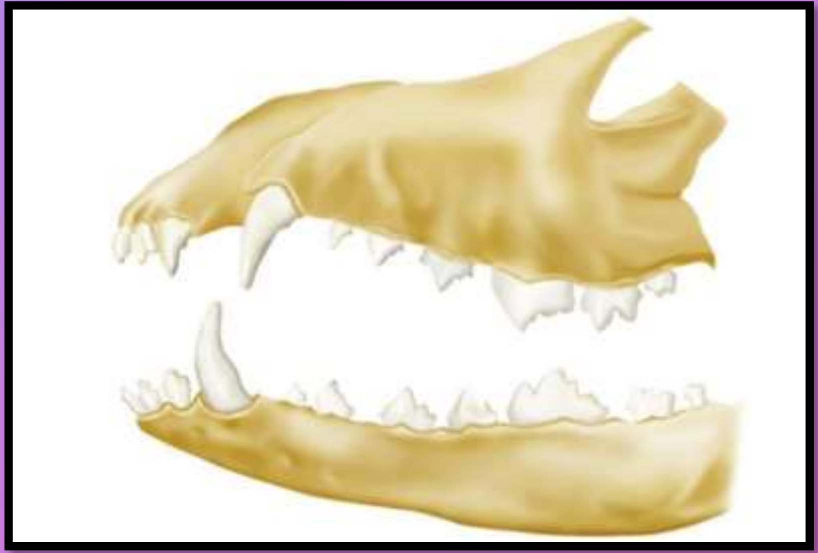
The triconodont class exhibits three cusps in line in posterior teeth as indicated in Anthropologically, the largest cusp is centered with a smaller cusp located anteriorly and another posteriorly.

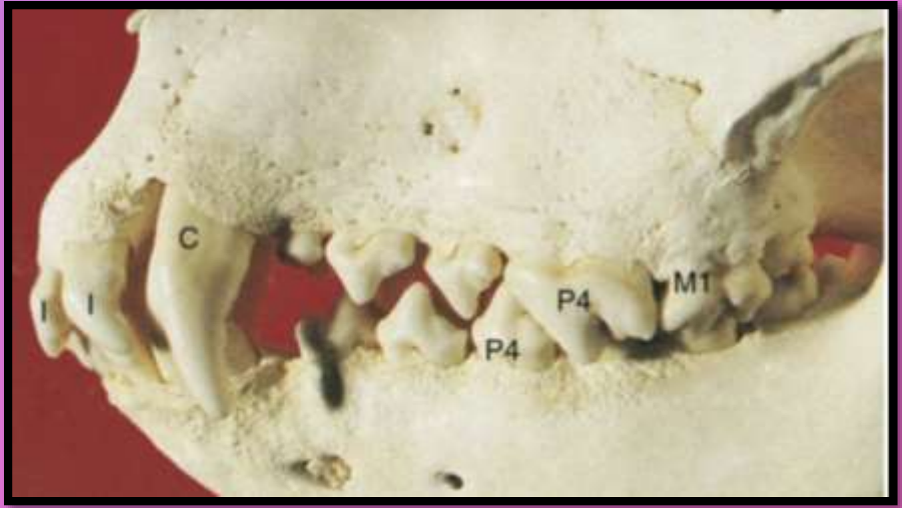
Purely triconodont dentitions are not seen, although certain breeds of dogs and other carnivores have teeth reflecting the triconodont form .

Nevertheless, dogs and other animals carnivorous by nature are considered to be in the third category namely, the tritubercular class

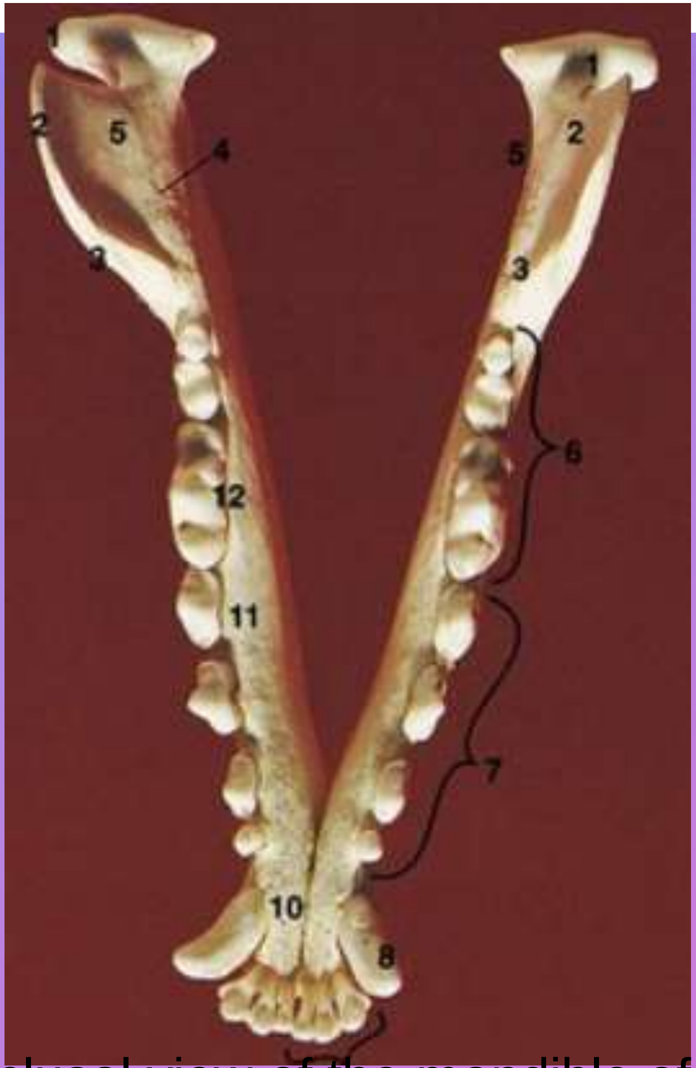
The three-cusp arrangement of the triconodont class and the more efficient three-cornered tritubercular molar arrangement are both consistent with the teeth's bypassing each other more or less when the jaw is opened or closed.

However, the quadritubercular class reflects an occlusal contact relationship between the teeth of the upper and lower jaws. Articulation of the jaws and teeth is consistent with jaw movements and functions of these classes of teeth.





Jaws of a dog (collie). The premolars are tritubercular and widely spaced; the upper carnassial (fourth premolar, P_4) articulates with the lower carnassial (first molar, M_1). *I,* Incisor; *C,* canine.

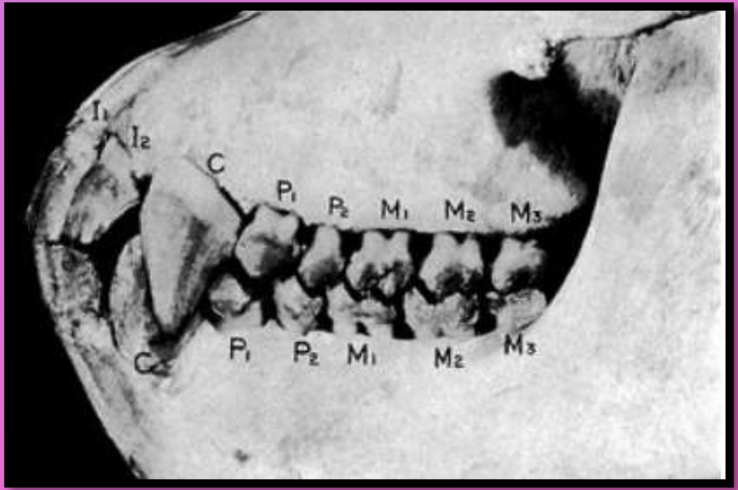


Animals that have dentitions similar to that of humans are anthropoid apes. This group of animals includes the chimpanzee, gibbon, gorilla, and orangutan .

The shapes of individual teeth in these animals are amazingly close to their counterparts in the human mouth. Nevertheless, the development of the canines, the arch form, and the jaw development are quite different.

Occlusal view of the mandible of a dog (collie).

The mandible is long and slender. The cutting edges of the four premolars and three molars are arranged in a sagittal plane.



Occlusal view of the upper jaw of an orangutan.

The arch is square, and the canines, premolars, and molars stand in a straight sagittal line. Note the diastema between lateral incisor and canine.

- **Bilophodont: -** Teeth having two ridge e.g. Tapir .
- **Polylophodont:** - Teeth having more than two ridges e.g. Elephant.
- **Bunodont: -** Tooth crown supporting tubercles or cones e.g. pig
- **Selenodont: -** Bicrescentic teeth elongated before backward e.g. Ox.

Tapir .
- **Polylophodont:** - Teeth having more than two ridges e.g. Elephant.
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Rodentia

- The rodent specimens comprised of rats (Muridae), rabbits (Lagomorpha), squirrel (Sciuridae) and guinea pigs (Caviidae).
- The rodent dentition is “monodont” indicating that they have only one set of dentition throughout their life except for rabbits and some species of squirrels.
- The characteristic features of rodent dentition observed were two long incisors placed centrally, one on each side of the midline of each jaw.
- The incisors exhibit variations in color from white to yellowish to orange

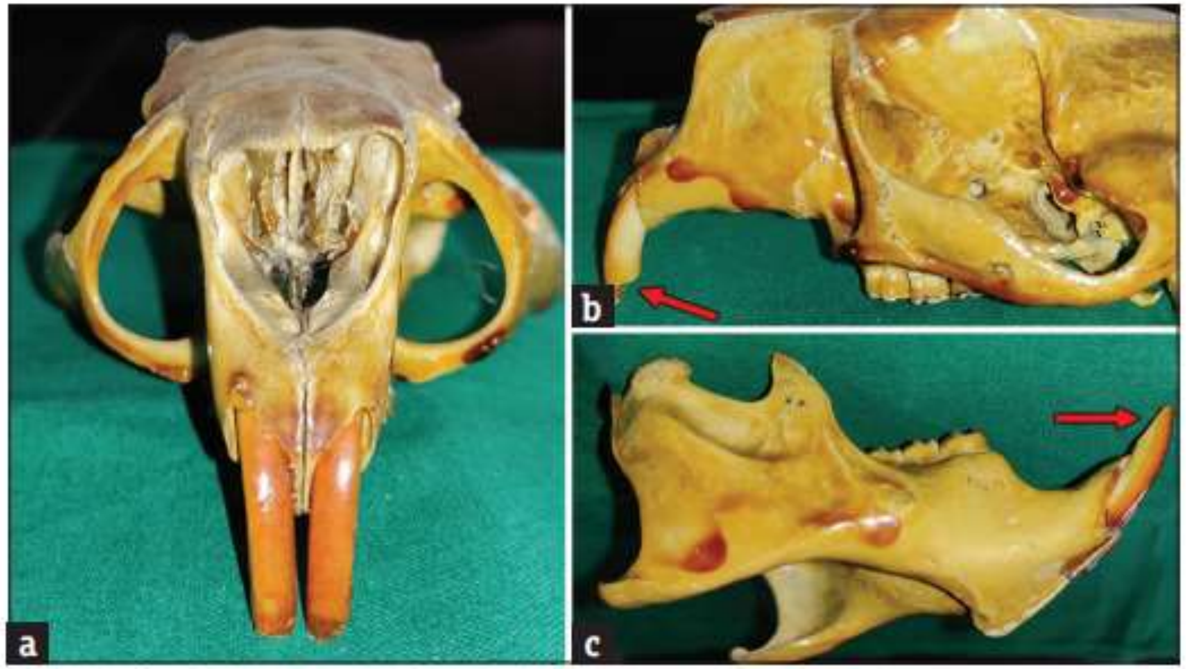
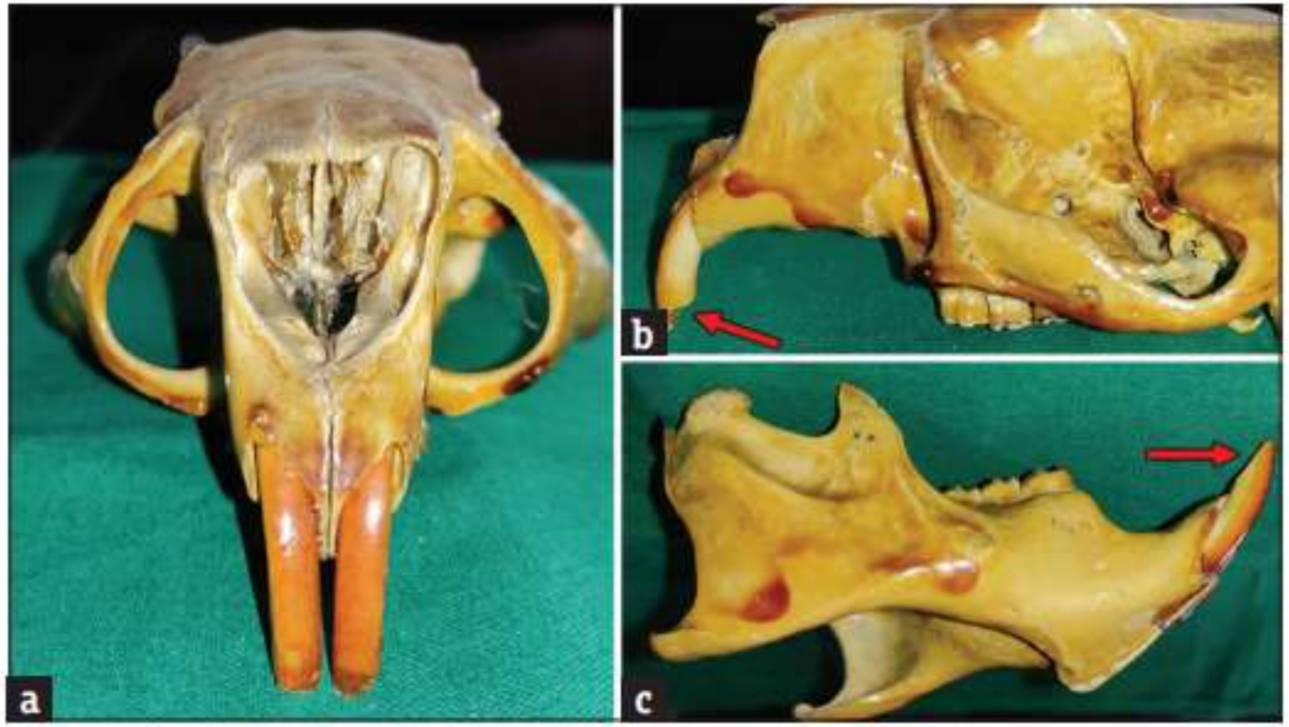


Figure 1: (a) View of long open-rooted orangish maxillary incisors of a guinea pig (Cavidae) from labial aspect. (b) Lateral view of guinea pig (Caviidae) maxillary dentition. Arrow denotes thegotic facets noted on chisel-shaped incisal edge. (c) Lateral view of guinea pig (Caviidae) mandibular dentition showing more proclined incisors

Rodentia

- Incisor are open-rooted and termed as “elodont
  since they grow continually.
- Due to constant gnawing, the incisal thirds of these incisors present with “thegotic facets”or “chisel-shaped” edges with a labial portion more preserved which was observed in all the specimens, owing to the presence of enamel.
- All the incisors showed proclination as they emerged from the alveolus.
- However, the upper incisors appeared to curve back, and a nearly perpendicular line could be drawn from their point of emergence to the incis edge.



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Rodentia

- The incisors were followed distally by the presence of large diastema bilaterally, the span of which was greater for maxillary arch than the mandibular arch.
- The combined anteroposterior dimension of diastema on both sides was five times the combined mesiodistal width of both the incisors.
- This dimension was slightly less than half of the total arch perimeter, except in rabbits and squirrel, where it was more than half of the arch perimeter, indicating that the diastema forms a major component of the arches.
- Their function is primarily to hold the food in readiness for subsequent grinding between the molars and are also said to contain vestigial tooth primordia.
- Posteriorly, three “anelodont” molars (having limited growth) were present in most of the species while some specimen exhibited “hypselodonty,” i.e., tall crowns with continual growt.
- The molars were generally attrited and exhibit enamel crests with dentinal grooves in between forming a sigmoid or zig-zag pattern and thus, such rodents are termed as “sigmodont.”

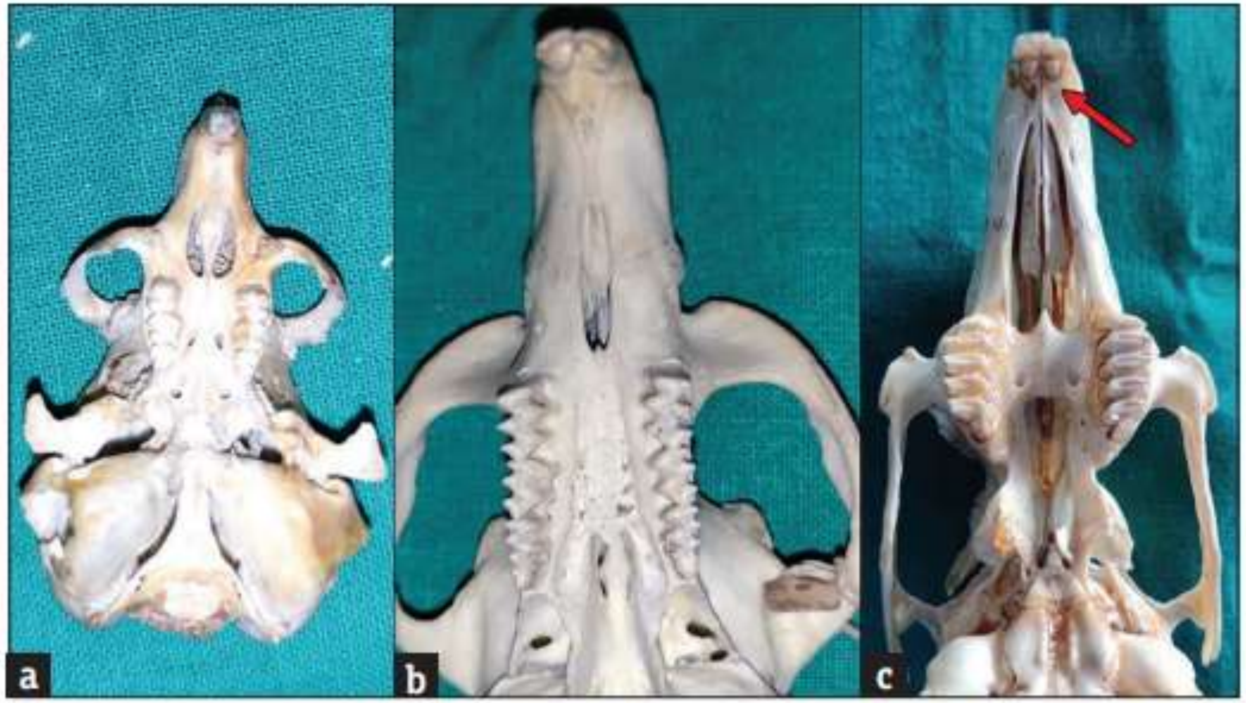

Figure 2: Images of maxillary dentition from occlusal aspect of (a) Squirrel (Sciuridae) having anelodont molars. (b) Rat (Muridae) presenting zig-zag pattern formed by ridges when viewed from occlusal aspect. (c) Rabbit (Lagomorpha) possessing additional pair of incisors i.e. peg teeth on the lingual aspect of maxillary central incisors (indicated by red arrow) and a pair of premolars anterior to the molars

Artiodactylae and perissodactylae

Commonly known as the “ungulates,”

The specimens comprised of horses (Equinae), camels (Camelidae), cattle (Bovidae) and boar (Suidae), deer (Cervidae)

“diphyodont”

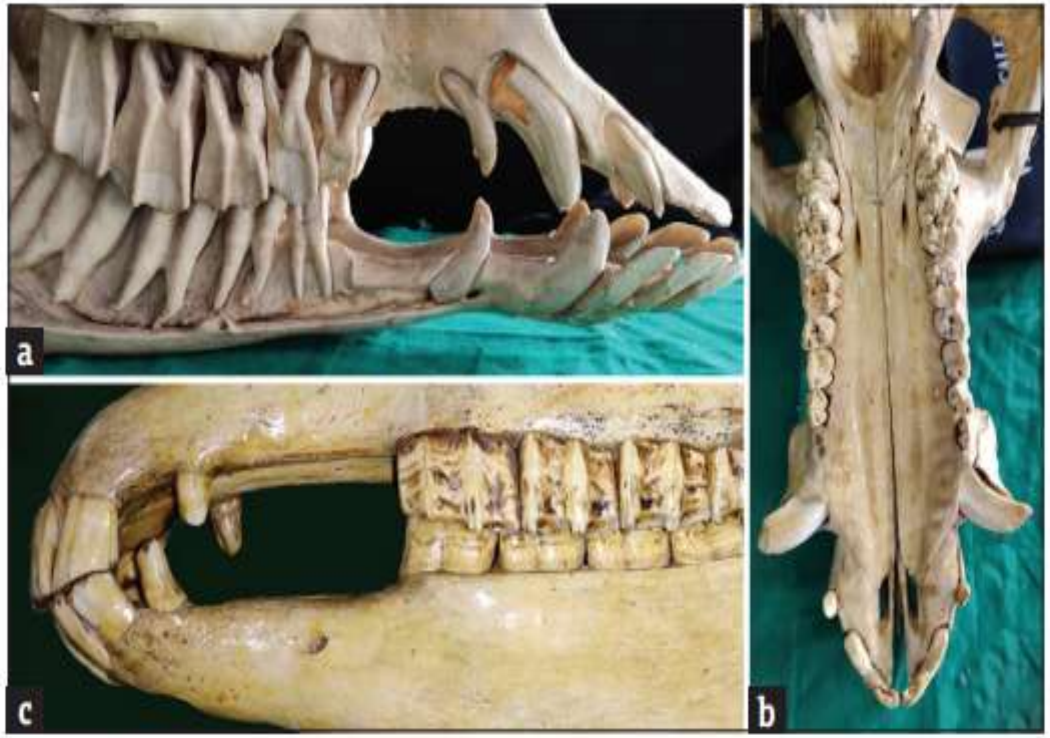

Figure 3: (a) Dentition of camel (Camelidae) exhibiting hypselodont teeth. (b) Maxillary dentition of boar (Suidae) exhibiting large prominent canines and bunodont molars. (c) Dentition of horse (Equine) exhibiting edge-to-edge relation of incisors and smaller canines

Horses and boars possess three pairs of maxillary incisors, whereas, camels have only two pairs with a wide midline diastema having thick gum pads.

The incisors are acutely proclined are followed by large sharp canines in boars and camels that help them dig wood and thick bushes.

The incisors in the equines curve, had an edge-to-edge relation

while the canines, separated by a diastema from the incisors, were short and not so well-developed “lophodont,”i.e., transverse ridges on the grinding surfaces rather than well-developed cusps

Tubercles or low rounded cusps, which was observed in some species (e.g. Suidae), termed as “Bunodont”.

specimens of some species (e.g. Bovidae) had molars with short crown referred to as “brachydont”.

Crescent-like ridges were observed on the occlusal surface on posterior teeth running anteroposteriorly, approximately linked to each other.

Thus, the teeth are also termed as “selenodont” which is another characteristic of artiodactylae and perissodactylae

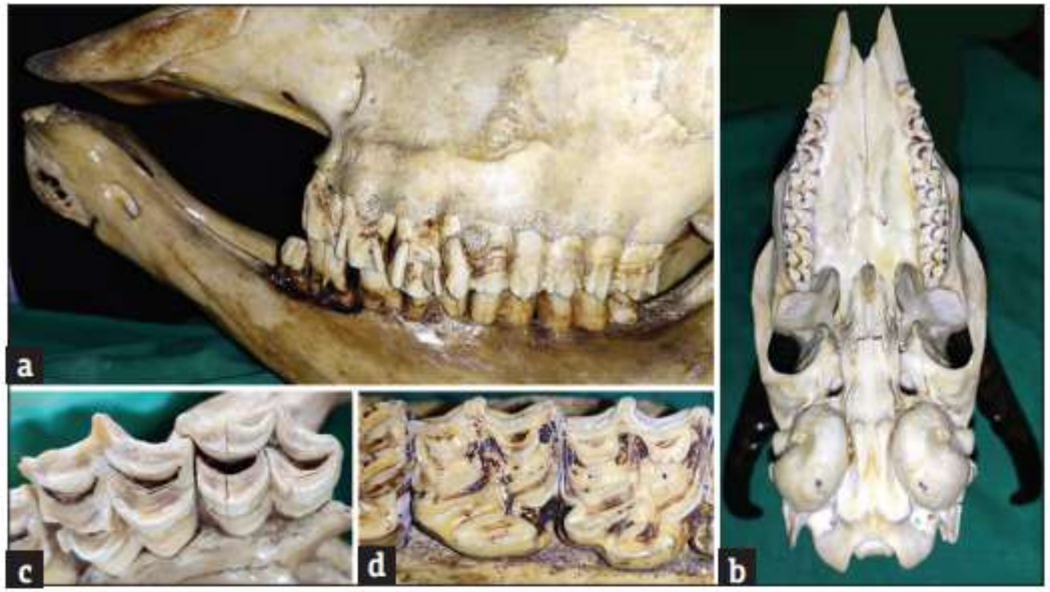

Figure 4: (a) Dentition of cattle (Bovidae) having absent maxillary anterior teeth with attrided mandibular anteriors. (b) Maxillary dentition of deer (Cervidae) exhibiting absence of maxillary anterior teeth and selenodont molars (c) Selenodont molars having crescent-shaped grooves on the occlusal aspect. (d) Equine molars exhibiting complex pattern of occlusal ridges and grooves

Canidae

Dog bites

Three pairs of relatively small incisors were present.

characterized by large and prominent canines with V-shaped elongated arches that were narrow anteriorly.

These were followed by the canines in the mandibular arch, while in the maxillary arch, they were followed by a diastema that accommodates the mandibular canine when the mouth is closed

The mandibular canines - a more curved architecture.

Distal to the canines, a relatively larger span of diastema was present, the function of which could be primarily to hold the food while the animal tears it away from its prey.

Four premolars followed this diastema with ascending sizes with the first premolar being the smallest and the fourth premolar being the largest.

The premolars were observed to be “triconodont” having three cusps in line with the central cusp (protocone) being the most prominent and the anterior cusp (metacone) being the smallest

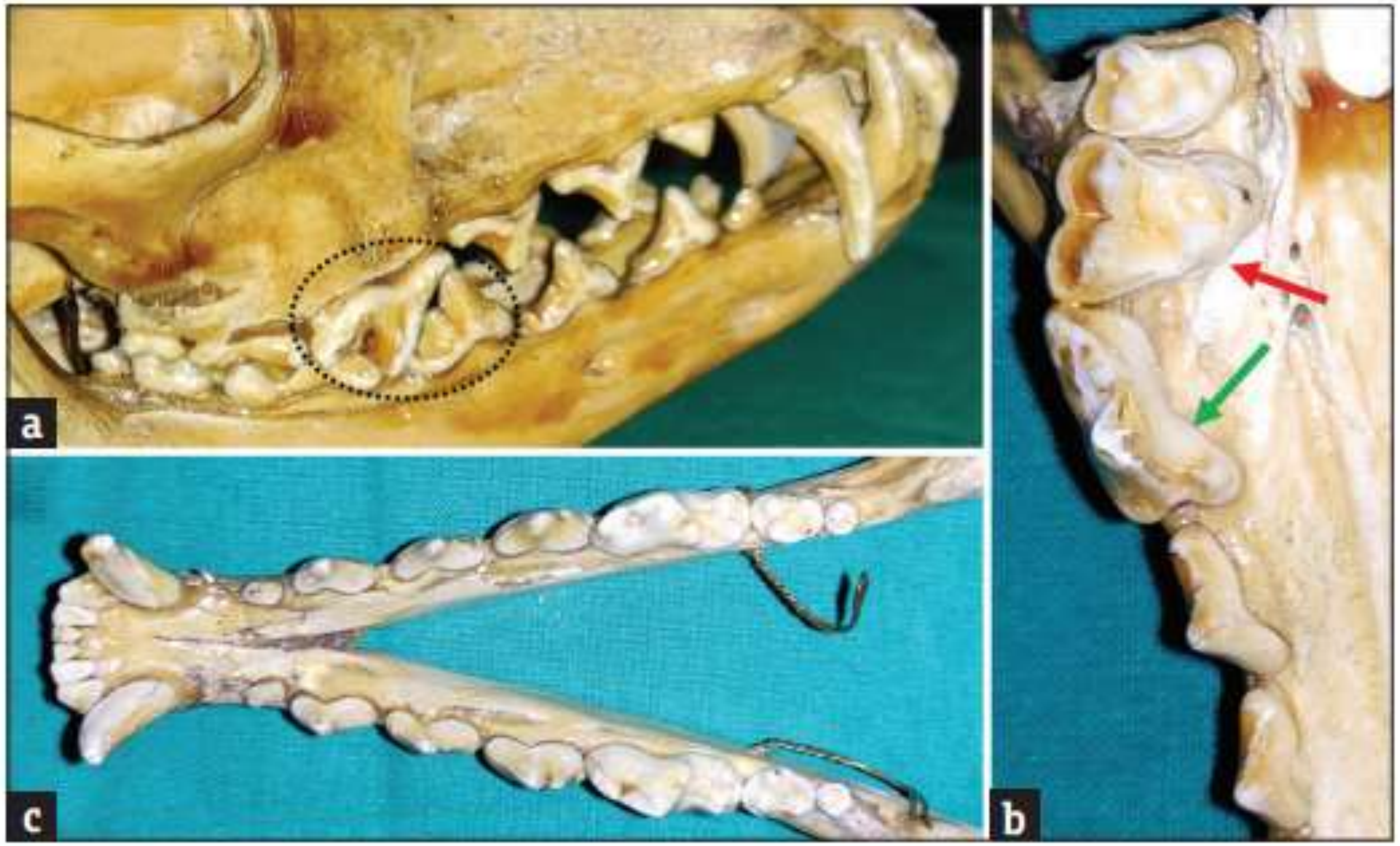

Figure 5: (a) Dentition of a dog (Canidae) from lateral aspect exhibiting triconodont teeth; Carnassial pair indicated by dotted circle. (b) Maxillary posterior teeth of dog (Canidae); Fourth premolar having talonid basin indicated by green arrow; Tribosphenic molars with trigonal outline indicated by red arrow. (c) Mandibular dentition of dog (Canidae) from occlusal aspect

Primates

The specimens primarily belonged to the Hominidae family which are diphyodonts and features of the dentition of specimens excluding the human specimens are described subsequently.

The classes of teeth and the number of teeth belonging to each class were also identical to those of human dentition.

A characteristic feature observed was prominent bimaxillary protrusion with sharp incisors.

maxillary lateral incisors- a distally sloping incisal ridge , making it resemble a canine.

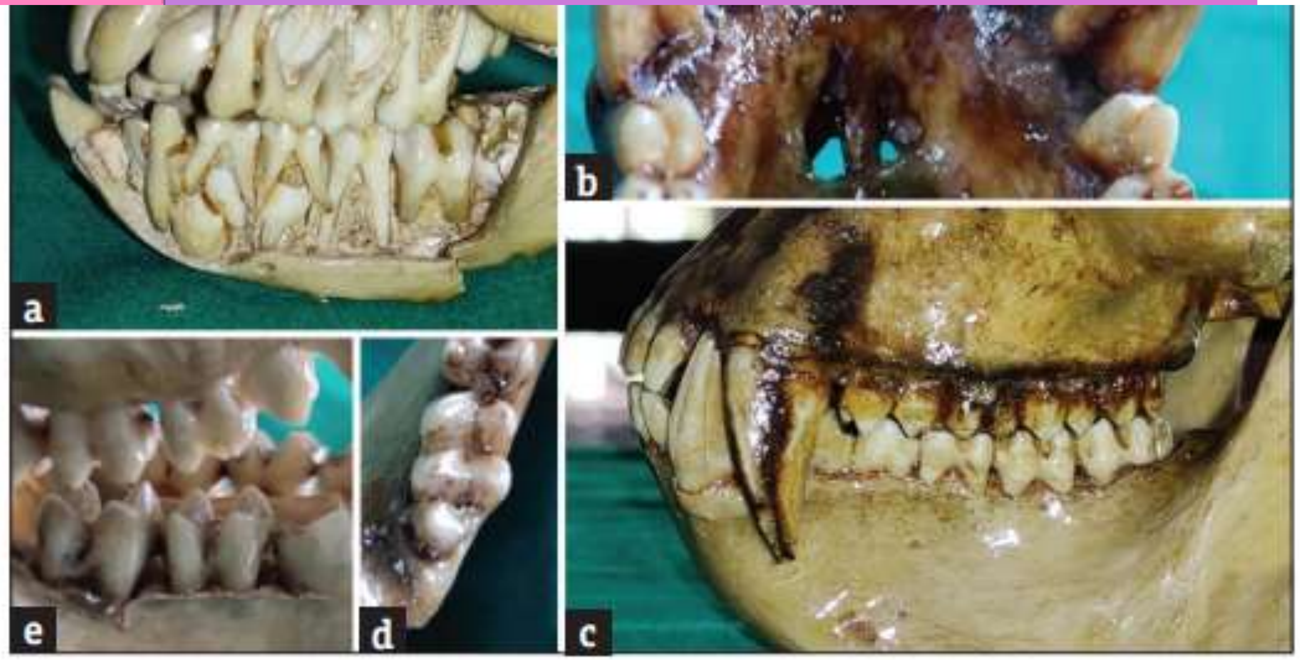

Figure 6: (a) Mixed dentition of a primate exhibiting diphyodonty. (b) Maxillary anterior

The rationale behind various adaptations in different classes of teeth shared commonly amongst various orders of mammals

Incisors	Large Diastema	Canines	Molars
Absent (Maxillary) Seen in: Cattle and Deers Rationale: Presence of thick gum pads instead of incisors suited primarily for grazing	Rationale in Rodents: For holding food in mouth until it is ready to be pushed towards the molars for crushing	Sharp and Proclined In Boars and Camels: Seen in: Boars and Camels Rationale: To dig through tough wood or desert plants	Presence of lophs on occlusal surface - "Lophodont" Seen in: Rodents, Artiodactylae and Perissodactylae Rationale: To dig through tough wood or desert plants
Elongated with open roots - "hypselodonty" Seen in: Rodents, Camel, Horse, Boar Rationale: To keep up with constant attrition throughout lifetime	Rationale in Artiodactylae and Perissodactylae: For holding plant parts in mouth while they are chewed slowly	Large and Sharp Seen in: Canidae and Primates Rationale: To tear through resilient flesh and bones of the prey	"Triconodont teeth" having three cusps aligned in a line Seen in: Dogs Significance: Evolutionary link between primitive reptilian teeth and tribosphenic molars seen in higher mammals
Large and Sharp/Pointed Seen in: Boar, Camel, Male Primates Rationale: Adaptation for coarse and tough diet	Rationale in Canidae: To hold the flesh in mouth after tearing it from the prey Hold the food in mouth while the animal runs away to a safer place	Strong and Prominent In Camels and Primates: Rationale: Adaptation for asserting social domination in Male-to-Male competition	"Dryopithecus" or Y-5 Pattern Seen in: Hominidae Significance: Evolutionary link between primitive reptilian teeth and tribosphenic molars seen in higher mammals

Order	Family	General Dentition Features	Characteristic Tooth Features
Rodentia	Muridae (Rat) Caviidae (Guinea pig) Sciuridae (Squirrel) Lagomorpha (Rabbit)	Monophydonty (except rabbit and squirrel) Long curved incisors followed by a large diastema comprising of half the length of arch perimeter Sigmodont pattern seen from occlusal aspect of molars	Thegotic facets or "chisel- shaped" incisal edges Hypselodont incisors (continually growing with open roots) Orangish incisors due to presence of pigments Anelodont molars i.e limited growth (hypselodont molars in some species) Lophodont molars for grinding
Artiodactylae	Bovidae (Cow) Cervidae (Deer)	Thick gum pads instead of maxillary anterior teeth Large diastema followed by premolars and molars	Hypselodont anterior teeth (except cattle and deer) Lophodont molars with complex pattern of lophs for grinding on tough plant parts
	Camelidae (Camel) Suidae (Boar)	Sharp proclined anterior teeth with diastema present in between Large diastema followed by premolars and molars	Bunodont molars in some species indicating more evolved tooth lobes (e.g Suidae) Selenodont molars
Perissodactylae	Equinae (Horse)	Curved incisors meeting edge-to-edge Short canines followed by diastema	
Carnivora	Canidae (Dog)	Shorter incisors followed by large prominent canines Diastema distal to canines followed by triconodont teeth	Carnassial pair for slicing meat Tribosphenic upper molars suggesting evolutionary link Talonid basin seen in maxillary 4^{th} Premolar and mandibular 1st molar
Primates	Hominoidea (Apes and Monkeys)	Sharper compared to corresponding human teeth Generalised spacing between teeth	Large canines in older species Molars exhibiting Dryopithecus pattern

Conclusion

- Dentition plays a key role in our understanding of mammalian adaptation and the evolution process.
- The characteristic features of dentition can provide valuable information regarding the dietary and social habits of an animal.
- Various species or orders of mammals possess certain similar or linking features that provide insight into their phylogenic or evolutionary relation
- Understanding the comparative dental anatomy of mammals reveals a wealth of information about their evolution, ecology, and behavior.
- This knowledge is crucial for fields like paleontology, veterinary science, and conservation biology.

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Thank you