E-CONTENT PREPARED BY

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(*Affiliated to Kazi Nazrul University, Asansol, West Bengal*)

NAAC Accredited "A" Grade College

(Recognized under Section 2(f) and 12(B) of UGC Act 1956)

E-Content prepared for students of

M.Sc.(Semester-IV) in Conservation Biology

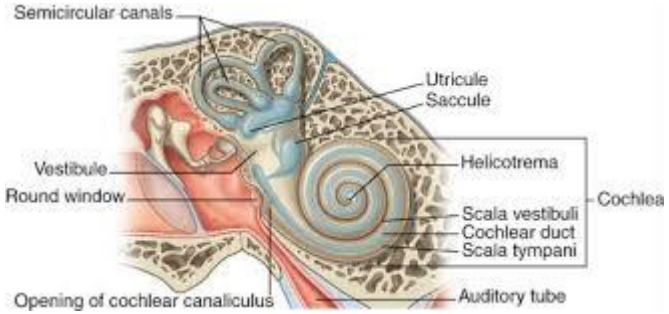
Name of Course:
Forest Wealth (Major Elective)

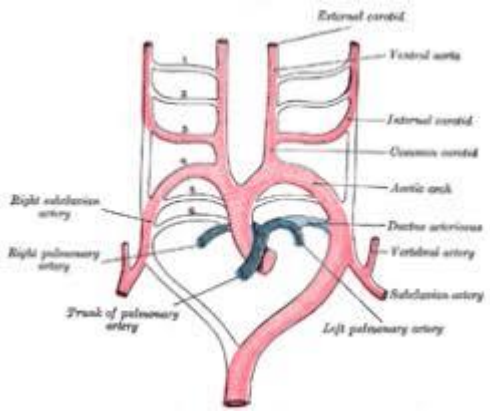
Topic of the E-Content:
Mammals

CLASSIFICATION OF MAMMALS

Definition of Mammals:

- Mammals can be defined as ‘highly percipient and mobile animals, with large brains, spiral cochlea, warm blood, left aortic arch, usually hairy skin, whose young are born alive, and are nourished by milk.


Semicircular canals
Utricule
Saccule
Vestibule
Round window
Helicotrema
Cochlea
Scala vestibuli
Cochlear duct
Scala tympani
Opening of cochlear canaliculus
Auditory tube

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General Characters of Mammals:

- 1. Body of mammals is covered by epidermal hair.
- 2. Integumentary glands are — sweat (sudoriferous), sebaceous (oil), scent (odoriferous) glands.
- 3. Mammary glands are present to supply milk for the nourishment of suckling young.
- 4. External fleshy pinna is present in mammals.
- 5. Eyes with upper and lower eyelids and often with eyelashes.
- 6. Nictitating membrane is translucent and hairless; it is vestigial in higher mammals.


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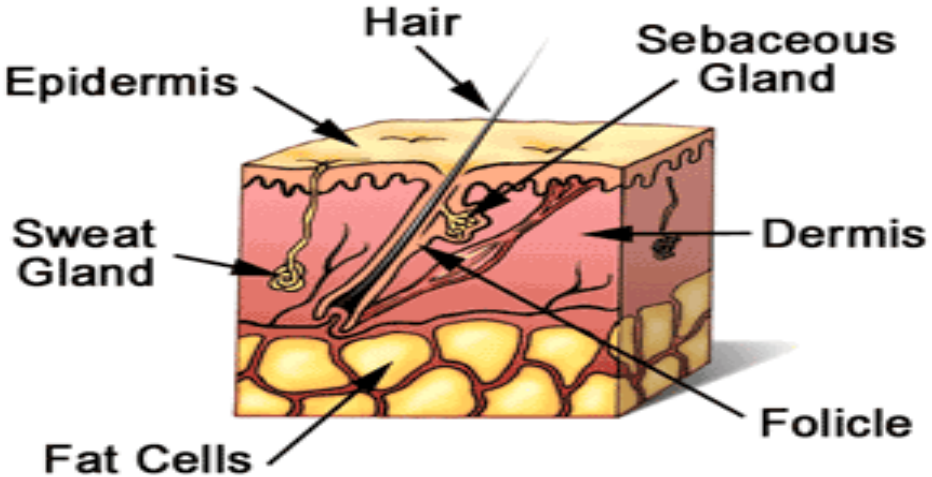
Hair
Sebaceous Gland
Epidermis
Sweat Gland
Dermis
Folicle
Fat Cells


Helix
Scapha
Fossa
Antihelical fold
Concha
Antihelix
External auditory meatus
Tragus
Antitragus
Lobule
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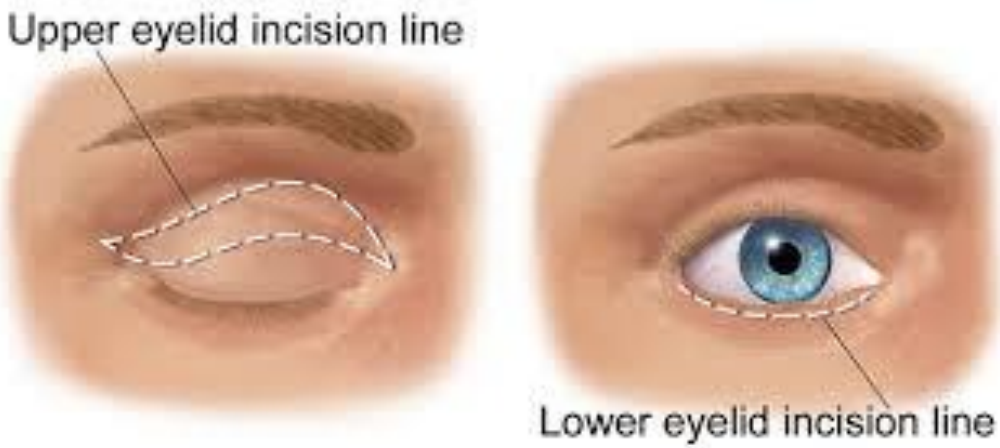
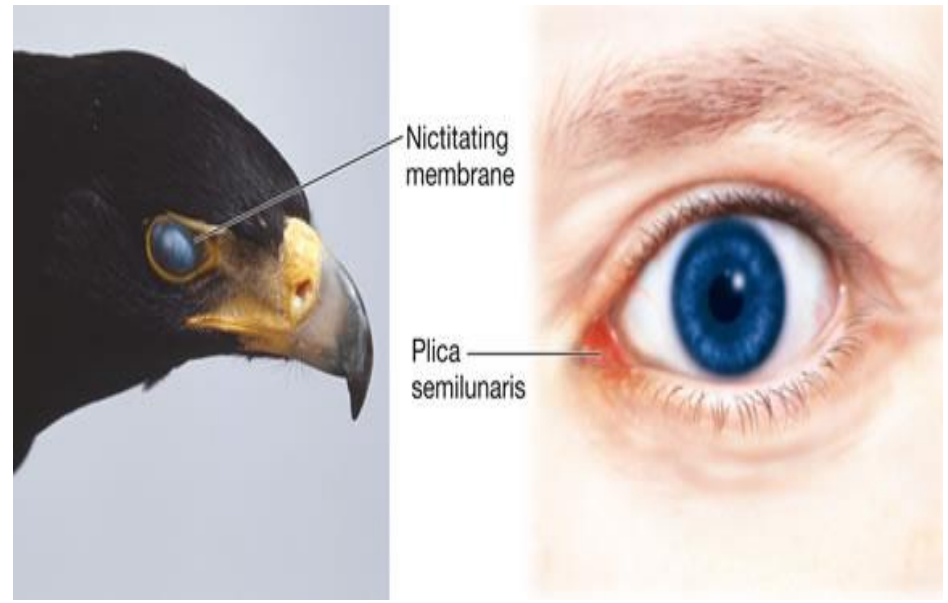
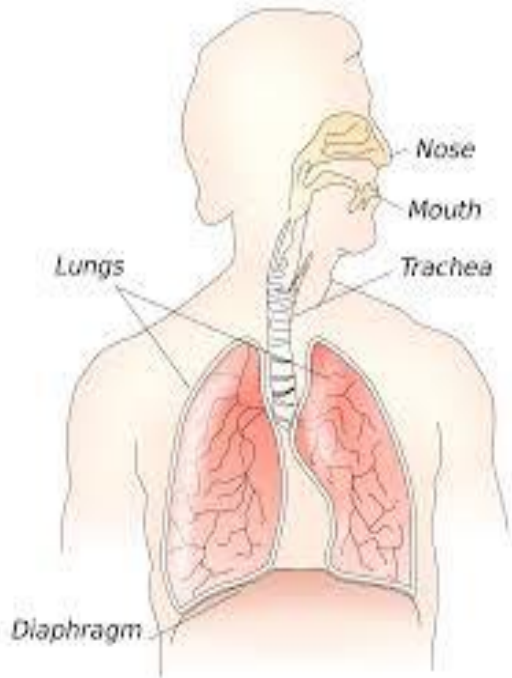
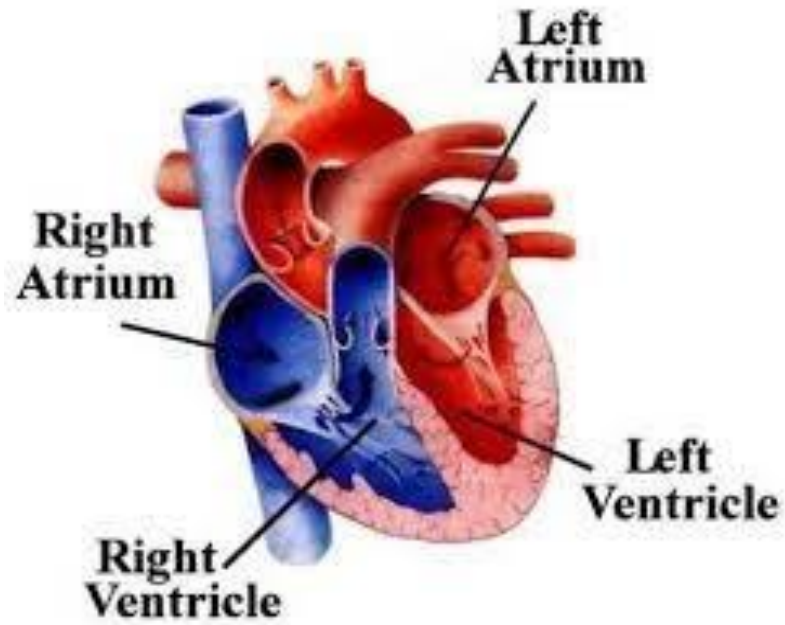


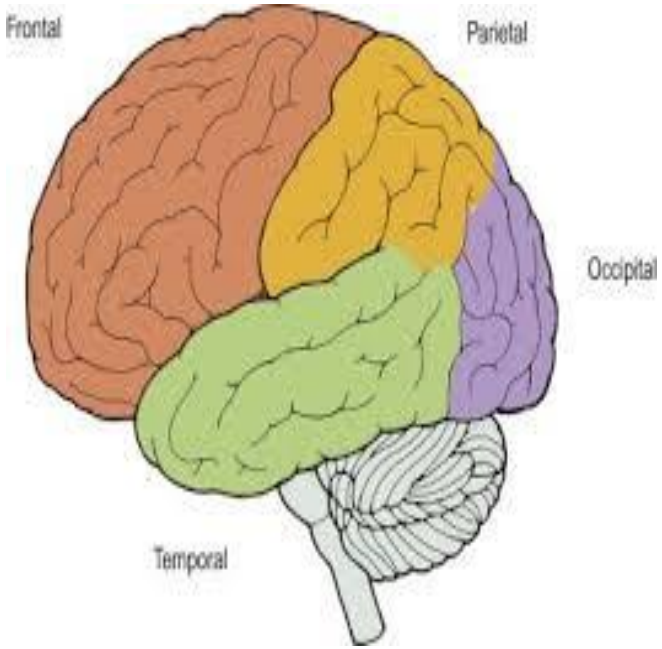
Blepharoplasty

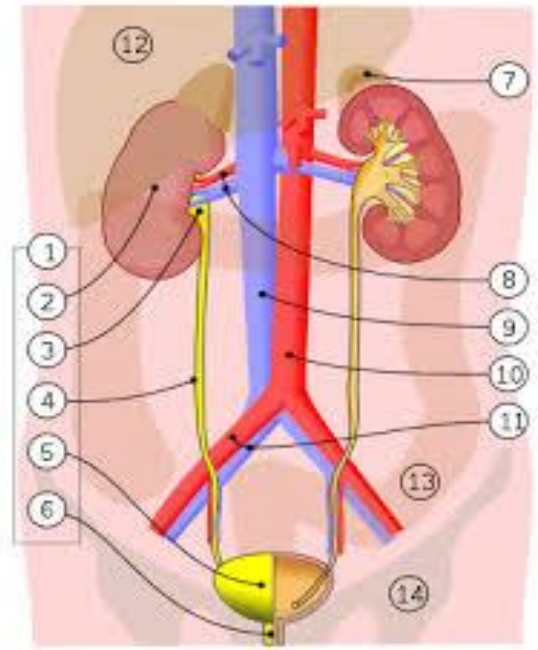


- 7. A muscular diaphragm is present in between the thoracic and abdominal cavities.
- 8. Endo-thermal homoeotherm animals.
- 9. RBCs are non-nucleated, biconcave and usually circular in form.
- 10. The four-chambered heart is highly powerful.
- 11. Only left aortic arch is present in the arterial system.
- 12. Cerebral hemispheres are very large and highly convoluted.
- 13. Cerebellum is large, complex and solid in mammals.
- 14. There is a single urinary bladder in mammals.
- 15. Testes remain in scrotal sacs.


Nose
Mouth
Lungs
Trachea
Diaphragm


Left Atrium
Right Atrium
Left Ventricle
Right Ventricle


Frontal
Parietal
Occipital
Temporal


12
7
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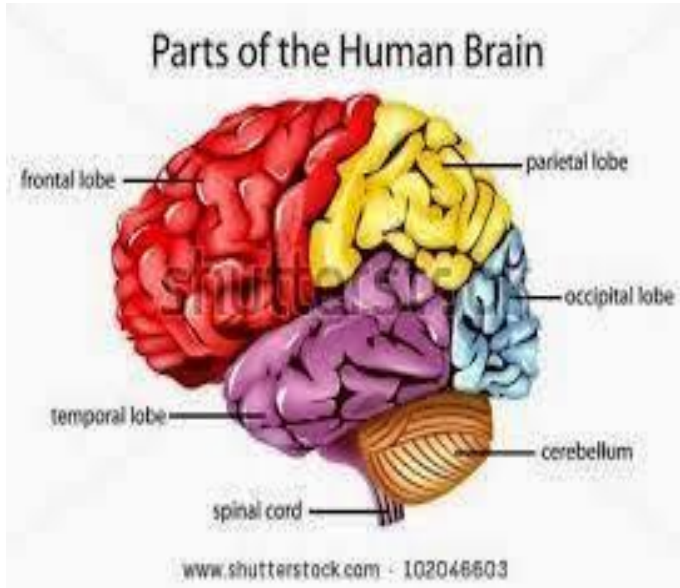
Parts of the Human Brain
frontal lobe
parietal lobe
occipital lobe
temporal lobe
cerebellum
spinal cord
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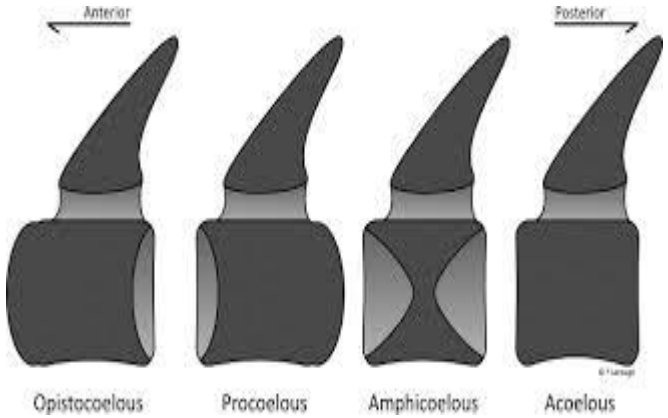
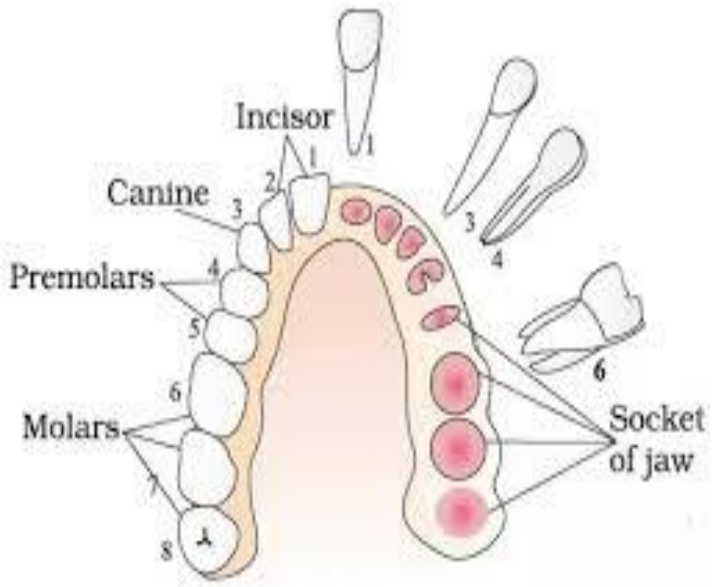
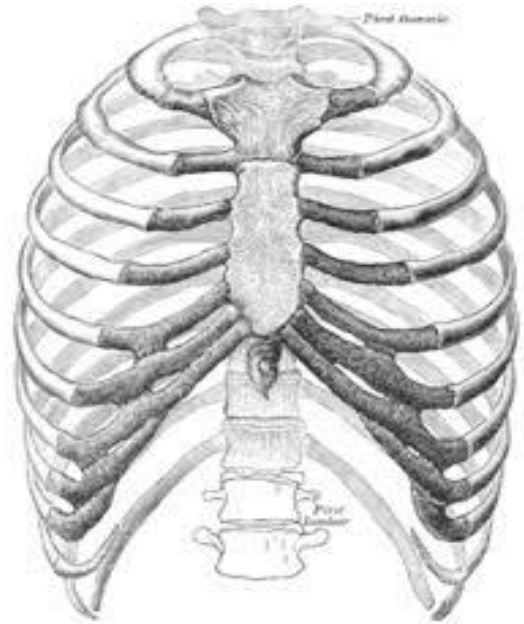
- 16. Small eggs are devoid of yolk. Fertilisation is internal.
- 17. Mammals are viviparous animals.
- 18. The skull has double occipital condyles. Quadrate absent.
- 19. A bony palate is formed by the union of premaxillae, maxillae and palatines that separates the nasal passage from the buccal cavity.
- 20. The lower jaw is composed of a pair of bones — the dentaries.
- 21. Vertebrae are acoelous type.
- 22. Ribs are double-headed — capitulum and tuberculum.
- 23. The teeth are heterodont, thecodont and diphyodont type.


Anterior
Posterior
Opistocoelous
Procoelous
Amphicoelous
Acoelous


Incisor
Canine
Premolars
Molars
Socket of jaw

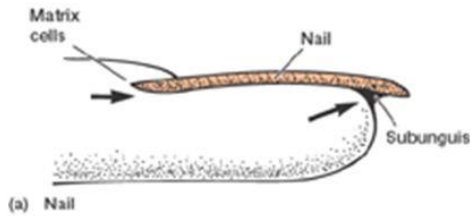


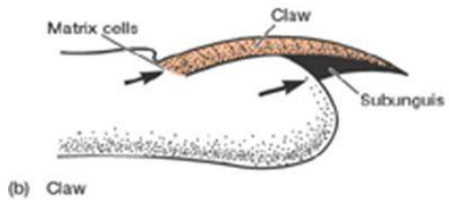
- 24. Molars are tribosphenic (three-cusped).
- 25. Paired forelimbs and hind limbs are present in mammals.
- 26. The digits of the limbs are provided with either claw or nail or hoof.
- 27. Cranial nerves twelve pairs.
- 28. Kidneys are metanephric type.

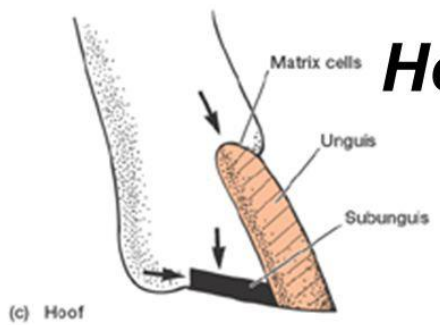
Claws and Talons

Amniotes: mammals, birds and reptiles and even in some amphibians (African Clawed frog)

curved, birds, mammals





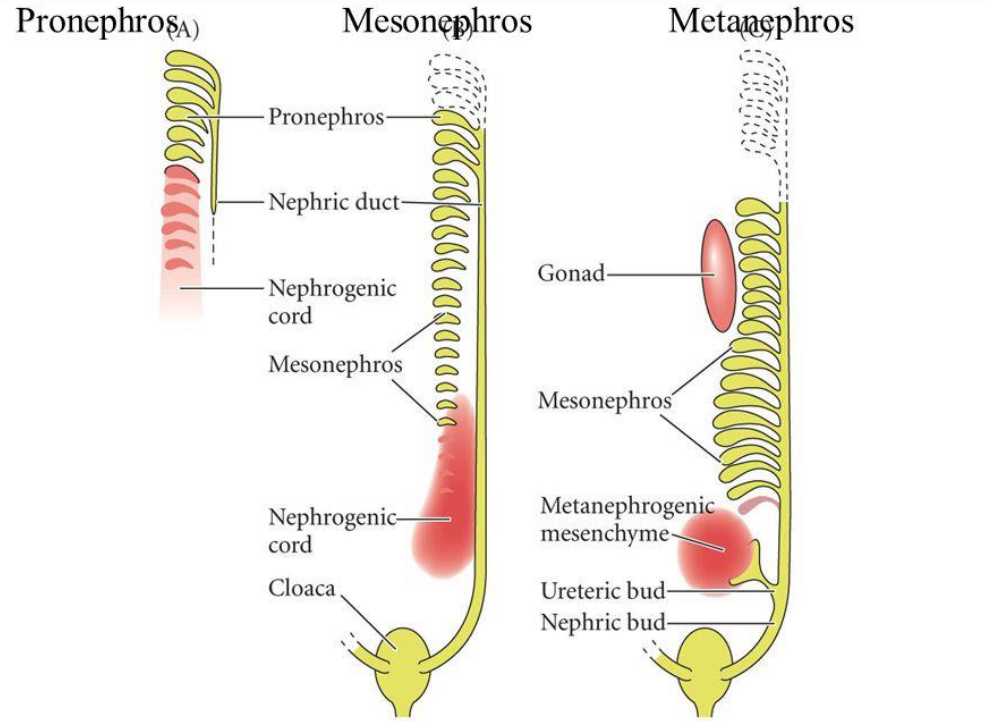


Hooves

Ungulates:

ungulates

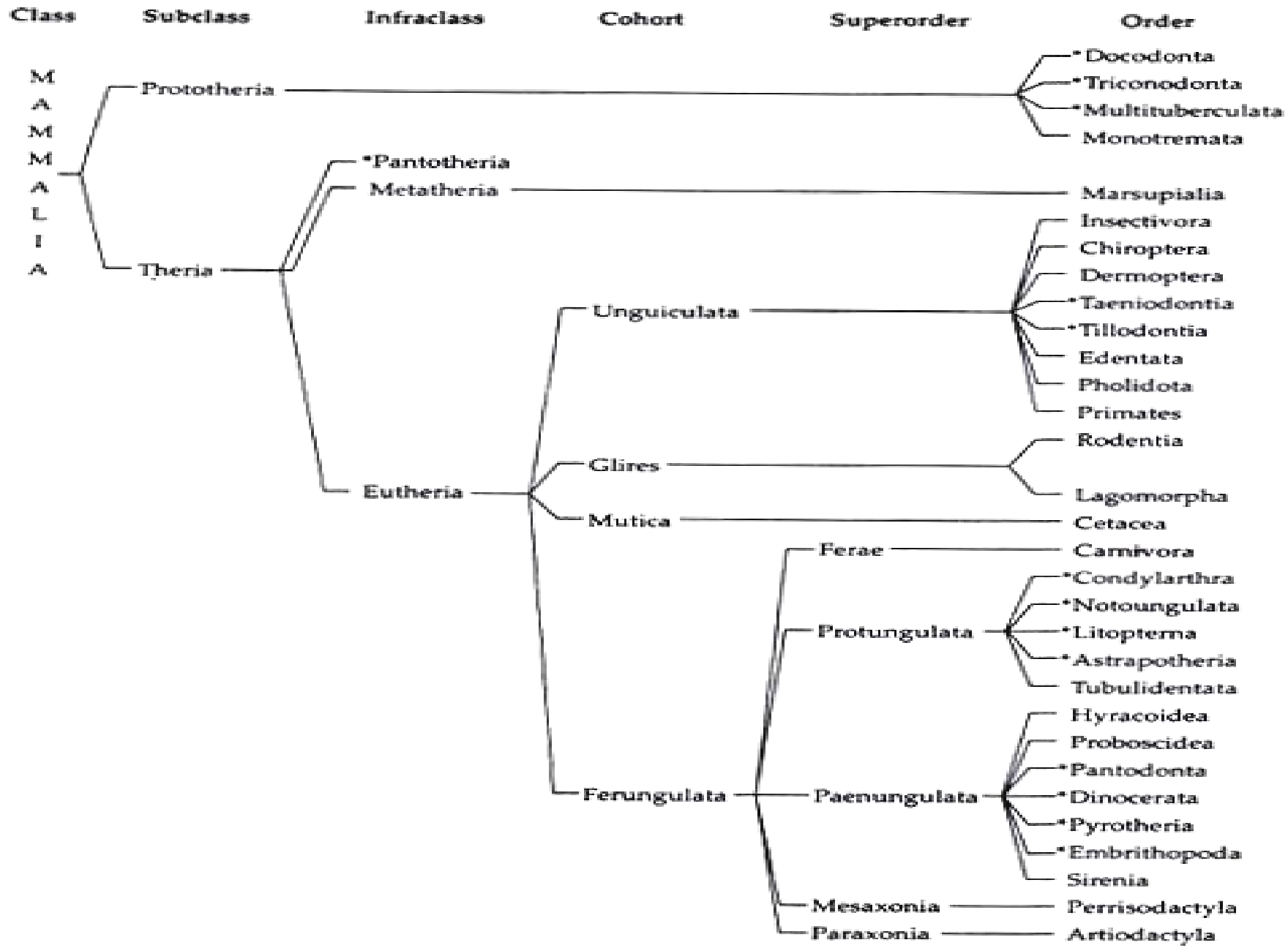
14.21 General scheme of development in the vertebrate kidney (Part 1)



Scheme of Classification of Mammals

- Like other chordates, the classification of mammals is a very controversial and complex matter. There are several schemes of classification that exists in different literatures. But none of the existing classifications is beyond criticism.

- However, in the present text, classificatory scheme of mammals as proposed by J. Z. Young (1981) is followed. In the scheme all the groups up to order are mentioned. But, for description, only living groups are considered. The extinct groups are marked with asterisks (*):


Class
Subclass
Infraclass
Cohort
Superorder
Order
MAMMALIA
Prototheria
Theria
*Docodonta
*Triconodonta
*Multituberculata
Monotremata
*Pantotheria
Metatheria
Eutheria
Marsupialia
Unguiculata
Glires
Mutica
Ferungulata
Insectivora
Chiroptera
Dermoptera
*Taeniodontia
*Tillodontia
Edentata
Pholidota
Primates
Rodentia
Lagomorpha
Cetacea
Ferae
Protungulata
Paenungulata
Mesaxonia
Paraxonia
Carnivora
*Condylarthra
*Notoungulata
*Litopterna
*Astrapotheria
Tubulidentata
Hyracoidea
Proboscidea
*Pantodonta
*Dinocerata
*Pyrotheria
*Embrithopoda
Sirenia
Perrisodactyla
Artiodactyla

Subclass — Prototheria (Greek: protos = first, therion = beast):

- 1. The females lay eggs.
- 2. The testes are abdominal.
- 3. The cloaca receives the openings of urinary bladder, vas deferens and ureters.
- 4. Ribs possess single head.
- 5. The mammary glands lack teats.
- 6. External pinna absent.
- 7. In childhood, teeth are present but adults lack teeth.
- This subclass includes four orders of which only Monotremata is the living group, others are extinct.

Order — Monotremata:

- 1. Body is covered over with soft hair. Hair on the dorsal side may be coarse or spine-like.
- 2. Webbed digits are ended in sharp claws.
- 3. Pinna is distinct but small.
- 4. In males, poison spur is present.
- 5. Brain lacks corpus callosum.
- 6. Tail may be present or absent.
- 7. Dental formula is i = 0/5, c = 1/1, p = 2/2, m = 3/3.

- 8. Body temperature varies in between 25°-28°C.
- 9. Pectoral girdles resemble that of reptiles.
- 10. Eggs are large and undergo meroblastic cleavage.
- 11. Tongue is long and sticky.
- 12. Sutures are obliterated in the skull.

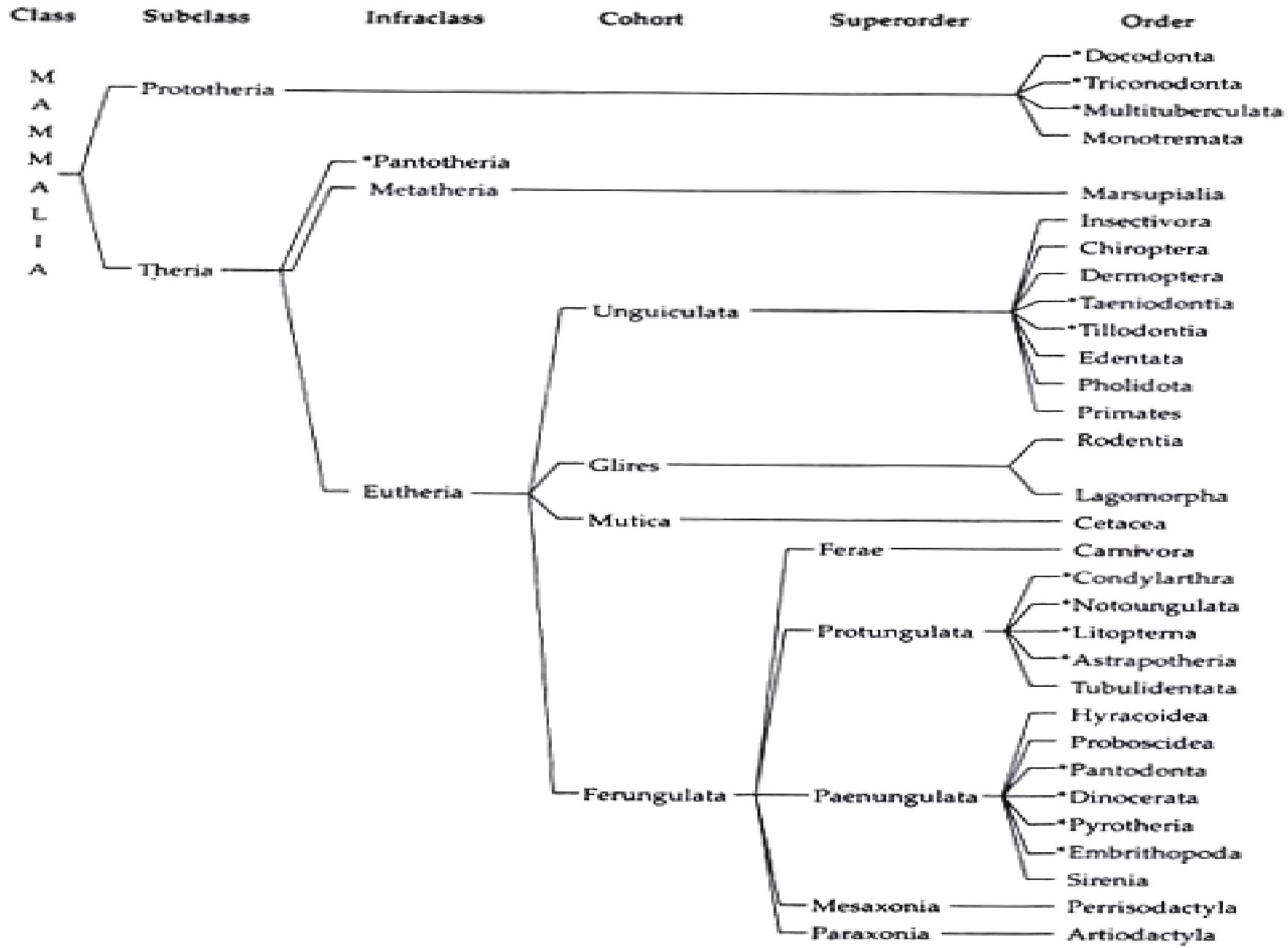
Examples:

- Ornithorhynchus, Tachyglossus, Zaglossus, Echidna.
- The monotremes occupy a most interesting position among mammals, because of their distribution, anatomical peculiarities and systematic position.
- Both the reptilian and mammalian characters are present in monotremes, which lead to consider them as connecting link.
- Only three genera of monotremes are found in Australia, Tasmania and New Guinea.

Ornithorhynchus

Zaglossus

Echidna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Ferae
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*Astrapotheria
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Hyracoidea
Proboscidea
*Pantodonta
*Dinocerata
*Pyrotheria
*Embrithopoda
Sirenia
Perrisodactyla
Artiodactyla

Subclass — Theria (Greek: therion = beast):

- 1. Female members of this subclass do not lay eggs but give birth to young ones.
- 2. Mammary glands are provided with nipples or teats.
- 3. Pinna or external ear is present.
- 4. The ureters open directly into the urinary bladder.
- 5. At the end of the digestive tract an anus is present.
- 6. Teeth are present throughout the life period.
- 7. Testes are situated in the scrotum.
- 8. Ribs possess two heads for articulation with vertebrae.
- This subclass includes three infraclasses, of which Pantotheria is extinct.

Infraclass — Metatheria (Greek: Meta = next to):

- 1. The youngs are born in an immature condition and undergo further development in the marsupium of females.
- 2. Mammary gland with teats opens into the marsupium.
- 3. Epipubic bone of the pelvic girdle protects the marsupial sac.
- 4. Placenta is chorioviteline type.
- This infraclass includes single order.

Order — Marsupialia (Latin: Marsupium = a sac):

- 1. Body in covered with soft fur.
- 2. Pinna is well developed.
- 3. Most of the female members possess marsupium.
- 4. Tail is well-developed and helps in balancing.
- 5. The second and third toes of the hind-limb are slender and remain enclosed in a sheath of skin, i.e., syndactylous digits. The fourth toe is largest. All digits are clawed.

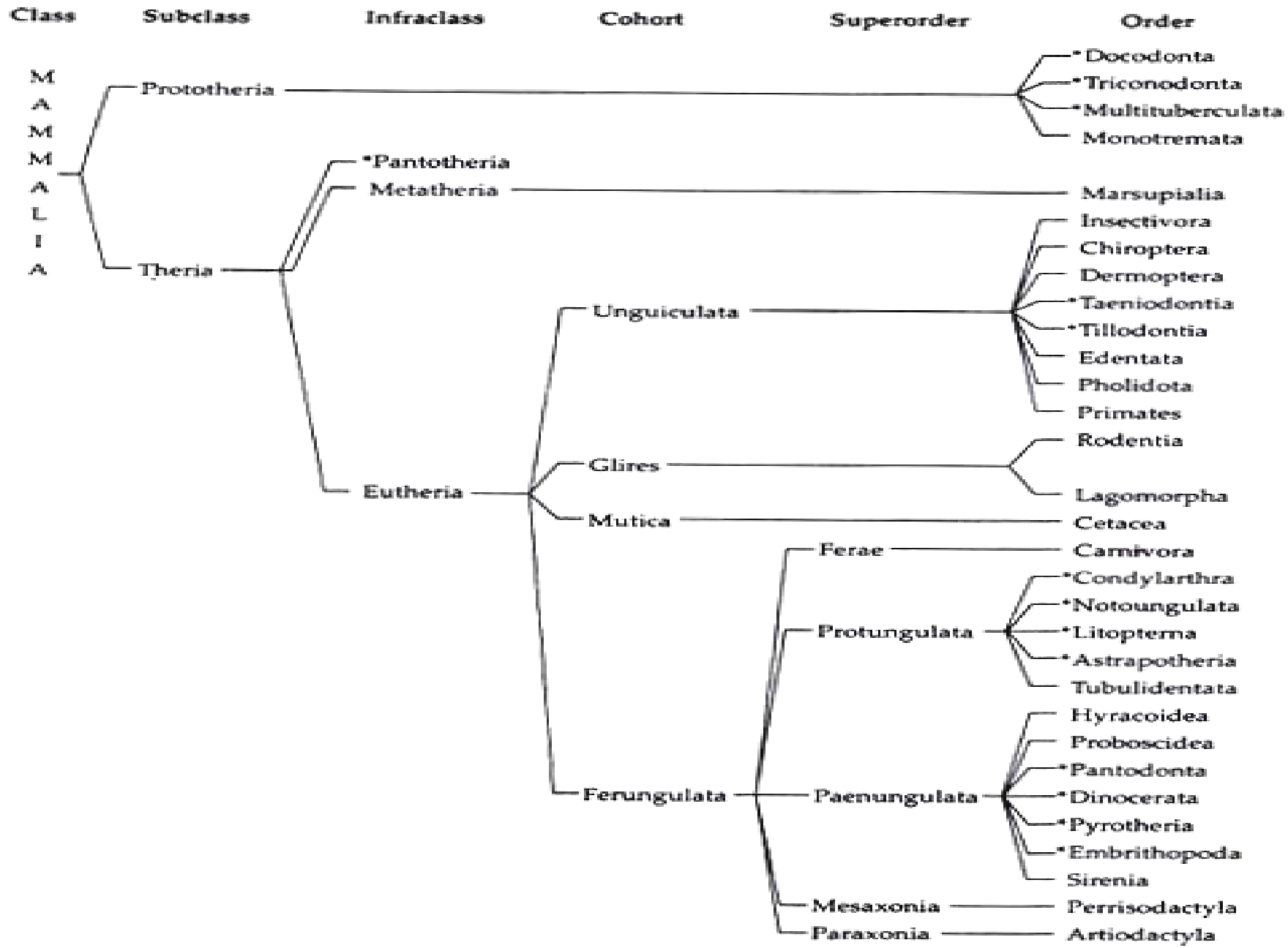
- 6. Forelimbs are shorter than the hind limbs.
- 7. Dental formula is i = 5/4, c = 1/1, p = 3/3, m= 4/4.
- 8. Caudal vertebrae are with chevron bone.
- 9. Atlas is incomplete and is provided with cartilage in the ventral incomplete side.

Examples:

- Macropus (Kangaroo), Didelphis (Opossum), Thylacinus (Tasmanian wolf – the mystery marsupials), Myrmecobius (Banded ant-eater), Nottoryctes (Marsupial mole), Petaurus (Flying opossum), Phascolarctos (Koala bear), Vombatus (Wombat), etc.

Macropus (Kangaroo)

Didelphis (Opossum)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Hyracoidea
Proboscidea
*Pantodonta
*Dinocerata
*Pyrotheria
*Embrithopoda
Sirenia
Perrisodactyla
Artiodactyla

Infraclass — Eutheria (Greek: eu = true):

- 1. The young are born as miniature adult and go through a considerable period of prenatal growth.
- 2. A highly-organised allantoic placenta attaches firmly with the uterine wall during developmental period.
- 3. Brain is highly-developed, cerebral hemispheres have well-developed neopallial region. The two hemispheres are connected by corpus callosum.
- 4. The anal and urinogenital apertures are separate.

- 5. The tympanic bone is ring-like and forms a tympanic bulla.

- 6. Dental formula is i = 3/3, c = 1/1, pm = 4/4, m = 3/3. In some forms there are modifications in dental formula, and in some cases teeth are absent.

- 7. Epipubic bone in the pelvis is absent.

Cohort — Unguiculata

- 1. These eutherians possess nails or claws in their digits.

- This Cohort contains eight orders, of which two are extinct.

Order — Insectivora (Latin: insecta= insects; voro = to eat):

- 1. Body covered with hair. Some members possess dorsal spines which are modified hair.
- 2. Nocturnal animals with long snout are insectivorous.
- 3. Skull is constricted in the middle.
- 4. The zygomatic arch and bony palate are incomplete.
- 5. Teeth have sharp molar cusps.
- 6. Each limb possesses five digits with claws.
- 7. Locomotion is plantigrade type.

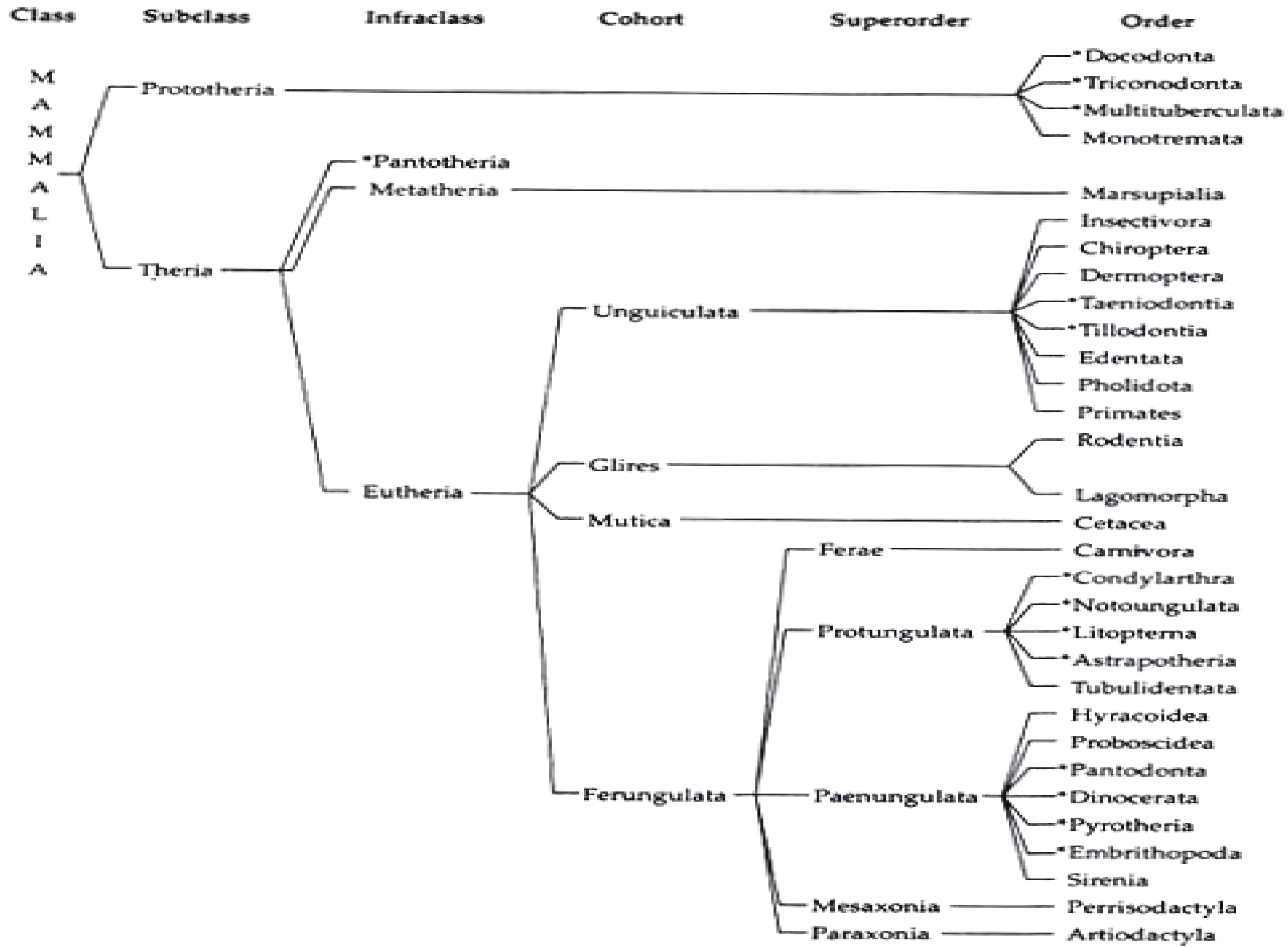
- 8. Caecum in the intestine is small or absent.
- 9. Scrotum is absent and the testes are internally situated.
- 10. Uterus is bicornuate type.
- 11. Mammary glands are many and are distributed all along the two milklines on the ventral surface.

Example:

- Talpa (Mole), Tupaia (Tree- shrew), Erinaceus (Hedgehog), Sorex (Shrew), Desmana (Water mole), Chrysochloris (Golden mole), Neomys (Water shrew).

Talpa (Mole)

Erinaceus (Hedgehog)


Class
Subclass
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Superorder
Order
MAMMALIA
Prototheria
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*Triconodonta
*Multituberculata
Monotremata
*Pantotheria
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Marsupialia
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*Litopterna
*Astrapotheria
Tubulidentata
Hyracoidea
Proboscidea
*Pantodonta
*Dinocerata
*Pyrotheria
*Embrithopoda
Sirenia
Perrisodactyla
Artiodactyla

Order — Chiroptera (Latin: cheir = Hand; pteron = wing):

- 1. The forelimbs are modified to form wings.
- 2. The bones of the digits of the forelimbs are elongated except pollex. These bones support a membrane that runs between forelimbs and hind limbs. This membrane is called as patagium.
- 3. An inter-femoral membrane is present between the femurs. It is supported by a cartilaginous calcar of the ankle.
- 4. A short tail is often included in the interfemoral membrane.
- 5. The wings are having direct arteriovenous connections.
- 6. Pollex is small, free from the wing and bears claw.
- 7. The hind limbs are weak, having five clawed-digits.
- 8. Pinna is well-developed.

- 9. These are nocturnal animals. They are able to fly and catch prey in the dark with the help of their special radar system. This capacity is called echolocation.
- 10. The sutures of the skull is obliterated.
- 11. The ribs are flat and fused with the vertebrae to become rigid during flight.
- 12. The hind limbs are rotated, so the knee is directed backward.
- 13. The testes are abdominal in position.
- 14. Only one young is born at a time.
- 15. The sternum is provided with a flat keel for the attachment of pectoral muscle.

Examples:

- Pteropus (Fruit bat) (Fig. 1.129A and C), Rhinolophus (Horseshoe bats), Desmodus (Vampire bats) (Fig. 1.129B), Vespertilio (European bats) (Fig. 1.129D).

Pteropus (Fruit bat)

Rhinolophus

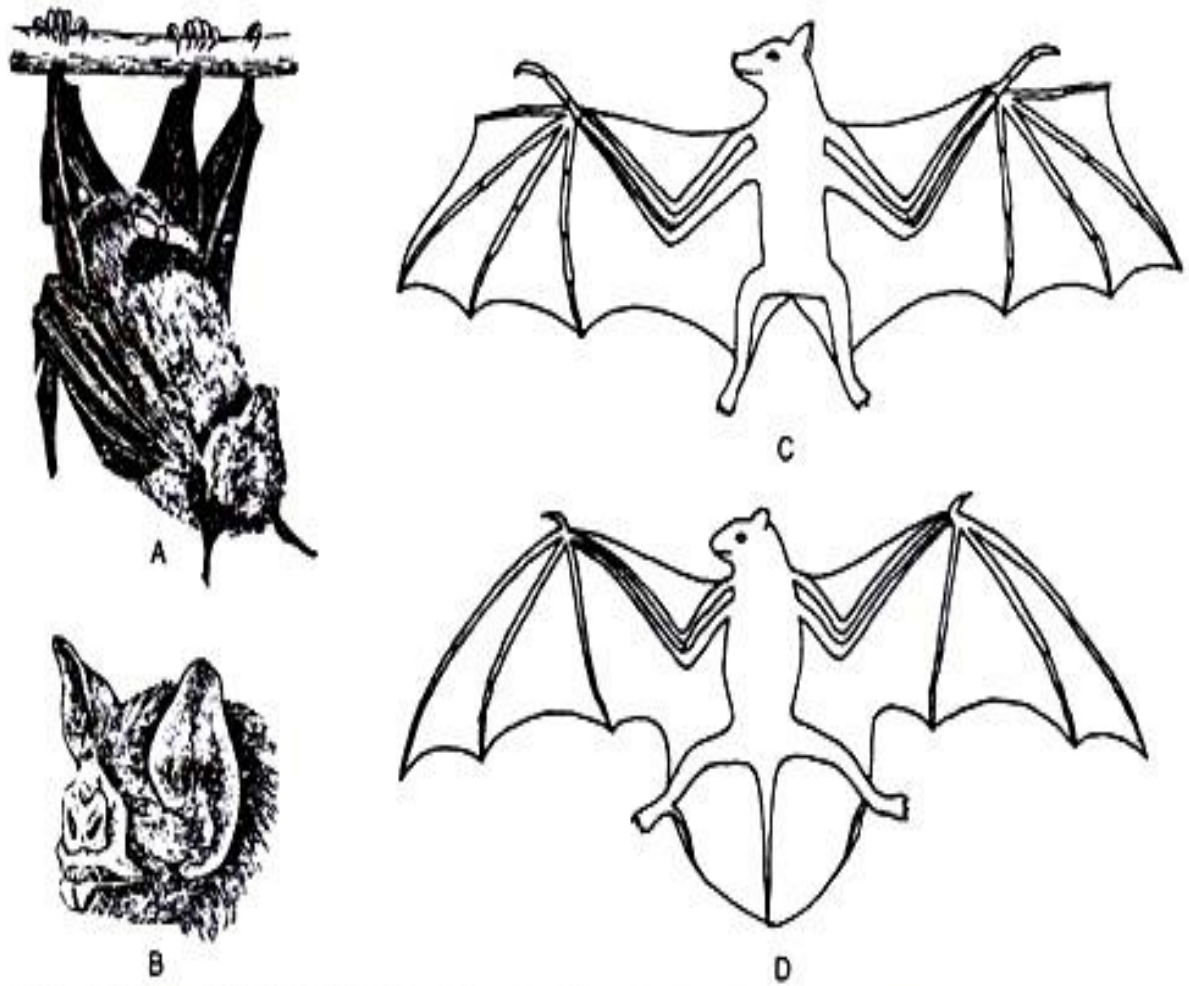
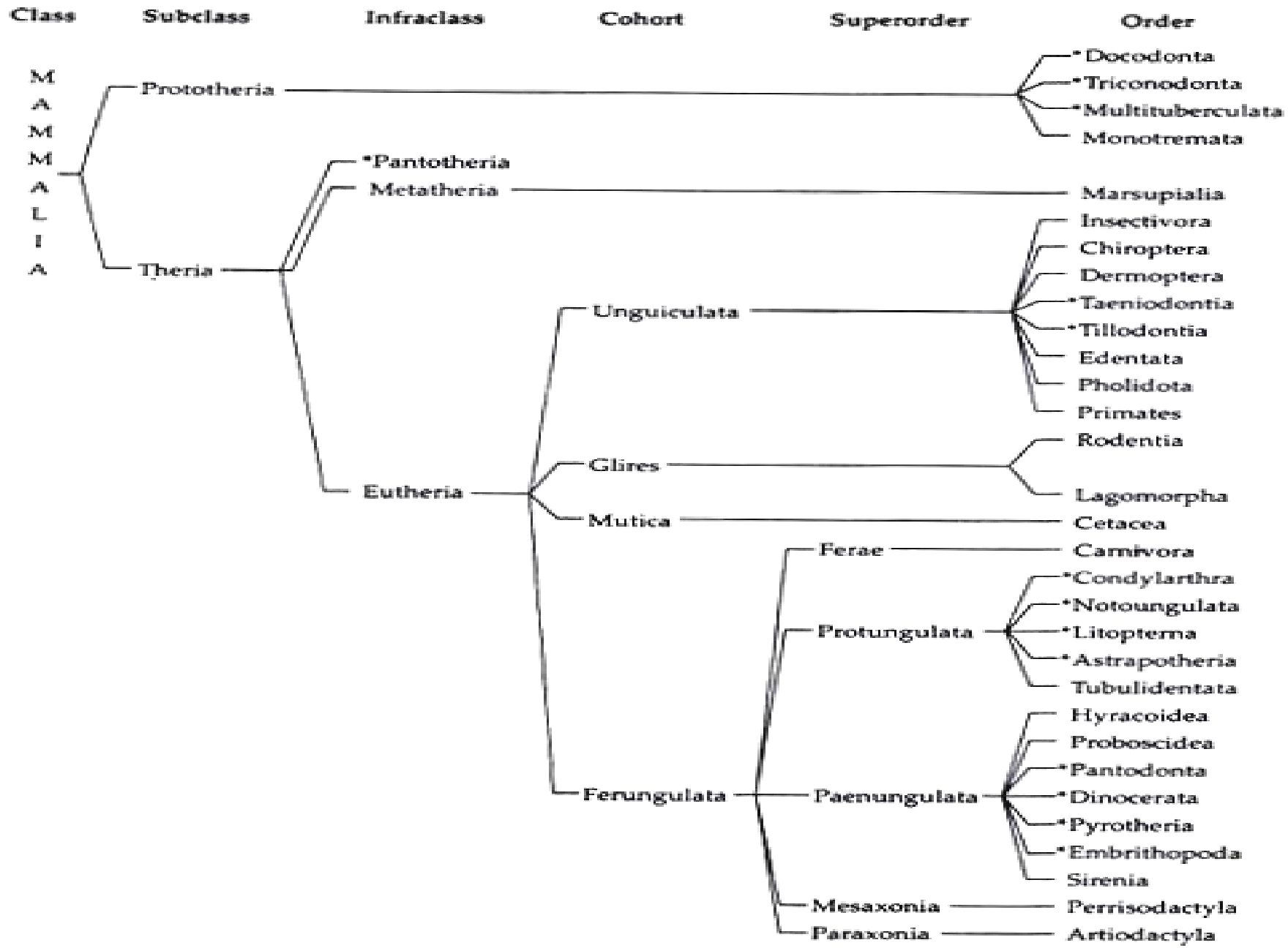


Fig. 1.129 : A. *Pteropus* (Fruit bat), B. Head of *Desmodus* (Vampire bat). C. & D. Diagrammatic figure of *Pteropus* and *Vespertilio*, respectivey. Note the patagium between the hind limbs in two groups of bats and the presence of tail in the latter

- Fruit bat (Pteropus) is the member of suborder Megachiroptera and others are member of suborder Microchiroptera. The chiropterans are the only mammals that truly fly, by flapping their wings, as distinct from the soaring of flying phalangers, colugos and others. In acquiring the power of flight they have evolved many features in parallel with birds.

- The method of flight of many forms is specialised to give the great maneuverability needed for catching insects by echolocation at short distances rather than by vision. The wings vary greatly but are thin aero foils, often with high camber, giving high lift at low speed.

- The evolutionary history of chiroptera is inadequately known. The first known bats are reported from the Eocene period. The bats are numerous and their distribution is worldwide.


Class
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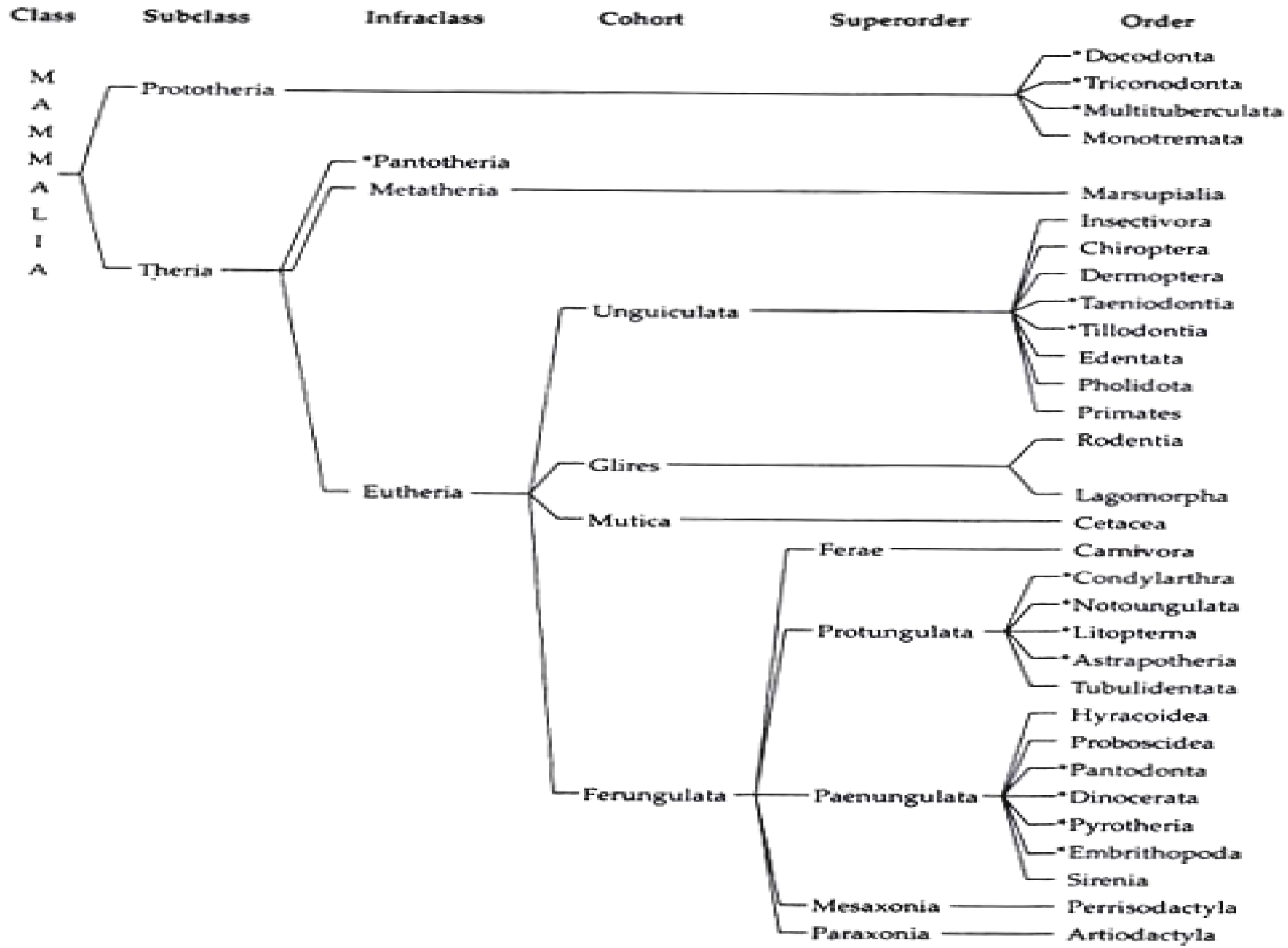
Metatheria
Eutheria
Marsupialia
Unguiculata
Glires
Mutica
Ferungulata
Insectivora
Chiroptera
Dermoptera
*Taeniodontia
*Tillodontia
Edentata
Pholidota
Primates
Rodentia
Lagomorpha
Cetacea
Ferae
Protungulata
Paenungulata
Mesaxonia
Paraxonia
Carnivora
*Condylarthra
*Notoungulata
*Litopterna
*Astrapotheria
Tubulidentata
Hyracoidea
Proboscidea
*Pantodonta
*Dinocerata
*Pyrotheria
*Embrithopoda
Sirenia
Perrisodactyla
Artiodactyla

Order — Dermoptera (Latin: Derma = skin; pteron = wing):

- 1. These are herbivorous, tree-living and their size is like that of a large squirrel.
- 2. The lower incisors are combed.
- 3. The tympanic ring forms the bulla and the lower margin of the external auditory meatus.
- 4. Brain is primitive and the optic lobes are not covered by cerebrum.
- 5. A broad fold of hairy skin extends between the legs and up to the tail, with which it glides long distances from one tree to another.
- 6. Fingers are not elongated to support the wings as in bats.

Example:

- Cynocephalus (= Galeopithecus) (Flying lemur or colugo).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Sirenia
Perrisodactyla
Artiodactyla

Order — Edentata (Latin: E/ex = without; dens = tooth):

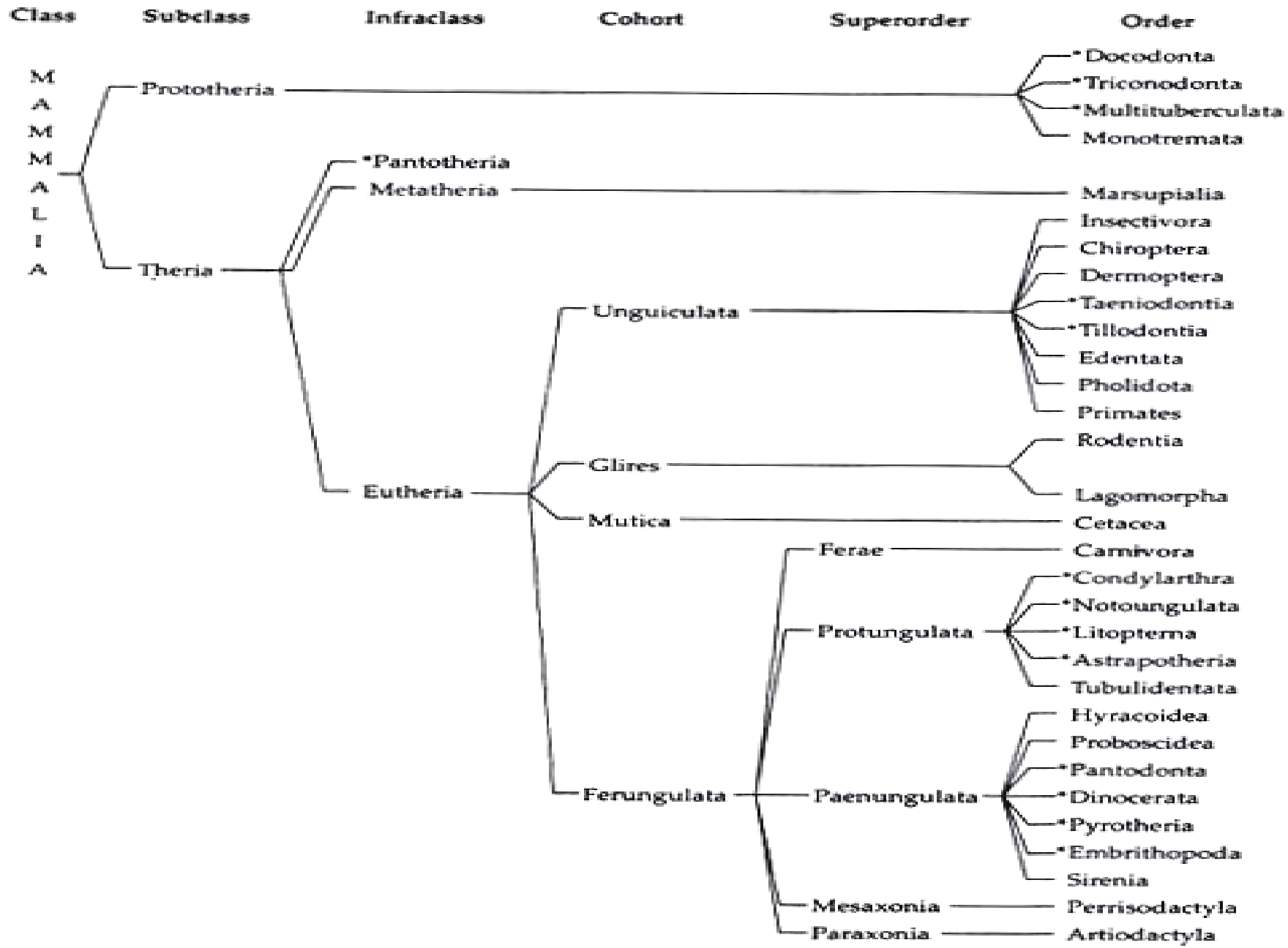
- 1. Incisors and canines are absent but molars are long and similar in appearance.
- 2. Enamel and root of the teeth are absent but pulp cavity is persistent.
- 3. Tongue is sticky in nature.
- 4. Skull is small in comparison to body size.
- 5. The zygomatic arch is reduced or absent.
- 6. Olfactory lobe of the brain is well-developed.
- 7. In the pectoral girdle, clavicle is present but the coracoid and acromion are fused.

- 8. In the pelvic girdle, ischium is united with anterior caudal vertebrae.
- 9. Posterior thoracic and lumbar vertebrae are with additional pair of zygapophyses

Example:

- Dasypus (Nine banded armadilo), Myrmecophaga (Giant ant-eater), Cyclopes (Two toed ant-eater), Bradypus (Three toed sloth), Choloepus (Two-toed sloth).

Dasypus (Nine banded armadilo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Order — Pholidota (Greek: pholis = scale):

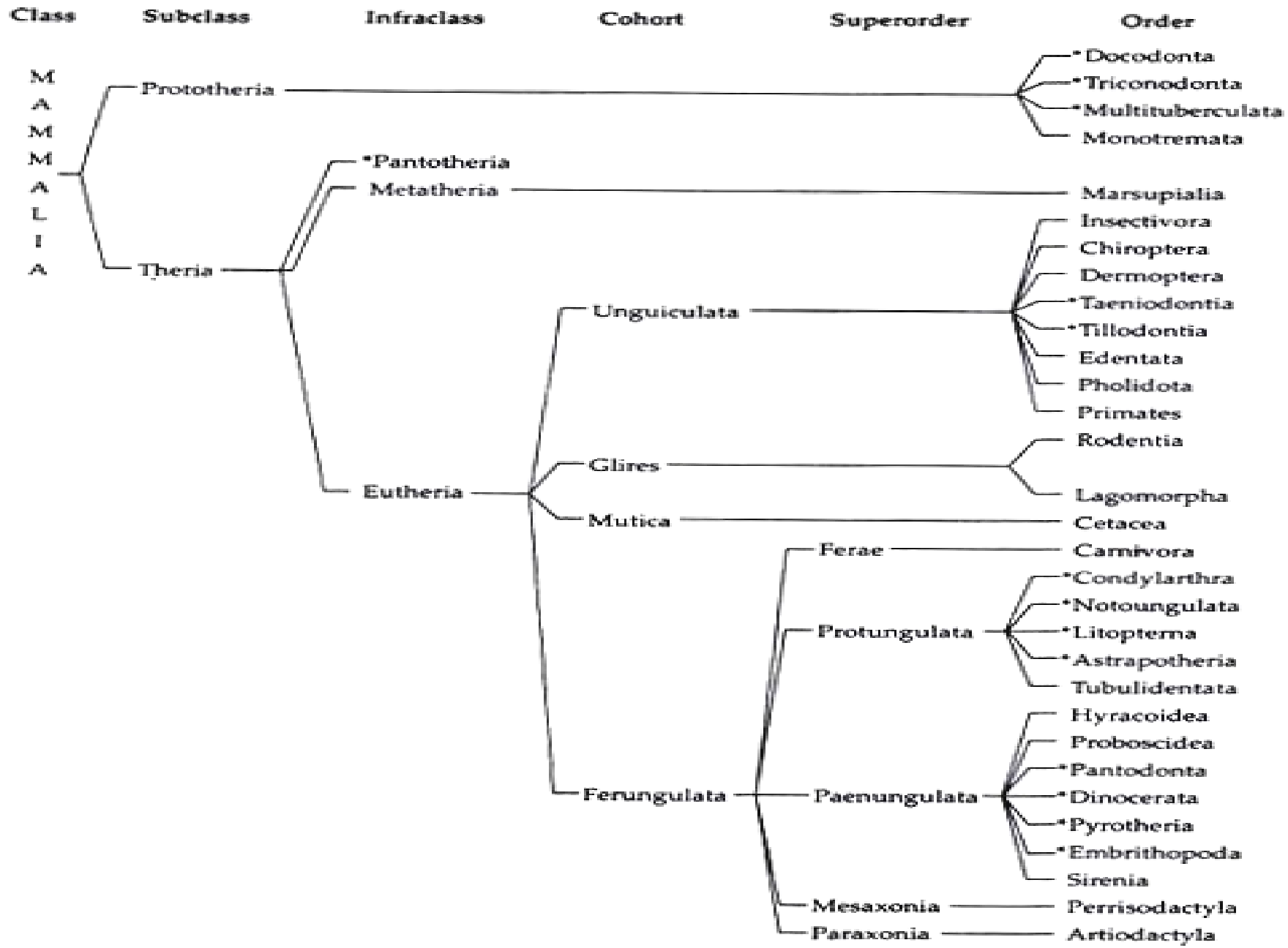
- 1. Horny scales are present in an imbricated fashion. On the dorsal side of the head, body and tail. Few hair peep through these scales.
- 2. The ventral side of the body is covered with hair.
- 3. Eyes are small and pinna is ill-developed.
- 4. Tail is long and tapering.
- 5. The short and powerful limbs possess five clawed-digits in each.
- 6. The claws of the forelimbs are curved and sharp.
- 7. Locomotion by hind limb is plantigrade in nature.

- 8. The facial part is prolonged to form a short muzzle.
- 9. Tongue is long, sticky and protrusible and is retained in a sac.
- 10. Teeth are absent.
- 11. Skull is long and cylindrical.

Example:

- Manis crassicaudata (Indian Pangolin), M. pentadactyla (Chinese Pangolin).

Manis crassicaudata (Indian Pangolin)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Order — Primates (Latin: primus = first; Primate = One first in rank):

- 1. Body is covered with thick hair except the palm, sole and some parts of the face.
- 2. Neck is short and mobile.
- 3. Forelimbs are shorter than hind limbs.
- 4. Pentadactyl limbs possess digits with flat nail.
- 5. The pollex or thumb, hallux or first toe are smaller than other digits and are opposable.
- 6. Locomotion is plantigrade type.
- 7. A tail is present.

- 8. Mammae are two and thoracic in position.
- 9. Testes lie in scrotal sac.
- 10. Highly developed brain possesses much convoluted cerebral hemispheres.
- 11. The eyes are directed forward and the vision is binocular and stereoscopic.
- 12. Teeth show reduction in number.
- 13. The skull is more inclined to the vertebral axis.
- 14. Zygomatic arch is complete.
- 15. Foramen magnum faces downward.

Example:

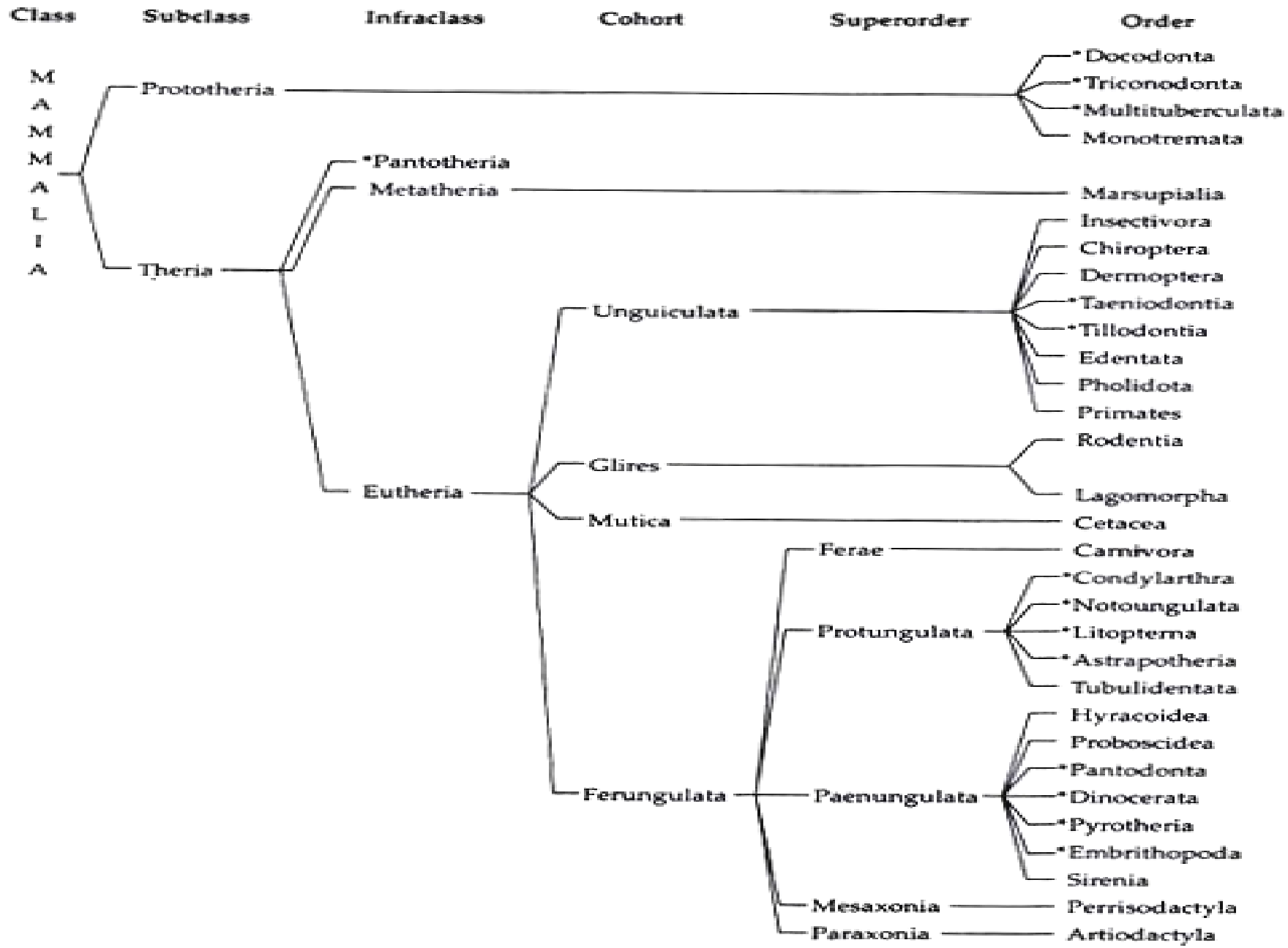
- Homo sapiens (Man), Gorilla, Presbytis (Langur), Macaca (Rhesus monkey, Macaque), Papio (Babon), Hylobates (Gibbon), Pongo (Orangutan), Pan (Chimpanzee), Callithrix (= Hapale) (Marmoset), Loris (Slender loris), Lemur, etc.

- The term ‘primate’ carries with it the implication that the animals in the group are not only the nearest to man but are also in some sense the first or most completely developed members of the animal world. But these are not so specialised as they are believed to be.

- The primates have retained many primitive and generalized eutherian characters. They are primarily arboreal and return to land as a secondary condition. These are omnivorous in habit.

Homo sapiens (Man)

Gorilla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Artiodactyla

Cohort — Glires:

- 1. Teeth are specialized for gnawing.
- 2. Skull is long and low.
- 3. Temporal fossa widely opens to the orbit.
- 4. Brain is small with small cerebral hemispheres.
- 5. Limbs are pentadactyle.
- 6. Radius and ulna are separate.
- This cohort is divided into two orders — Rodentia and Lagomorpha

Order — Rodentia (Latin: rodere = to gnaw):

- 1. Body is covered with soft hair.
- 2. Eyes are small but pinna is well-developed.
- 3. Limbs are provided with blunt claws.
- 4. Forelimbs are smaller than the hind limbs.
- 5. Locomotion is plantigrade type.
- 6. Jaw muscles are well developed for gnawing. Intestine and caecum are large.
- 7. Testes are inguinal.

- 8. Prolifically reproducing animals. Females possess abdominal teats.
- 9. Single pair of large, chisel-shaped incisors are present both in upper and lower jaws.
- 10. Canine and anterior premolars are absent forming a diastema between incisors and cheek teeth.
- 11. There are two premolars in the upper jaw and one in lower jaw.
- 12. The scapula is provided with acromion process.

Example:

- Sciurus (Squirrel), Petaurista (Flying squirrel), Rattus (Rat), Mus (House mouse), Hystrix (Porcupine), Cavia (Guinea- pig) (Fig. 1.130), Bathyergus (Mole-rat), Cricetus (Hamster), Mesocricetus (Golden hamster), Microtus (Vole), Dipus (Jerboa), Castor (Beaver), Geomys (Pocket gopher), Dipodomus (Kangaroo rat), Citellus (Ground squirrel), Marmota (Moarmot, woodchuck).

Cavia (Guinea- pig)

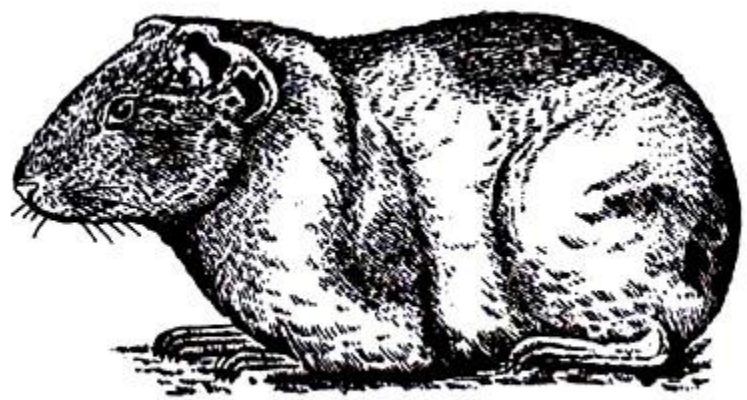
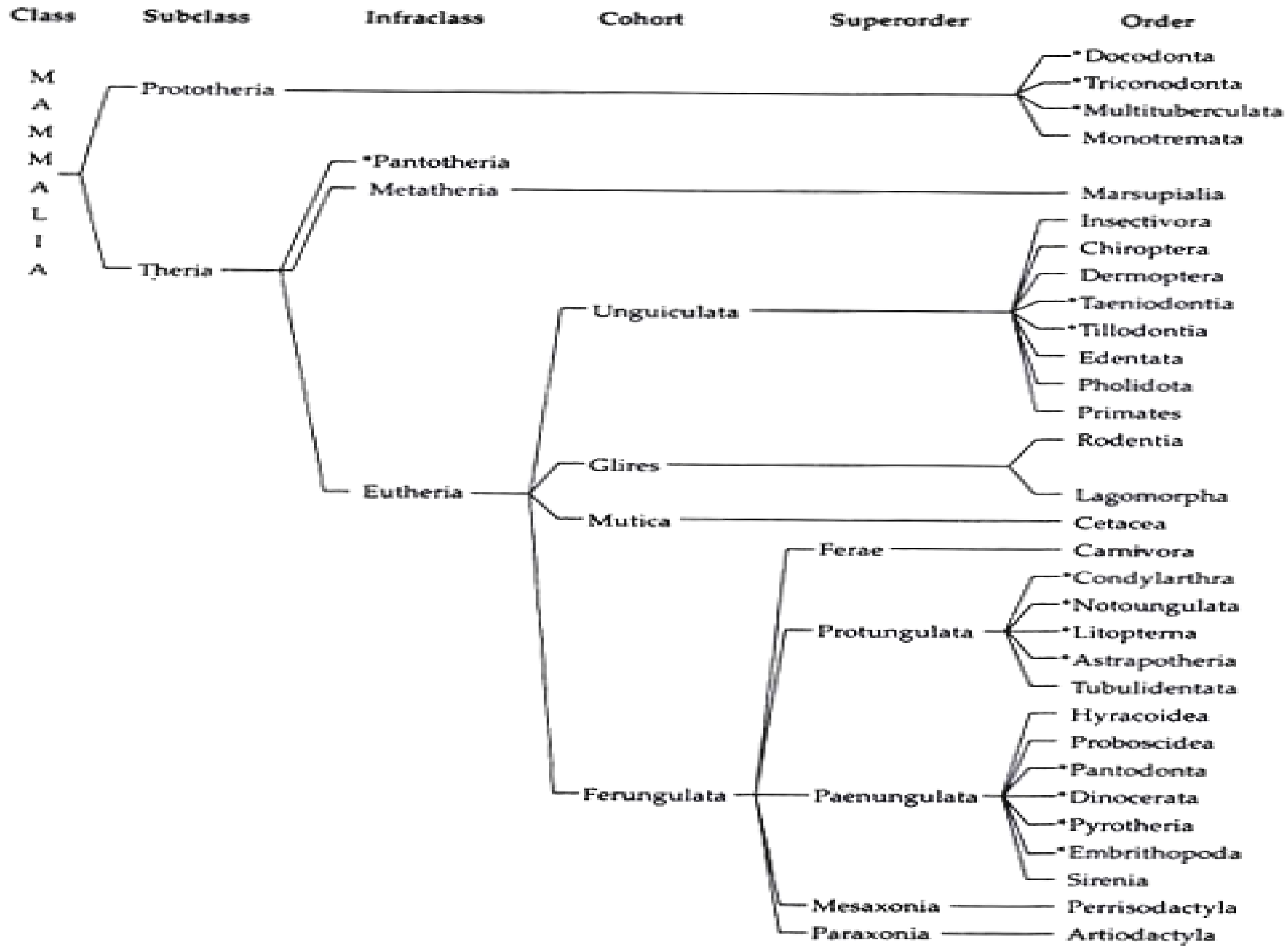


Fig. 1.130 : *Cavia* (Guineapig)

Sciurus (Squirrel)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Order — Logomorpha (= Duplicidentata) (Latin: logos = hare; morph = form):

- 1. Body is covered with soft hair.
- 2. Eyes are large and pinna is long.
- 3. Pentadactyle limbs possess clawed digits.
- 4. Hind limbs are larger than forelimbs.
- 5. The upper lip is provided with a cleft in the middle.
- 6. Tail is almost vestigial.
- 7. Masseter muscles are enormously developed but temporal muscles are weak.
- 8. Testes lie inside the scrotum.
- 9. Mammary glands are abdominal in position.

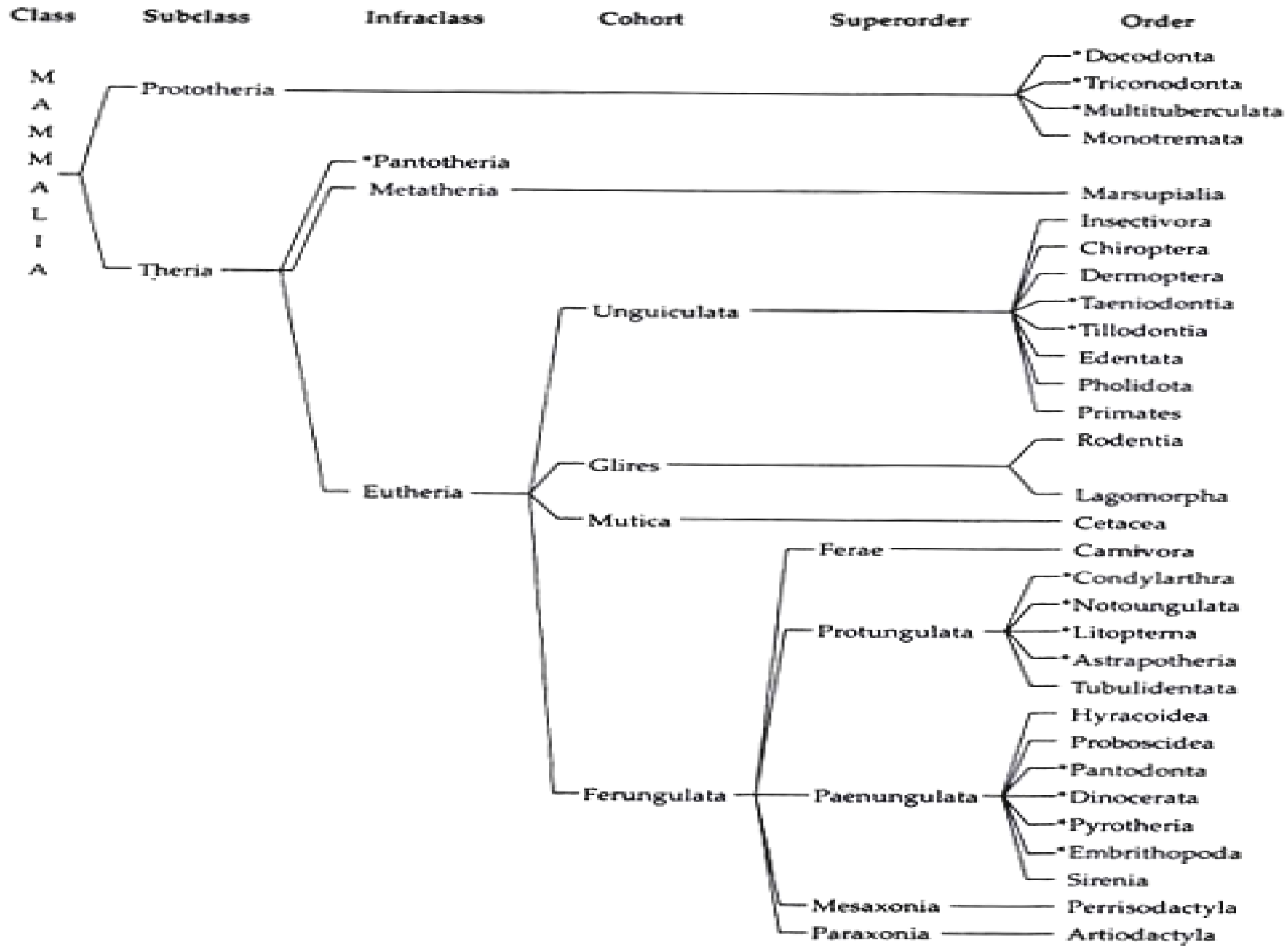
- 10. Maxillae are laterally fenestrated.
- 11. There are two pairs of incisors in the upper jaw, while it is one pair in lower jaw.
- 12. The incisors of the upper jaw are unequal. A larger pair situated in front and smaller pair lie behind it.
- 13. Canine absent and diastema is present.
- 14. There are three premolars in upper jaw and two in lower jaw.
- 15. Scapula is with acromion and metacromion process.
- 16. Tibia and fibula are fused.

Example:

- Lepus (Hare), Oryctolagus (Rabbit), Ochotona = Lagomys (Pika, Cony), Lepus nigricollis (Indian hare), Ochotona roylei (Himalayan mouse hare), Caprologus hispidus (Hispid hare of Himalaya).

Lepus (Hare)

Oryctolagus (Rabbit)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Cohort — Mutica:

- 1. These animals lack vocal cords and are known as silent animals. But can emit sound for various purposes, which is called ‘whale song’.

- 2. These animals are completely aquatic throughout their life cycle.

Order — Cetacea (Latin: cetas = whale):

- 1. The large, torpedo shaped body devoid of hair.
- 2. The skin is smooth and skin glands are absent.
- 3. The nictitating membrane of eye, pinna of ear and nail of the digits are absent.
- 4. Forelimbs are modified to form flippers, hind limbs are absent.
- 5. The nasal openings are asymmetrical, located far back on the upper surface of the head and can be closed by valves.
- 6. The tail terminates in a horizontal fin, called fluke. It is a neomorphic structure.
- 7. Dorsal fin is fleshy; it is also a neomorphic structure.

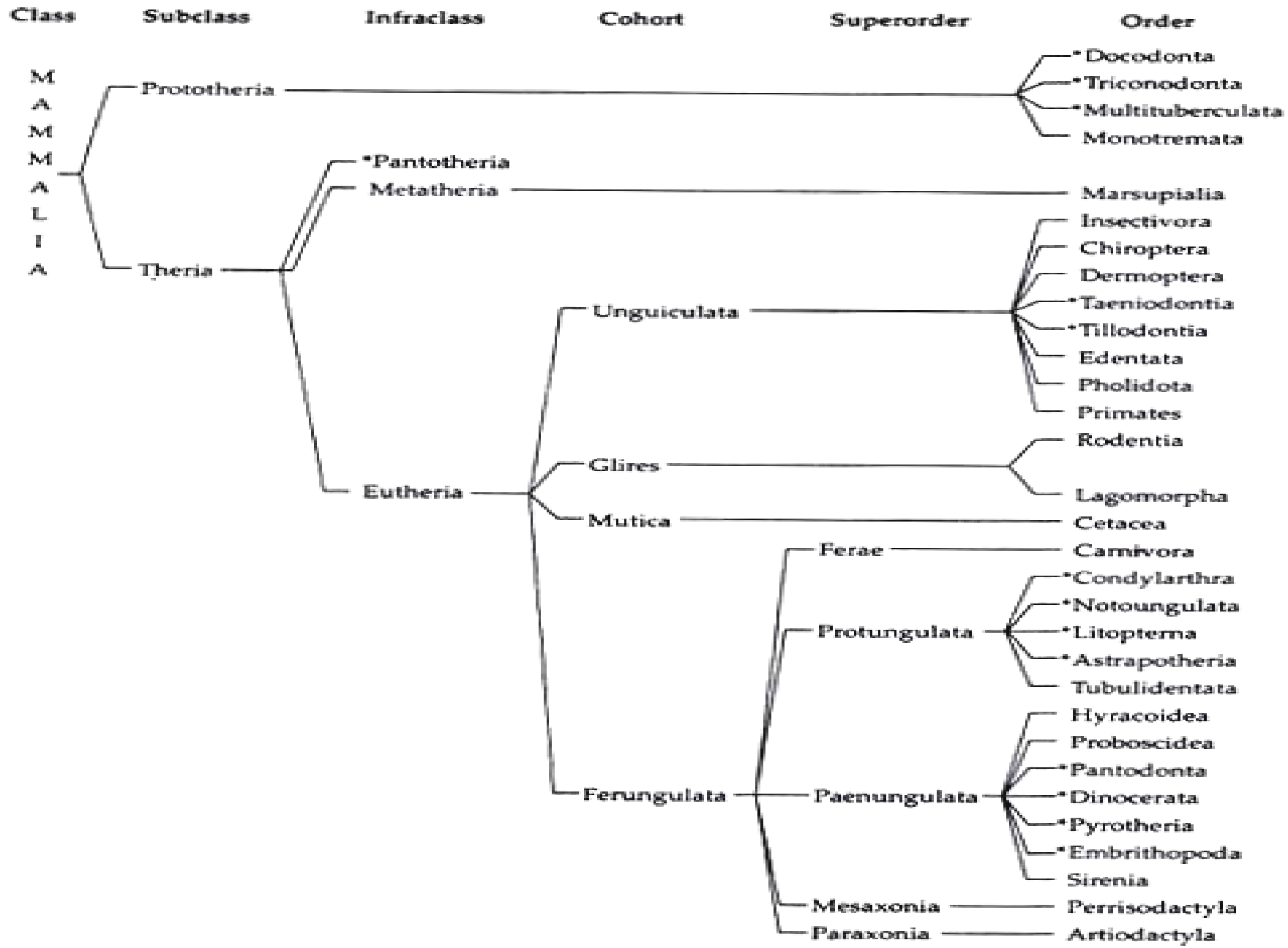
- 8. A thick subcutaneous fat layer, called blubber, is present.
- 9. The lungs are highly elastic and extensible.
- 10. Brain is highly developed but olfactory lobe is reduced.
- 11. Two mammary glands are located in the inguinal area.
- 12. Single, large, well-formed young is born at a time.
- 13. The cranium is dorsoventrally flattened and the facial part is elongated.
- 14. Cervical vertebrae are fused to form a bony mass.

- 15. Sacral vertebrae are absent.
- 16. Caudal vertebrae are with chevron bones.
- 17. Ribs lack heads.
- 18. Number of digits are either reduced to four or increased to more than five (hyperdactyly). Numbers of phalanges are more than the usual number in second and third digits (hyperphalangy).
- 19. Humerus is short, stout and its head moves freely in the glenoid cavity.

Example:

- Platanista (Ganges dolphin), Physeter (Sperm whale), Delphinus (Dolphin), Phocaena (Porpoise), Balaenoptera (Blue whale), Balaena (Right whale).

Platanista (Ganges dolphin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Cohort — Ferungulata:

- 1. Modern carnivores and hoofed animals, all are members of this group.

- 2. From the fossil records it is evident that all of them arose from a common ancestral population in Palaeocene period.

- The cohort Ferungulata is divided into five super orders for the convenience of classification.

Superorder — Ferae:

- 1. All the living members of this group are carnivorous.

Order — Carnivora (Latin: carno = flesh; voro = to eat):

- 1. Pentadactyle limbs, with digits ending in sharp claws and claws may be retractile.
- 2. Locomotion is either digitigrade or plantigrade type.
- 3. Intelligence in the form of mental alertness and coordinated actions is evident.
- 4. Brain is highly developed.
- 5. Intestine is short and caecum is small or absent.
- 6. Testes are present in scrotal sac.
- 7. Mammae are abdominal in position.
- 8. Placenta is deciduate and zonary.
- 9. Uterus is bicornuate in shape.

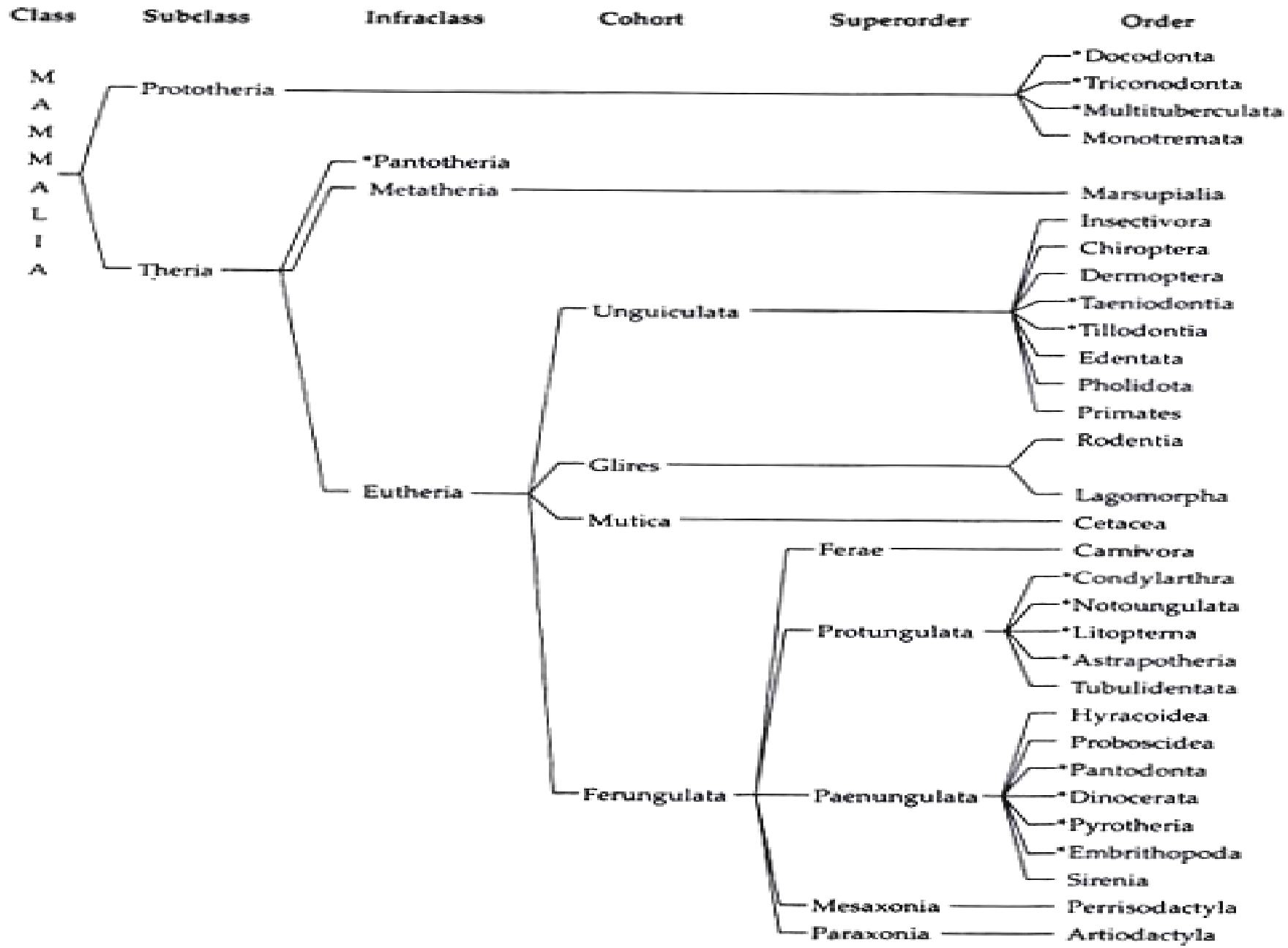
- 10. Skull is short. Sagittal and lambdoidal crests are well-developed.
- 11. Zygomatic arch is strongly built.
- 12. Each jaw possesses three pairs of incisors. Canines are large, sharp and pointed.
- 13. The last upper premolar and first lower molar transformed into blades, and act as incisors — they are jointly known as carnassial teeth.
- 14. The atlas is large and is provided with wing like lateral processes.
- 15. Thoracolumbar vertebrae are 20 to 21 in number.
- 16. Sternum is long narrow and made up of 8 to 9 sternibrae. Sternal ribs are not calcified.

Examples

- Canis (Wolves, Dogs, Jackals etc.), Vulpes (Fox), Ursus (Bear), Procyon (Raccon), Ailurus (Panda), Ailuropoda (Giant Panda), Viverra (Civet), Herpestes (Mongoose), Hyaena (Hyena), Felis (Cats, Pumas, Leopards, Lions, Tigers, Jaguars), Eumetopias (Sea lion), Odobenus (Walrus), Phoca (Seal), Mephitis (Shunk), etc.

Vulpes (Fox)

Ursus (Bear)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Superorder — Protungulata:

- All the members of this group are unguiligrade and herbivorous. This super order includes five orders, among which four are extinct.

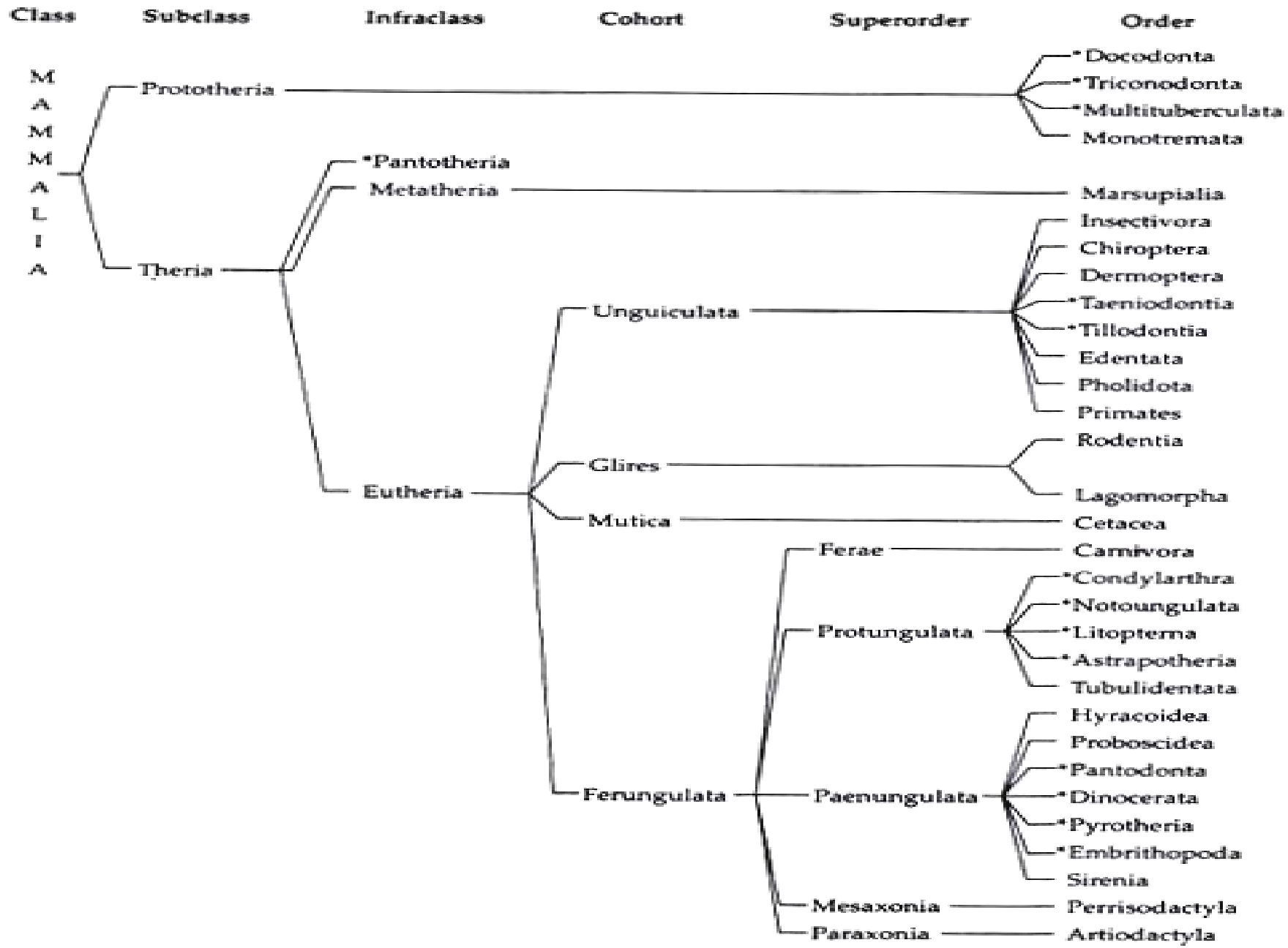
Order — Tubulidentata (Latin: tubulus = small tube; dens = teeth):

- 1. Body is covered by a dull-grey skin with unevenly distributed hair.
- 2. Head is elongated to form a tubular snout.
- 3. Pinna is long in size.
- 4. Four toed forelimbs possess clawed digits. Hind limbs possess five toes with clawed digits. The limbs are powerful.
- 5. Small mouth possesses long, protrusible tongue.
- 6. The cheek teeth are 4 or 5 in number, which lack enamel but a coating of cement is present. Incisors and canines are absent.
- 7. These are ant-eater in habit.

Example

- There is only one representative species present till now. Orycteropus after (ardvark) living in Africa and known as cape ant-eater.

Orycteropus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Superorder — Paenungulata:

- 1. They are all herbivorous animals.
- 2. The legs are with long upper segments, ulna and fibula complete.
- 3. They possess several digits, with nail but no well-marked hoofs.
- 4. The incisors and canine become reduced to single pair of large tusks in each jaw and the molars are specialised for grinding, with development of crossridges.
- Simpson (1945) suggested the name paenungulata (= near ungulates).

Order — Hyracoidea (Greek: hyrax = shrew; eides = form):

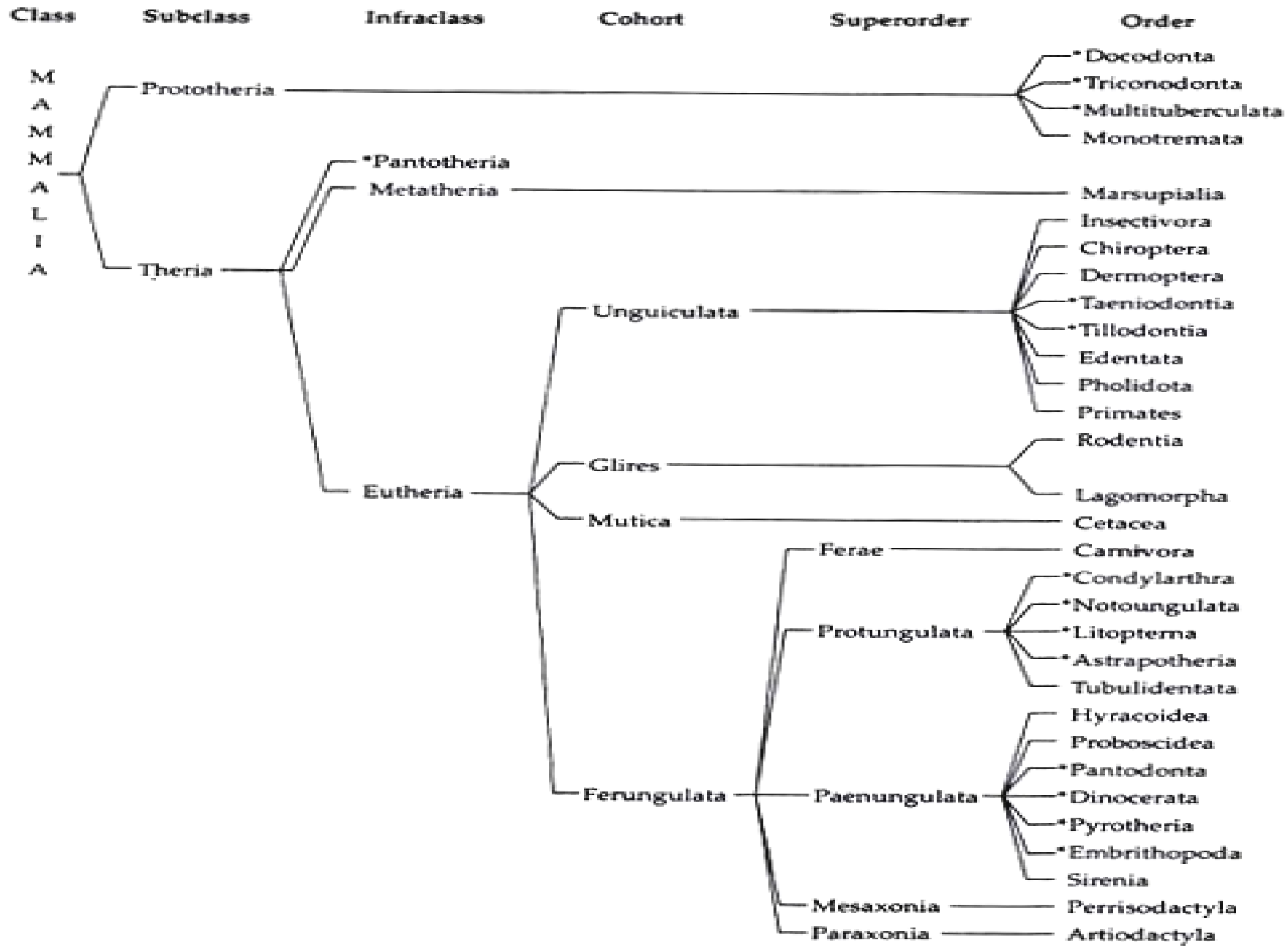
- 1. These are rabbit-like animals, with short tail and short pinna.
- 2. Locomotion is plantigrade type.
- 3. Forelimbs possess four functional digits and fifth one remains as vestige.
- 4. There are three digits in each hind limb. First and third digits possess hoof while second digit is clawed.
- 5. The caecum has a pair of caecal pouches.
- 6. Abdominal testes are present.
- 7. Mammae are pectoral in position and two in number.

- 8. Uterus is paired; the placenta has an annular avascular allantois and haemochorial in nature.
- 9. Single pair of large and curved upper incisors with persistent root is present. Canines are absent.
- 10. The lower incisors are comb-like and four in number.
- 11. There is a diastema and seven grinding molariform teeth of bunoselenodont type, with transverse ridges.
- 12. Brain is of macro somatic type.

Example:

- Procavia (= Hyrax), Dendrohyrax (Tree hyrax).

Procavia (= Hyrax)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Lagomorpha
Cetacea
Ferae
Protungulata
Paenungulata
Mesaxonia
Paraxonia
Carnivora
*Condylarthra
*Notoungulata
*Litopterna
*Astrapotheria
Tubulidentata
Hyracoidea
Proboscidea
*Pantodonta
*Dinocerata
*Pyrotheria
*Embrithopoda
Sirenia
Perrisodactyla
Artiodactyla

Order — Proboscidea:

- 1. These are largest living land vertebrates.
- 2. Thick skin with scanty hair.
- 3. An enormously elongated nose and upper lip, with appropriate muscles and sensitive grasping tip makes the proboscis.
- 4. Only one pair of continually growing upper incisors forming the two enormous uncurved tusks. These are composed of solid dentine except for a temporary cap of enamel at the tip.
- 5. Nostrils are situated at the tip of the trunk.
- 6. Eyes are small but pinna is large.
- 7. Pentadactyle limbs are pillar-like. Digits are hoofed.

- 8. The weight of the head is reduced by extensive development of air sinuses between the inner and outer tables of bones of the skull.
- 9. The immensely large hypsodont molars with numerous sharp transverse ridges are parts of the powerful grinding apparatus.
- 10. The skeleton shows typical graviportal features. The backbone is based on a ‘single girder’ plan, with twenty ribs and high thoracic neural spines.
- 11. The ilium is nearly vertical and expanded transversely for the attachment of large muscles.
- 12. Cerebral hemispheres are relatively small and leave the cerebellum uncovered.
- 13. Stomach and intestine are simple. There is no special chamber in stomach for fermentation of herbaceous food.

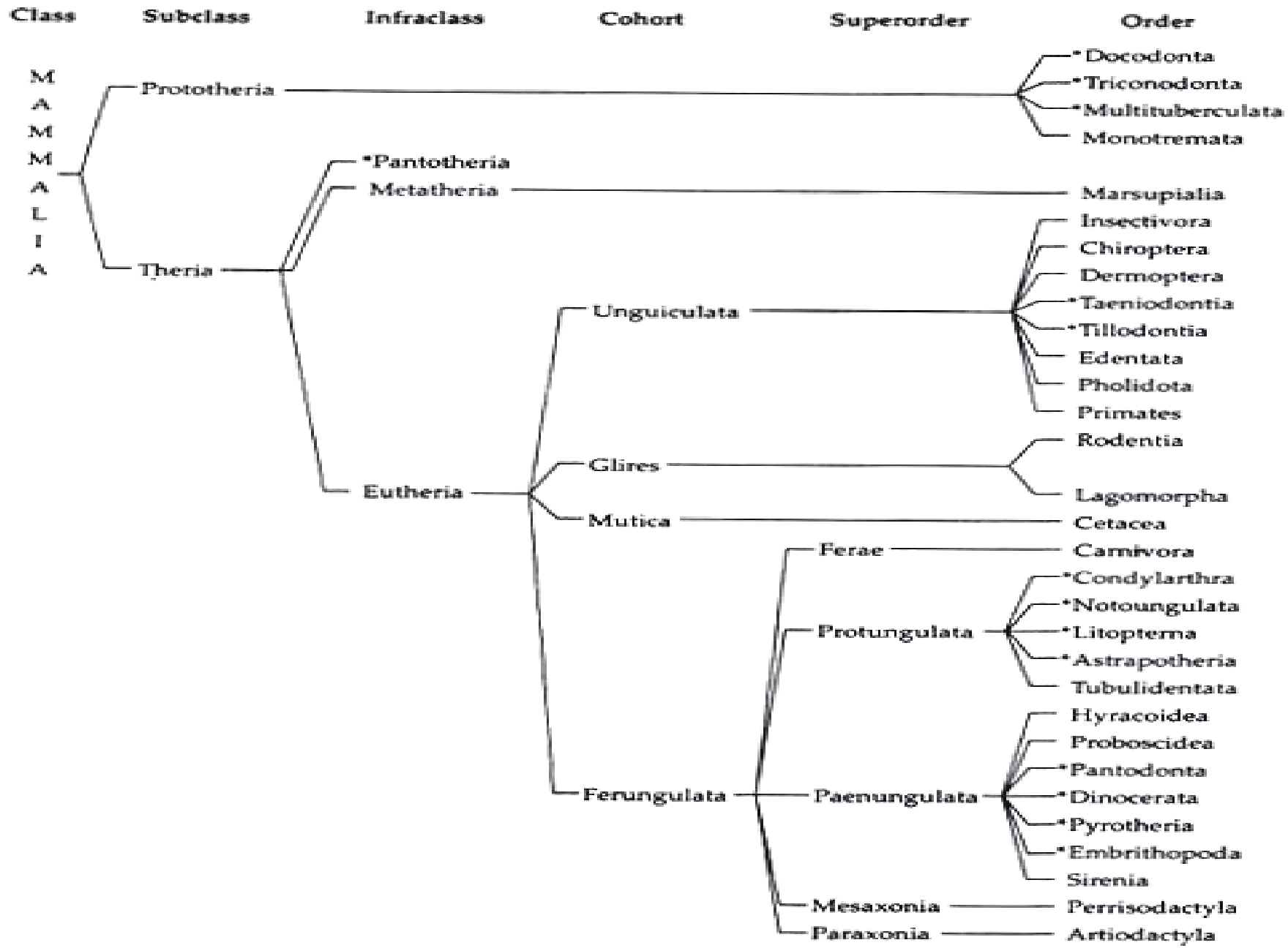
- 14. The caecum is long and sacculated and there is an ileocaecal sphincter.
- 15. Testes lie close to kidneys, no scrotal sac is present.
- 16. The two horns of the uterus remain separate, though united externally.
- 17. Only one young is born at a time. Gestation period 22 months.
- 18. Placenta have at the poles, areas of diffuse, non-deciduate structure, while in an annular zone round the middle there is much invasion of the trophoblast.

Example

- Elephas (Asian elephant), Loxodonta (African elephant).

Elephas (Asian elephant)

Loxodonta (African elephant)


Class
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Order
MAMMALIA
Prototheria
Theria
*Docodonta
*Triconodonta
*Multituberculata
Monotremata
*Pantotheria
Metatheria
Eutheria
Marsupialia
Unguiculata
Glires
Mutica
Ferungulata
Insectivora
Chiroptera
Dermoptera
*Taeniodontia
*Tillodontia
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*Dinocerata
*Pyrotheria
*Embrithopoda
Sirenia
Perrisodactyla
Artiodactyla

Order — Sirenia (Greek: siren = sea nymph):

- 1. These are herbivorous animals, highly adapted for aquatic life.
- 2. They have a streamlined body form, with few hair and thick blabber.
- 3. The muzzle is round and the upper lip is protruding.
- 4. Nostrils are located on the upper surface of head and are provided with valves.
- 5. Neck is short and pinna is absent. Eyes are small with muscular eyelids.
- 6. There are no hind limbs and the pelvic girdle remains only as small rods.
- 7. The forelimbs are large; the digits are joined to form paddles, with a full pentadactyle structure

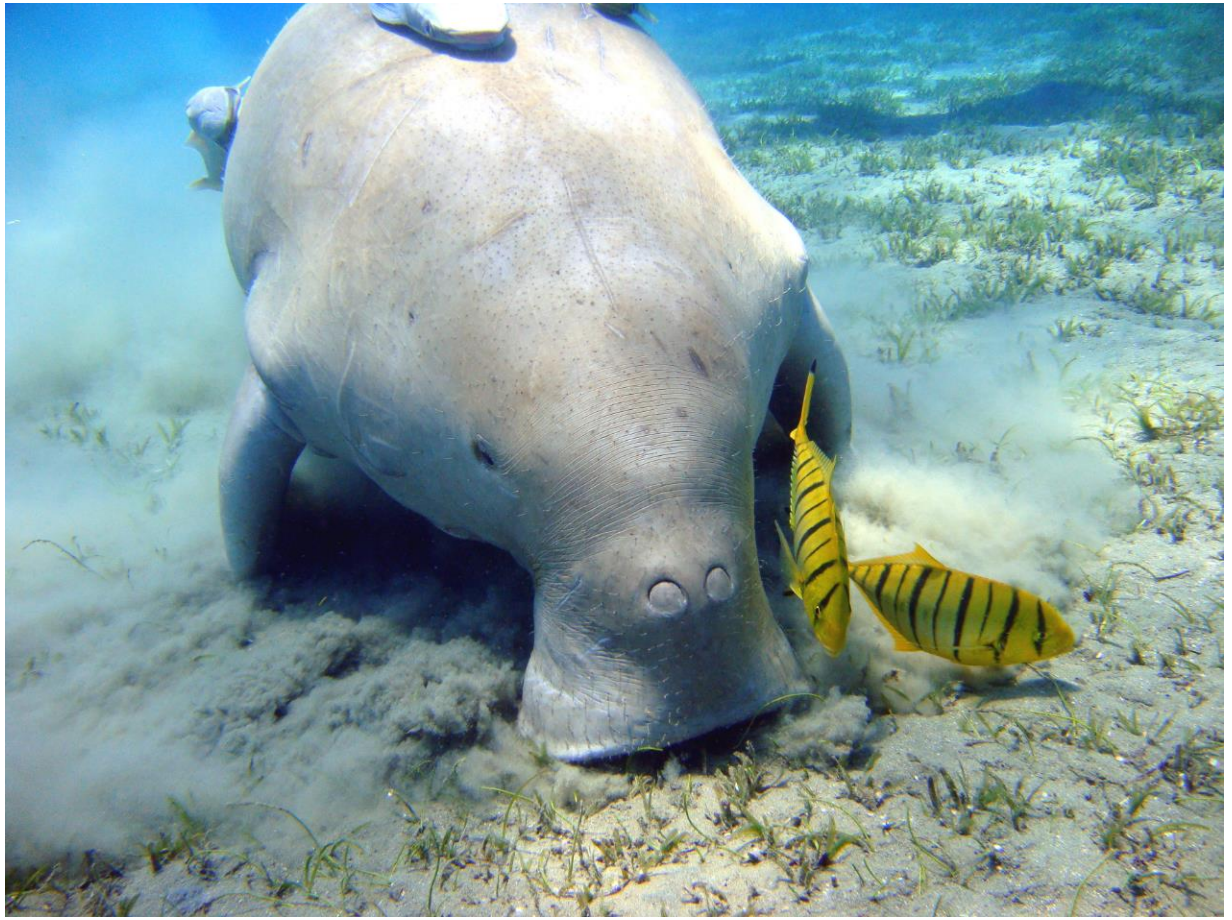
- 8. Caudal vertebrae are well-developed.
- 9. A strong terminal horizontal fin is present.
- 10. Ribs are round and the diaphragm is oblique.
- 11. Lungs contain large air sacs.
- 12. Brain is small and the ventricles are exceptionally large.
- 13. The front parts of the jaw carry no teeth at the front, but have horny pads. The teeth form a series of pegs, with two transverse ridges.

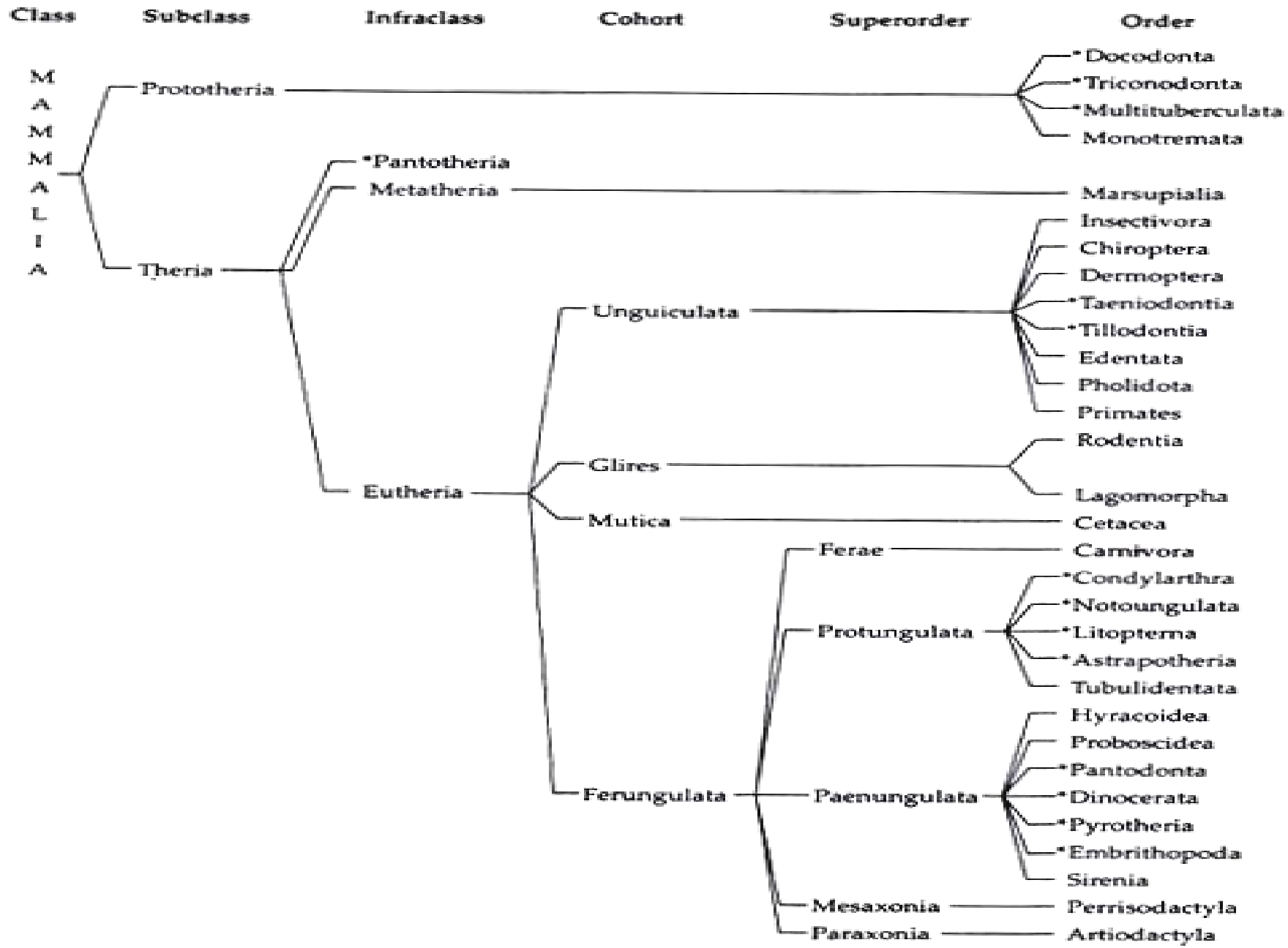
- 14. Stomach is complex and intestine is very long.
- 15. Testes are abdominal. Uterus is bicornuate.
- 16. Placenta shows a zonary arrangement and haemochorial structure,
- 17. The young are born in water and nursed at pectoral teats.

Example:

- Dugong (= Halicore) (Sea cow), Manatus (= Trichechus) (Manatee).

Dugong (= Halicore) (Sea cow)

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Sirenia
Perrisodactyla
Artiodactyla

Superorder — Mesaxonia:

- 1. Axis of the limbs passes through the third digit (middle axis). This is called the mesaxonic condition. The remaining digits are reduced.

Order — Perissodactyla (Greek: perissos = odd; daktylos = finger):

- 1. These are large, herbivorous mammals having streamlined body.
- 2. The neck and facial parts are elongated.
- 3. Tail is with long tuft of hair.
- 4. The powerful limbs are suitable for fast movement.
- 5. The lower part of the limbs became elongated and the upper segments shortened.
- 6. One distal carpal, the capitate (magnum), become enlarged and interlocked with the proximal carpals.
- 7. Of the five digits, the first and fifth digits are lost. The second and fourth digits remain as splints. The middle or third digit is stout and is provided with hoof

- 8. Stomach is simple and undivided.
- 9. Digestion of cellulose takes place by symbionts in the caecum and large intestine.
- 10. Brain is relatively small and macrosmatic type. Olfactory lobe is highly developed.
- 11. Skull is elongated.
- 12. The incisors are three in each quadrant of the jaws. The incisors having pit on the free surface.
- 13. The canine may be reduced or absent and there is often a diastema.

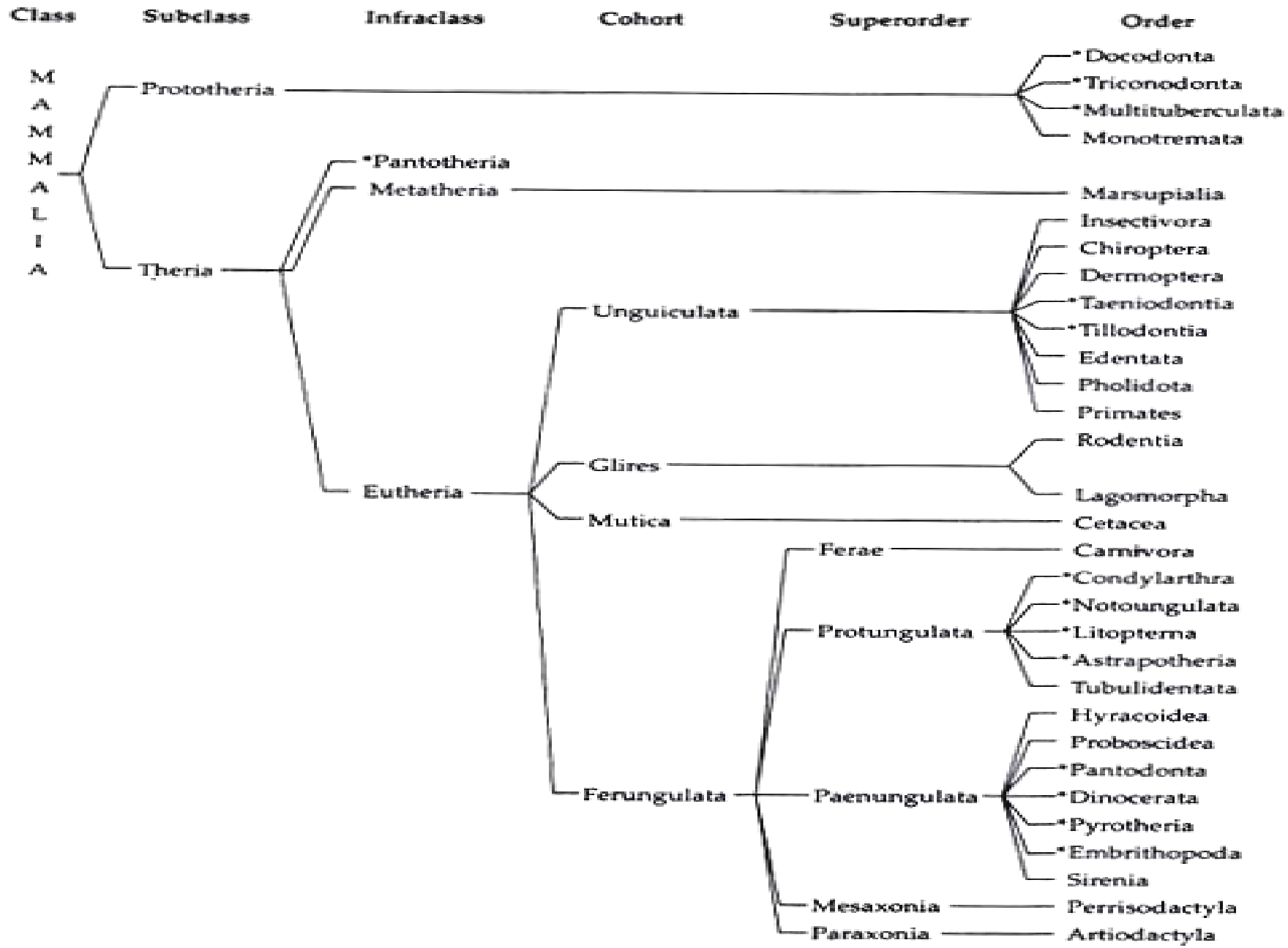
- 14. The molars have developed an elaborate grinding surface with the formation of a longitudinal ectoloph along the outer edge of the upper molar and parallel transverse ridges, the protoloph and metaloph.
- 15. Ulna and fibula are reduced.
- 16. The femur is provided with a prominent process on the other surface of the shaft. The process is called third trochanter.

- 17. Astragalus has a double-keeled pulley-shaped surface for articulation with tibia.
- 18. The third metatarsal of the hind limb is long and erect and is known as cannon bone.
- 19. Uterus is bicornuate. Placenta is of diffuse epitheliochorial type, with a large allantoic sac.
- 20. The yolk sac grows to a large size and forms a yolk sac placenta during the early part of the development.

Example:

- Tapirus (Tapir), Rhinoceros (Rhinos — Indian and Javan), Dicerorhinus (Horses, Asses, Zebras).

Tapirus (Tapir)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*Embrithopoda
Sirenia
Perrisodactyla
Artiodactyla

Superorder — Paraxonia:

- 1. Axis of the limbs passes through the third and fourth digits.

Order — Artiodactyla (Greek: Artios = even; daktylos = finger):

- 1. These are even toed ungulates and latest mammalian herbivores.
- 2. Neck is elongated but tail is small.
- 3. Usually possess a pair of epidermal horns. Horns may be hollow or solid and are located on the frontal bone of the skull.
- 4. The characteristic of the limbs is the equal development of third and fourth digits, with reduction of the rest.
- 5. Gait is digitigrade type. Hoofs have developed on the toes.
- 6. The long metapodials have become united to make the cannon bone.
- 7. The presence of two digits has led to the retention of two bones in the distal row of carpals, the hamate (unciform) and fused magnum-trapezoid. These articulate in interlocking fashion with the three proximal carpals

- 8. In the hind foot the two cuneiforms are fused to provide thrust upon the third digit, while the fourth sends its thrusts to the cuboid and the latter is fused with the navicular.
- 9. The eyes are large with horizontal pupil. Pinna is large with an acute sense of hearing.
- 10. Tongue is long, mobile, prehensile and pointed.
- 11. The upper incisors are lost, which crop up by means of the lower incisors biting against the hardened gum of the premaxilla.
- 12. The canine may form tusks.
- 13. Molars are of hypsodont and solenodont (moon-tooth) condition.
- 14. Stomach is complicated and divided into several chambers.

- 15. Intestine is short and a short caecum is present.
- 16. Mammae are abdominal or inguinal in position and may be more than one pair.
- 17. Brain is moderately developed. The olfactory organ and related parts of the brain are well-developed.
- 18. The uterus is bicornuate type.
- 19. Placenta of pig is of diffused epitheliochorial type. In ruminants there is a cotyledonary placenta, but the contact between maternal and foetal tissues is never very close (Syndesmochorial) and the allantois is usually large.

Examples:

- Sus (Pig), Hippopotamus (Hippo), Camelus (Camel, dromedary — Asia), Moschus (Musk deer), Ceruus (Red deer), Dama (Fallow deer), Rangifer (Rein deer), Giraffa (Giraffe), Gazella (Gazelles), Bos (Cattle, Yak), Bison (Buffalo), Capra (Goat), Ovis (Sheep).

Hippopotamus (Hippo)

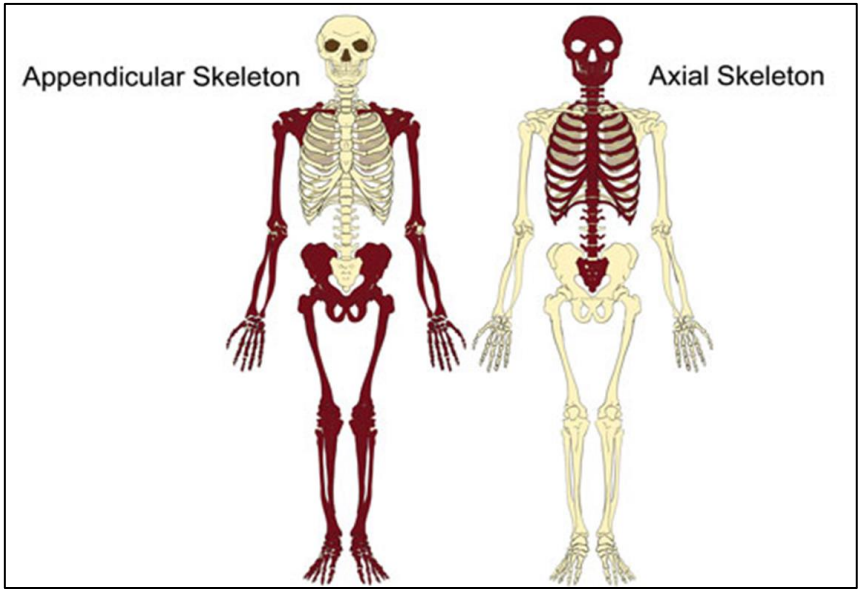

Thank You

Anatomy And Skeleton Of Mammals

WHAT DOES A SKELETON DO?

- The skeleton is the body's framework
- it provides structural support against the force of gravity,
- a system of levers that function in locomotion,
- attachment points for the muscles that drive movement
- Protects internal organs
- Site of blood cell production
- Plays a role in endocrine regulation to control blood sugar
- Acts as a reserve of calcium and phosphorus

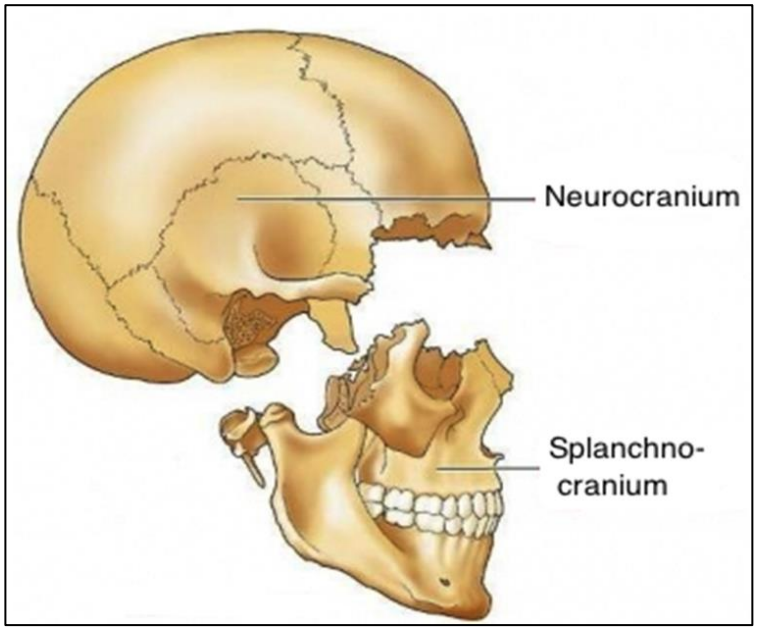
Components



Vertebrate skeletons consist of two subdivisions:

1. the **axial skeleton** corresponds to the skull, vertebral column, ribs, and sternum;
2. the **appendicular skeleton** comprises bones of the pectoral and pelvic girdles and their associated limbs

SKULL



- Comparative anatomists divide the skull into three portions, each with a distinct developmental origin:

1. the *neurocranium* (or primary braincase),
2. the *dermatocranium* (membrane bones that surround the neurocranium), and
3. the *splanchnocranium* (jaws and other derivatives of the embryonic pharyngeal arches).

- The *neurocranium* consists of bones, few of which are visible on the surface of the skull, that ossify in the shape of a bowl to hold the brain.

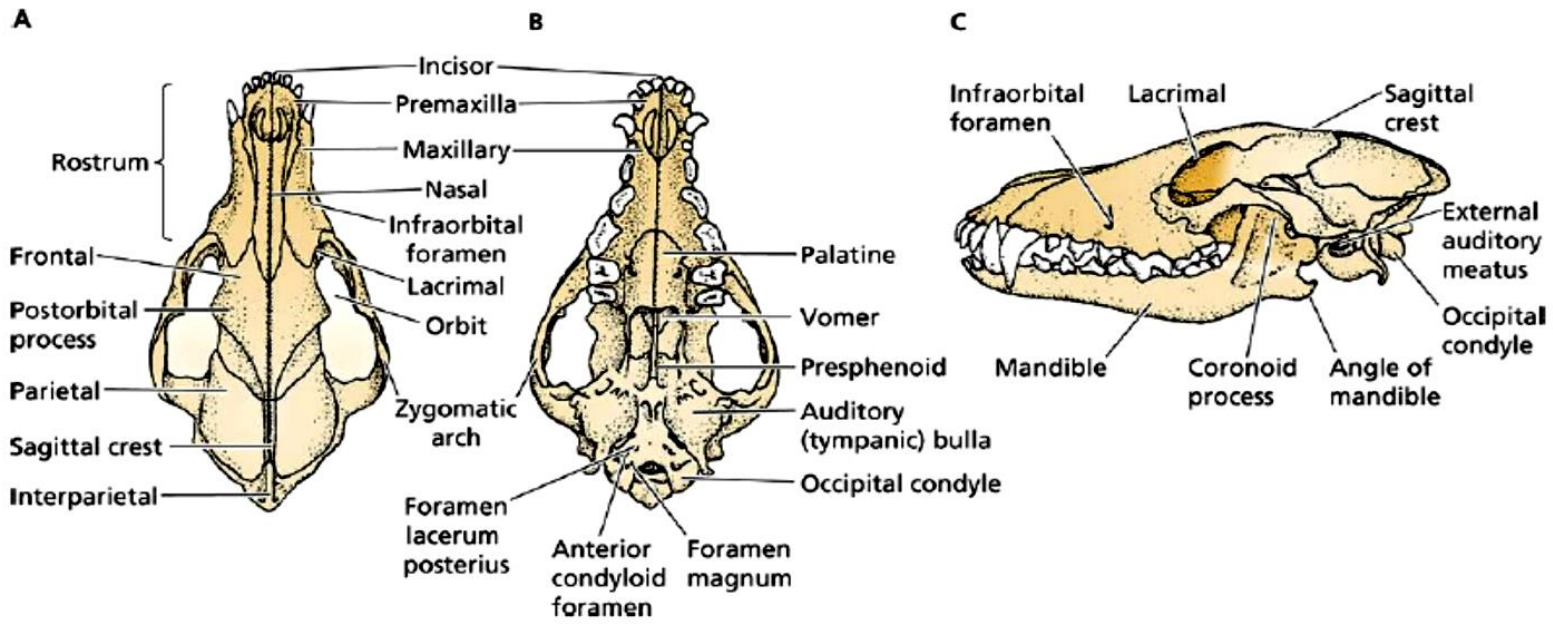
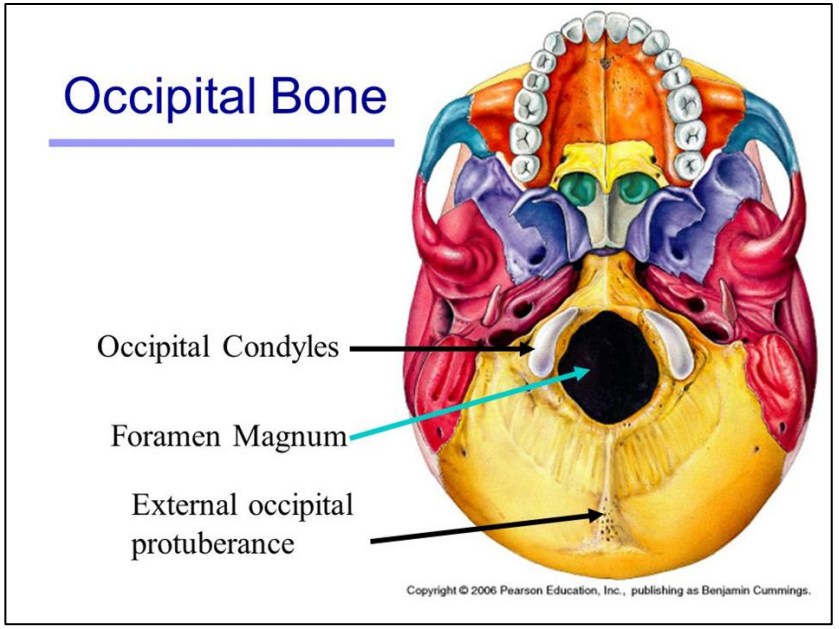


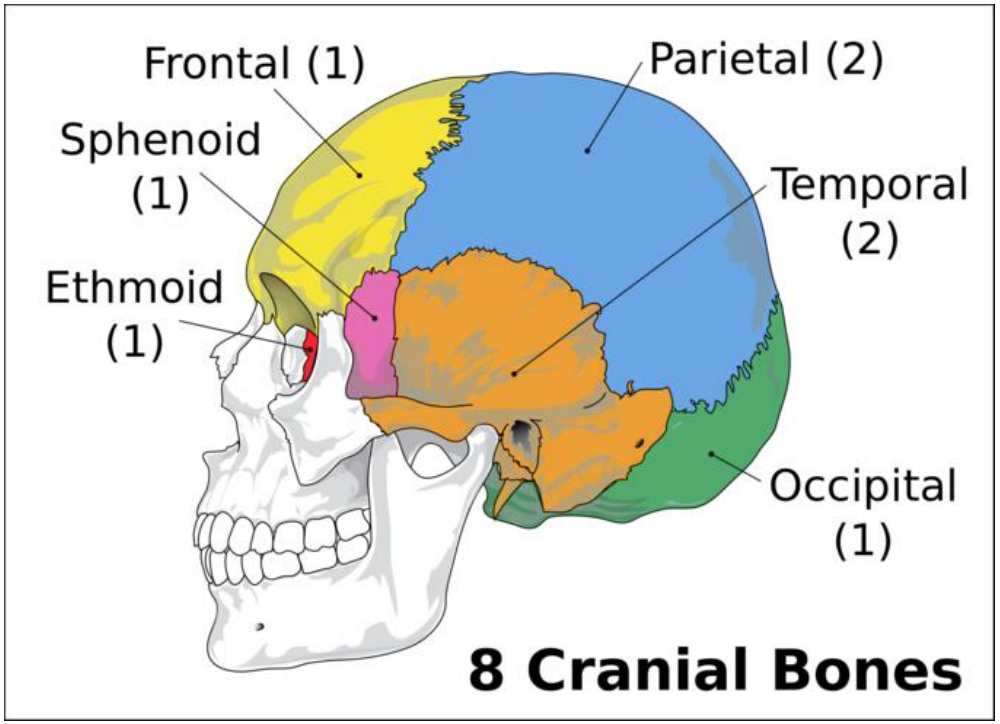
Figure 7.10 Anatomy of the skull. The skull of a coyote (*Canis latrans*). (A) Dorsal view of cranium. (B) Ventral view of cranium. (C) Lateral view of cranium and mandible. *Adapted from Gunderson and Beer (1953).*

- Many of the bones are perforated by openings (foramina) that allow passage of nerves and blood vessels

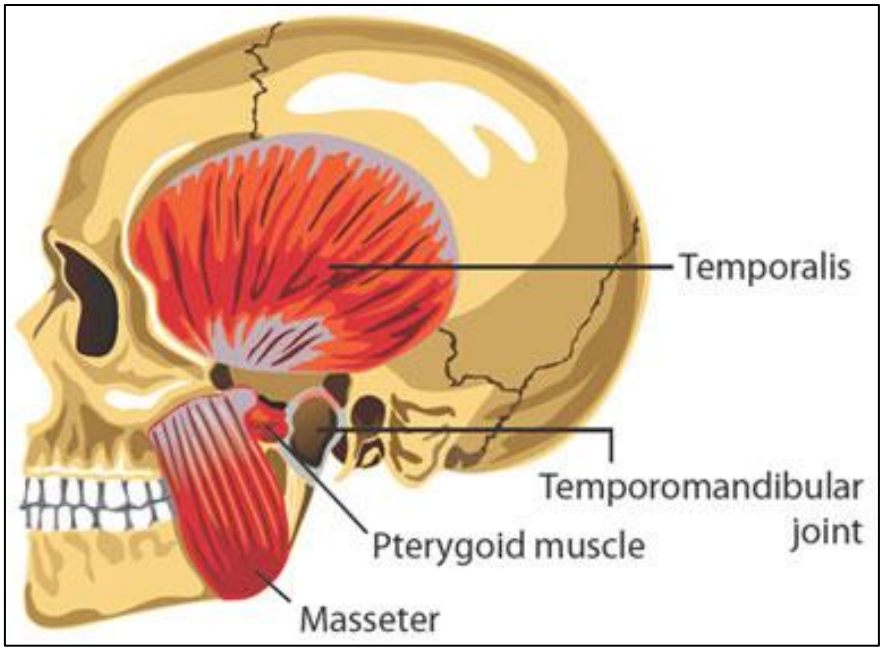


- At the back of the skull, a ring of *occipital* bones (basioccipital, exoccipitals, supraoccipital) forms a **foramen magnum,** through which the spinal cord passes, and a pair of *occipital condyles* on either side that articulate with the vertebral column.

- Sphenoid bones form the anteromedial floor of the braincase (basisphenoid, presphenoids) and contribute to the wall of the orbit (orbitosphenoid).
- Ethmoid elements surround the nasal area, giving rise to scroll-like turbinal bones that support the olfactory and nasal epithelia, a perforated cribiform plate through which pass fibers of the olfactory nerve.

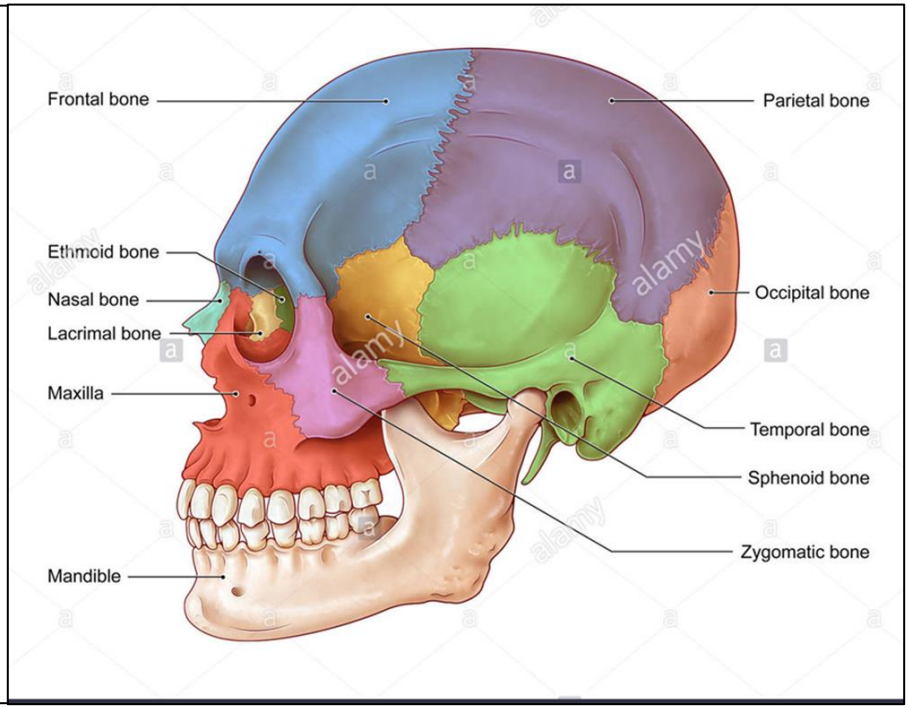


- Paired *roofing bones* (frontals, parietals) occur on either side of the dorsal midline, forming a medial **sagittal crest** that marks the dorsal-most origin of the temporalis jaw muscle.



- At the rear angle of the skull (the *temporal* region), a squamosal bone contributes to the jaw joint and the posterior portion of the **zygomatic arch.**
- The arch, a point of origin for the masseter muscle, is completed anteriorly by a jugal bone.
- Lacrimal bones form in the anteromedial corners of each orbit.

- Remnants of embryonic cartilage in the upper jaw are invested by dermal bones to form paired, tooth-bearing premaxillae and maxillae; portions of the same embryonic cartilages ossify in the posterior walls of the orbits as alisphenoid bones.



- On the ventral portion of the cranium, bones of the primary palate (vomer, palatine, pterygoid) lie alongside neurocranial bones.
- The premaxillae, maxillae, and palatines develop wing-like processes that grow ventrally and medially to meet at the midline and form a complete secondary palate.

- The lower jaw, or **mandible,** consists of right and left tooth-bearing bones (dentaries) that meet anteriorly at the mandibular symphysis.
- Each dentary articulates with a squamosal bone of the cranium to form the characteristic dentary-squamosal jaw joint of mammals.
- A depression, the masseteric fossa, on the lateral surface of the dentary marks the insertion site of the masseter muscle; the temporalis muscle inserts dorsally on the coronoid process.

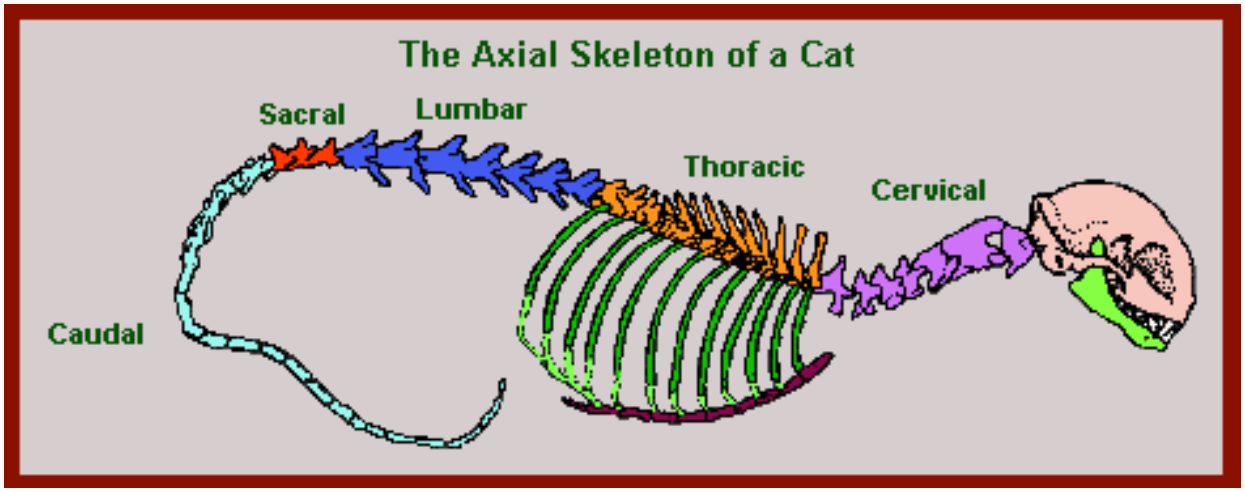
- The dentary bone develops by ensheathing the anterior portion of the embryonic lower-jaw cartilage.
- At its posterior end, however, remnants of this cartilage and that of the upper jaw ossify as small *ossicles* (malleus and incus, respectively) within the middle ear cavity.
- A third ossicle, the stapes, is common to all tetrapods and is derived from the dorsal most element of the second pharyngeal arch in fishes.
- A fourth lower-jaw bone of mammalian ancestors, the angular, is homologous to the tympanic bone that frames the eardrum (tympanum) of mammals.

- The protrusion of the jaw and snout varies considerably among mammals, ranging from the nearly flattened face of primates to the elongated rostrum of carnivores.
- These variations relate to differences in diet, the importance of olfaction, the angle of the skull relative to the vertebral column, and the location of muscles that move the skull.
- The flattened face of primates is an adaptation for binocular vision; a short snout allows the eyes to face forward and their visual fields to overlap, a prerequisite for stereoscopic perception.
- The hyoid apparatus, located in the throat region, consists of an H shaped array of small bones that support the tongue and larynx

VERTEBRAL COLUMN

- FIVE TYPES OF VERTEBRAE:

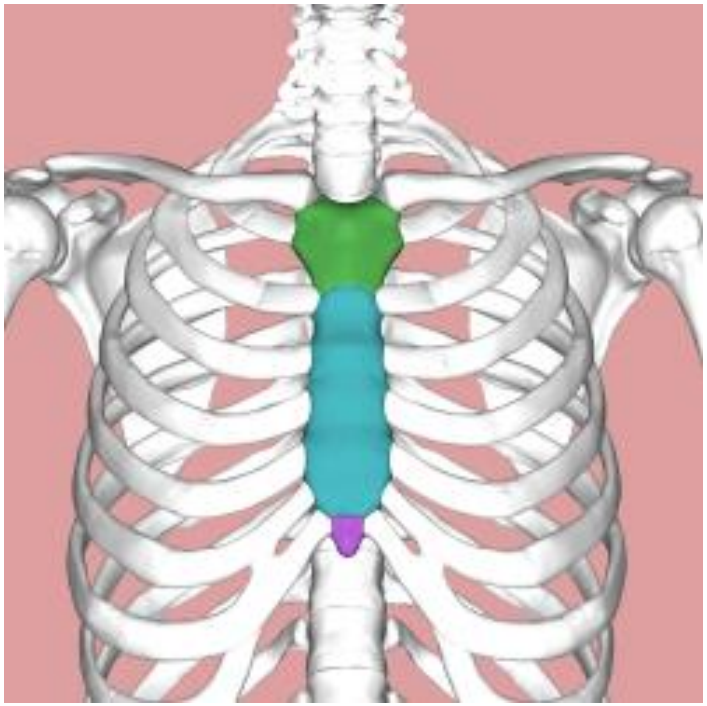
A. Cervical
B. Thoracic
C. Lumbar
D. Sacral
E. Caudal



- All mammals except sloths and manatees have 7 cervical vertebrae in the neck.
- The first cervical vertebra, the axis, articulates anteriorly with the occipital condyles of the skull and posteriorly with the second cervical, the atlas.
- The structure of this joint allows mammals to move their skulls both vertically and horizontally, independent of the body trunk, improving their ability to position sensory receptors on the head for maximum sensitivity to external stimuli.

- Posterior to the cervicals, 12–15 thoracic vertebrae occur in the chest region and articulate with ribs; the long, dorsocaudally oriented spinous processes of mammalian thoracics make these vertebrae readily identifiable.
- In the lower back region are 4–7 lumbar vertebrae, which may be partially or entirely fused to one another.
- In most mammals, the sacral vertebrae (usually 3–5, but as many as 13 in edentates) are fused to form a sacrum that articulates with the pelvic girdle.
- A variable number of caudal vertebrae occur in the tail, usually diminishing in size and structural complexity toward the distal end.
- The 4–5 vestigial caudals of hominoid primates fuse to form a rigid coccyx (“tailbone”) posterior to the sacrum.

RIBS, AND STERNUM

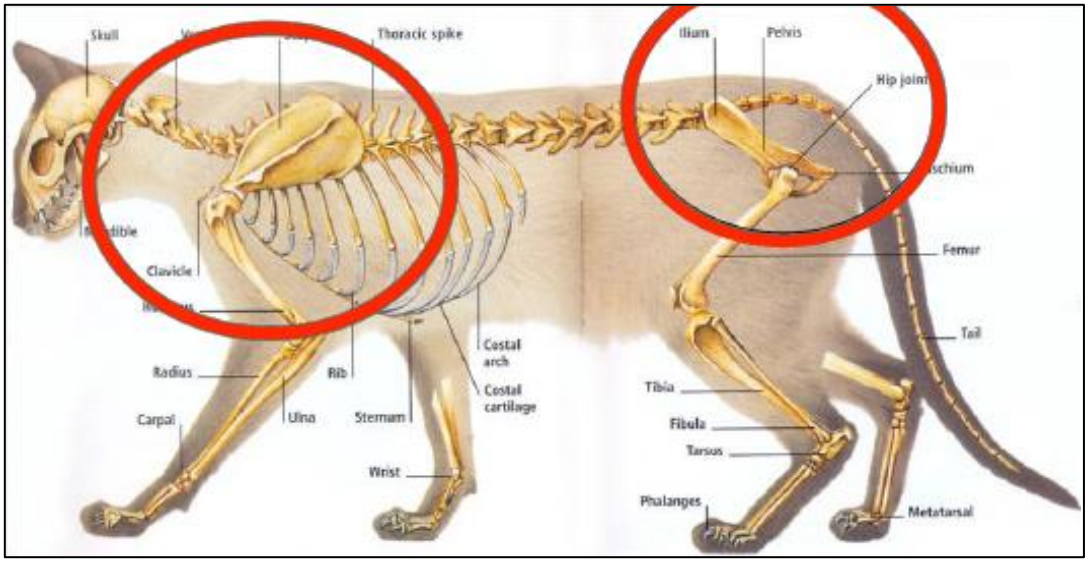


- The remainder of the axial skeleton consists of ribs attached to thoracic vertebrae at their dorsal ends and to the sternum via costal cartilages or a more anterior rib at their ventral ends.
- Most mammals have 12 pairs of ribs, but the number ranges from 9 (in whales) to 24 (in sloths).
- The posterior ribs usually fail to reach the sternum, terminating instead as “floating” ribs.
- The rib cage, or thoracic basket, surrounds and protects the heart and lungs.
- Ribs also provide attachment surfaces for muscles that expand or compress the thoracic cavity.

APPENDICULAR SKELETON

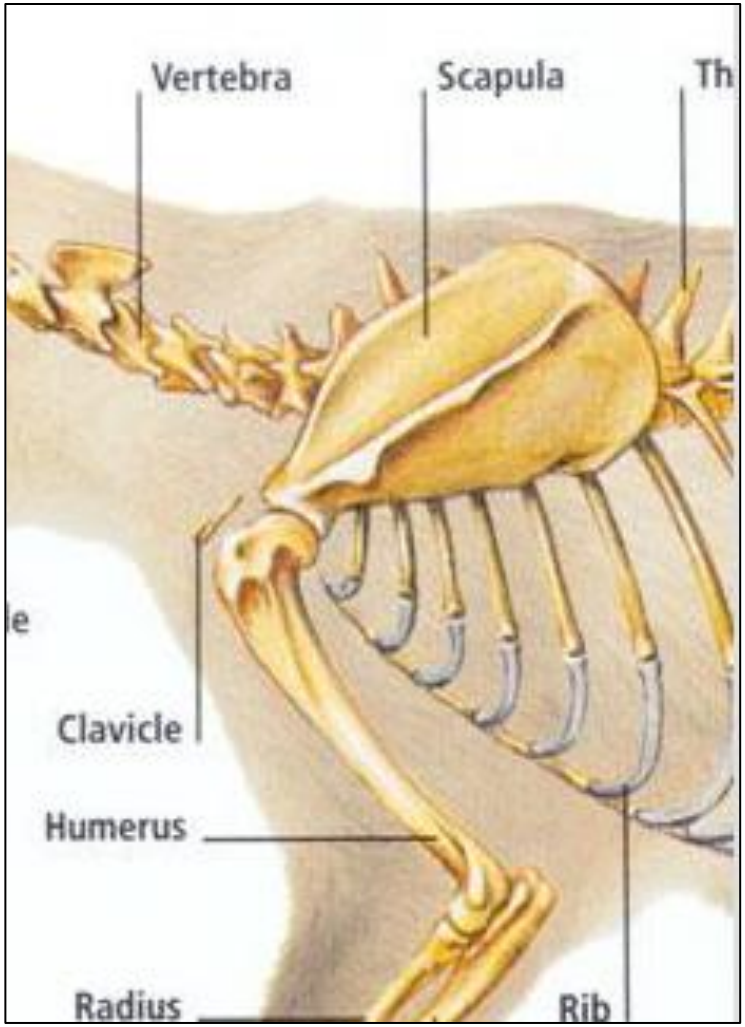
- Two sets of structures link the limbs to the axial skeleton:

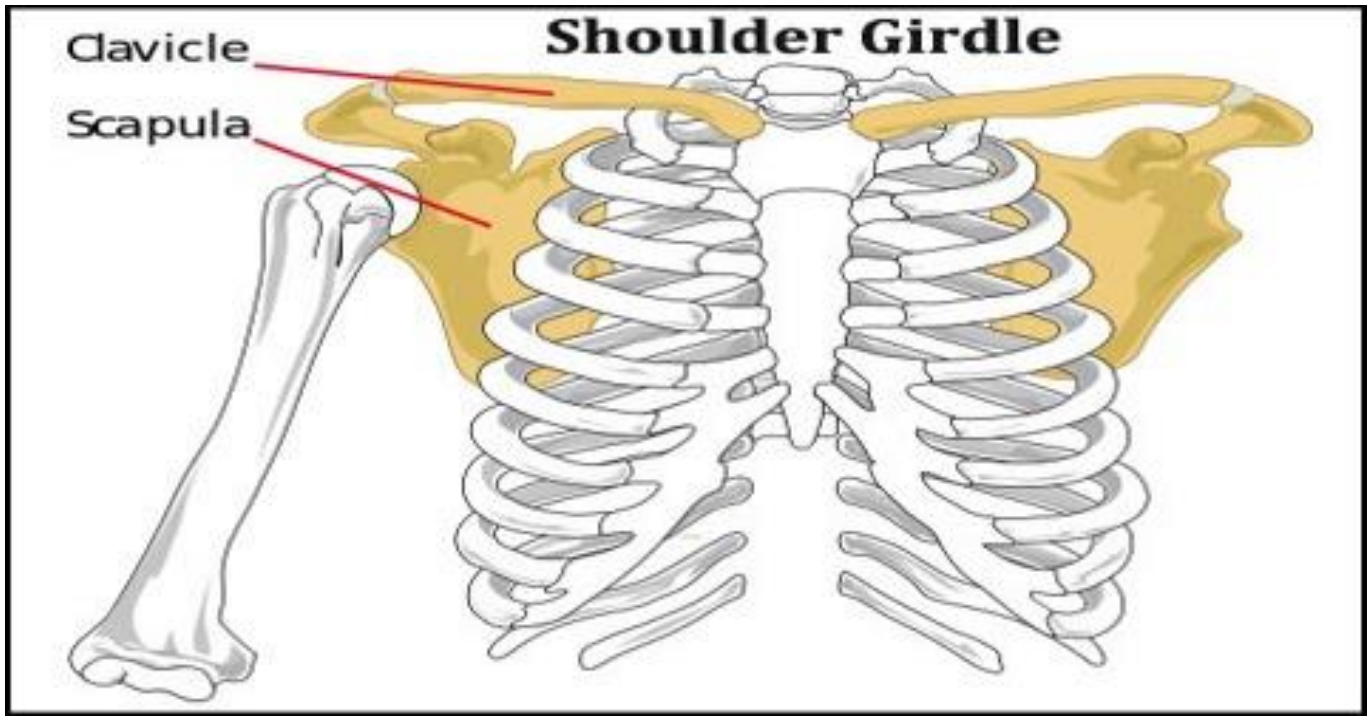
1. Pectoral Girdle: Links Forelimbs
2. Pelvic Girdle: Links Hindlimbs



- Two sets of structures link the limbs to the axial skeleton:
- Pectoral Girdle:

1. Clavical (Collar Bone)
2. Scapula (Shoulder Blade)

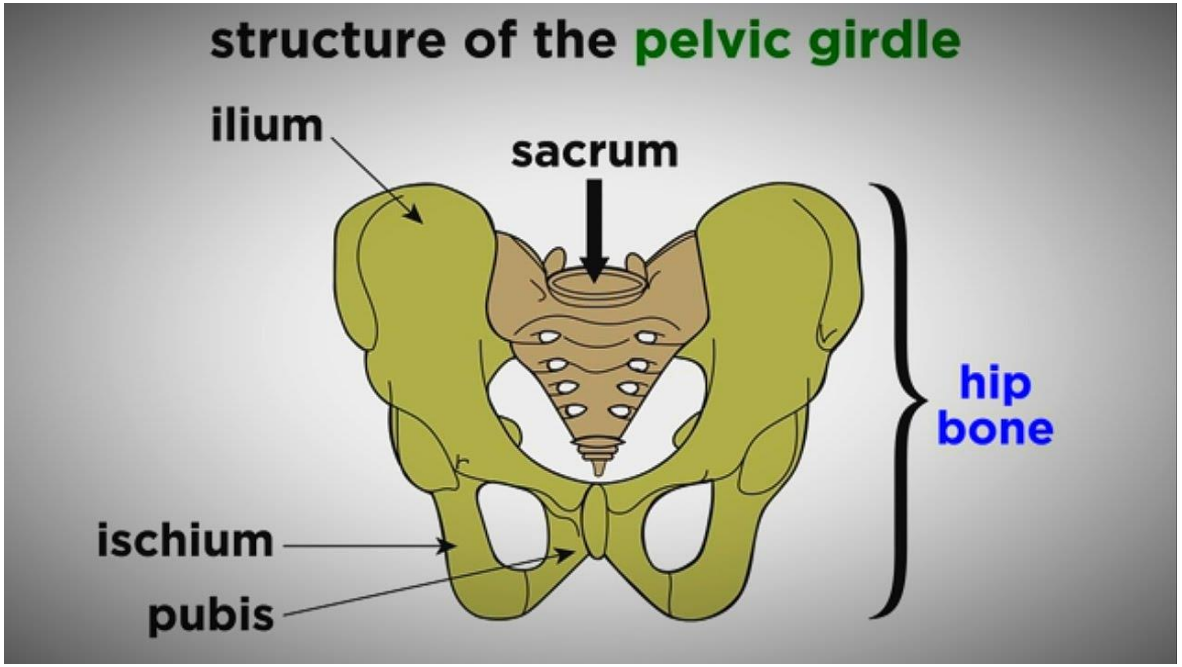



Shoulder Girdle
Clavicle
Scapula

- Two sets of structures link the limbs to the axial skeleton:

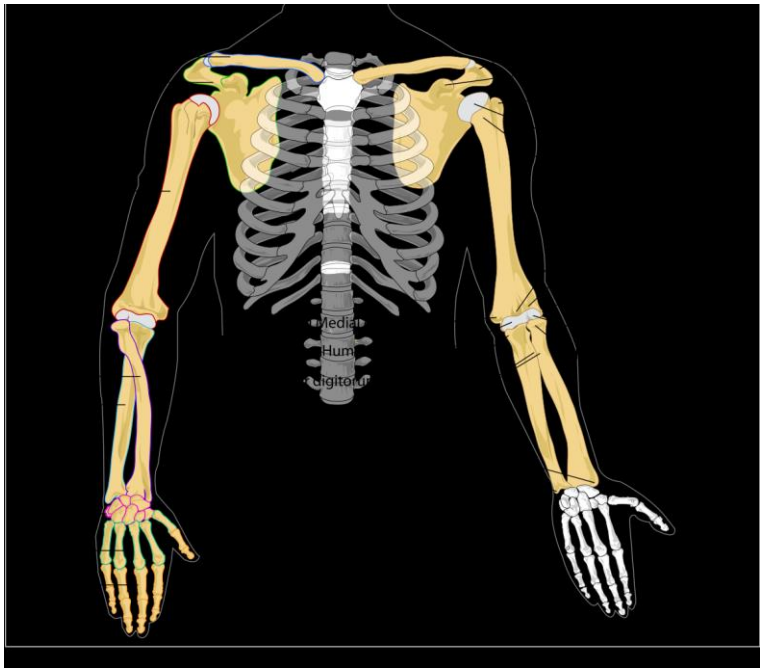
Pelvic Girdle:

- Ilium
- Ischium
- Pubis



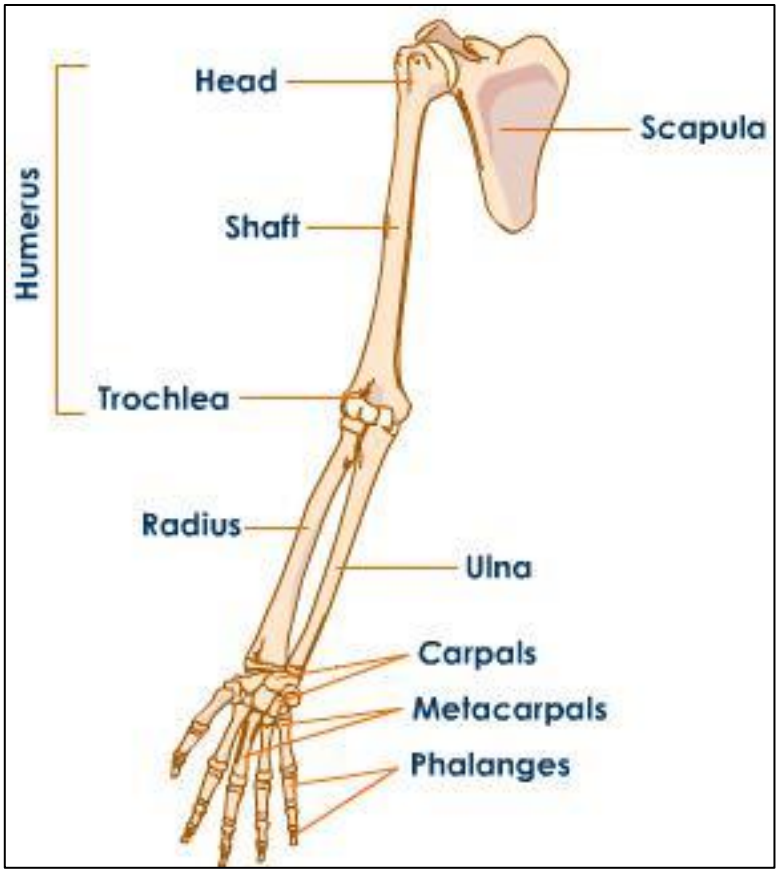
- Forelimbs and hind limbs have a common architecture, consisting of a

1. proximal propodium,
2. an intermediate epipodium, and
3. a distal autopodium.



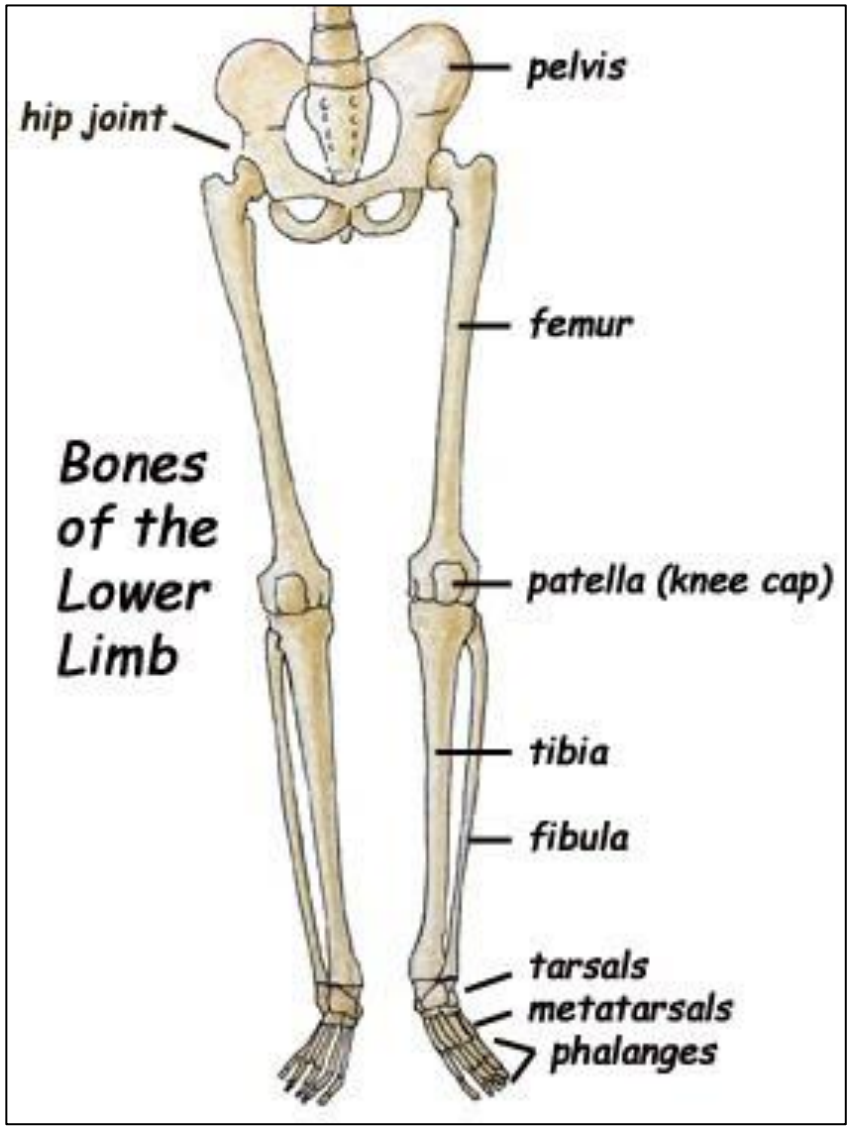
- In the forelimb, the propodium consists of a single long bone, the humerus, which articulates proximally at the glenoid fossa of the scapula.
- Distally the humerus articulates with the paired epipodial bones of the forearm, the medial radius and lateral ulna, forming the elbow joint.

- The proximal part of the autopodium consists primitively of three rows of small carpal (wrist) bones, but these are often reduced or fused in extant mammals.
- Beyond the wrist, there are primitively five metacarpal bones forming the palm, followed by two or more phalanges comprising each digit.



- Metacarpals and phalanges may be reduced or lost in some cursorial species that have fewer than five digits.

- In the hind limb, the propodial bone is the femur, articulating proximally at the acetabulum of the pelvis to form the ball-and-socket hip joint.
- Distally, the femur meets the paired epipodial bones (the tibia and fibula) to formthe knee joint.
- Tarsal bones form the ankle joint and were primitively arranged much like the carpals.



- In modern terrestrial mammals, the number of tarsals is usually reduced, but one of the proximal bones is expanded posteriorly to form a heel, the insertion site of the powerful shank muscles (via Achilles' tendon).
- Metatarsals (one per digit) form the sole, articulating distally with one or more phalanges in the digits.
- Hind limbs are absent in cetaceans and sirenians.

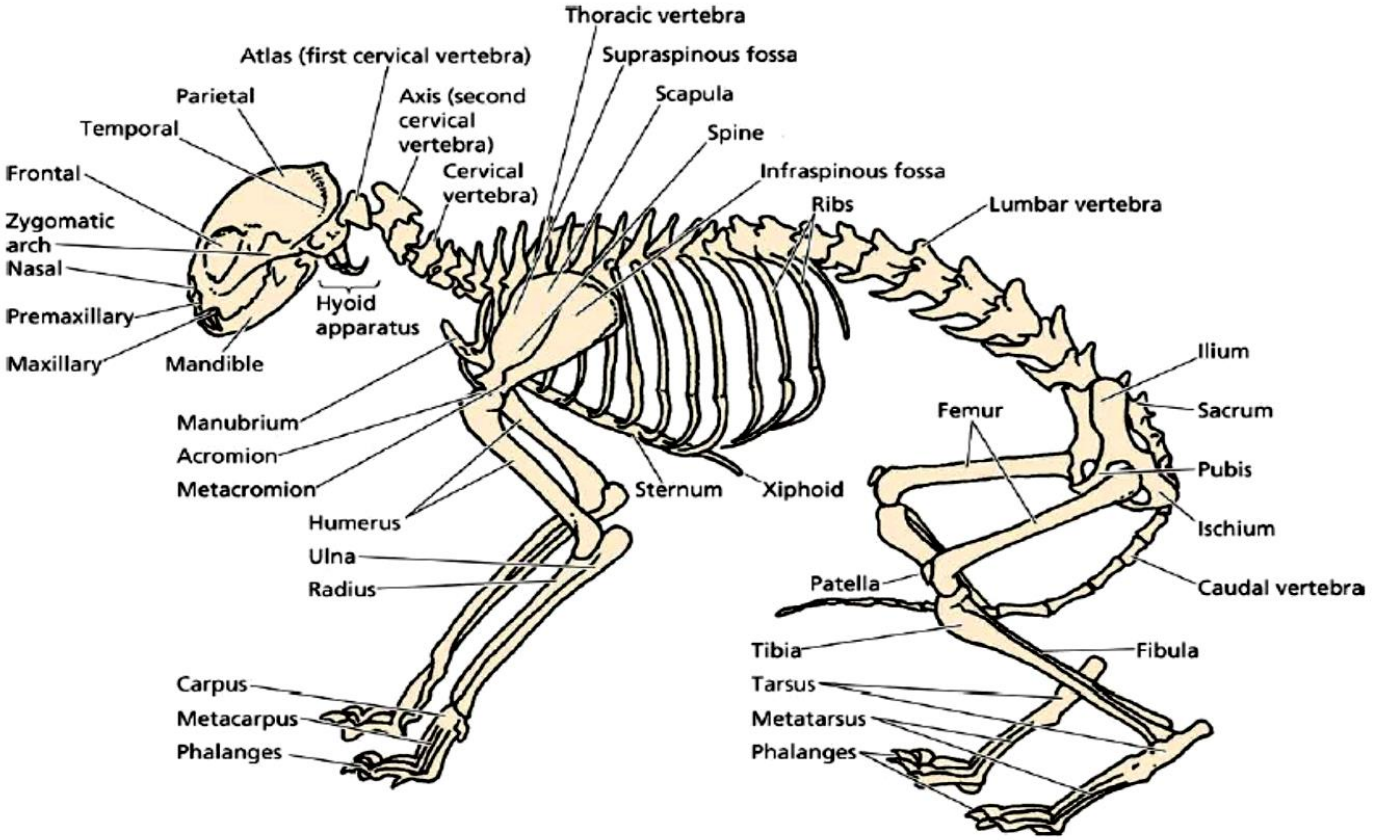


Figure 7.12 Cat skeleton. Lateral view of the skeleton of a domestic cat (*Felis catus*). Note the digitigrade foot posture and reduced clavicle (the small bone just anterior to the head of the humerus) that does not articulate

Muscles

- Muscular tissue in general develops from the mesoderm of the embryo but the muscles of the iris of the eye and myoepithelial cells of the salivary, mammary and sweat glands arise from the ectoderm of the embryo.

Special Properties of Muscle Tissue:

- The special property of muscular tissue is contractility i.e., the cells of muscular tissue can shorten considerably and return to the original relaxed state.
- The muscle cells contract in a definite direction.
- Another property of muscle is the electrical excitability. It is due to the energy stored in the electrical potential difference across the plasma membrane.

Functions of Muscle Tissue:

- 1. It brings about movements of the body parts and locomotion of the individual.
- 2. Muscles are responsible for peristalsis in tubular viscera, heartbeat, production of sound, etc.
- 3. Facial expression also depends on muscles.
- 4. It supports the bones and other structures.
- 5. Muscles are required for delivering a baby.

Types of Muscle Tissue:

- 1. Striped or striated or skeletal or voluntary muscles.
- 2. Un-striped or non-striated or visceral or smooth or involuntary muscles.
- 3. Cardiac muscles.

1. Skeletal Muscle Tissue (Striated or Striped Muscles):

- These muscles are found in the limbs, body walls, tongue, pharynx and beginning of oesophagus and are under the control of animal's will.
- These muscle fibres occur in bundles and are normally attached to the skeleton.
- Each muscle fibre is an elongated cell surrounded externally by a delicate membrane, the sarcolemma.
- Just beneath the sarcolemma in each fibre many nuclei occur at irregular intervals. Thus, these fibres are multi-nucleated or syncytial in nature.

- The cytoplasm of each fibre (sarcoplasm) has a large number of myofibrils which are tightly packed.
- Skeletal muscles are under the control of animal's will.
- Calcium is an essential element for the contraction of muscles.
- In the presence of calcium ions and energy from ATP, actin and myosin interact forming actomyosin which causes contraction of muscles.

2. Smooth Muscle Tissue (Non-striated Muscles):

- Non-striated muscles are found in the posterior part of oesophagus, stomach, intestine, lungs, urinogenital tract, urinary bladder, blood vessels, iris of eye, dermis of skin and arrestor pili muscle of hair.
- Smooth muscles never connect with skeleton.
- These muscle fibres or cells are elongated and spindle shaped.
- Each fibre contains a single oval nucleus surrounded by the cytoplasm (sarcoplasm).

- In the cytoplasm the myofibrils are arranged longitudinally.
- There is no sarcolemma, however, the fibre is enclosed by plasma membrane.
- These muscles help in peristalsis which happens in tubular viscera.
- Action of these muscles is controlled by autonomic nervous system and hence they are not under the control of the animal's will.
- Functionally smooth muscles are of two types — single-unit smooth muscles and multi-unit smooth muscles.

(i) Single-unit smooth muscles

- are composed of muscle fibres closely joined together.
- All the fibres of the single smooth muscle contract simultaneously as a single unit.
- These muscles are found in the walls of hollow visceral organs like gastrointestinal tract and urinary bladder.

• (ii) Multi-unit smooth muscles

- are composed of independent muscle fibres and are not closely joined together.
- Their fibres contract more or less independently as separate units.
- Arrector pili muscles of skin dermis, ciliary and iris muscles in the eyes, and muscles of the walls of the large blood vessels are some examples of multi-unit smooth muscles.

3. Cardiac Muscle Tissue:

- The cardiac muscles are found in the wall of the heart and in the wall of large veins (e.g., pulmonary veins and superior vena cava) where these veins enter the heart.
- These fibres show the characters of both un-striped and striped muscle fibres.
- Each fibre is a long and cylindrical structure which has a definite sarcolemma.
- The fibres are uninucleate and the nuclei lie near the centre.

- Cardiac muscle fibres are supplied with both central and autonomic nervous system and are not under the control of the will of the animal.
- However, these muscles never get fatigued.
- Thus they are immune to fatigue.
- Blood capillaries penetrate the cardiac muscle fibres. They have very rich blood supply.
- They have the property of contraction, even when they are isolated from the body temporarily.

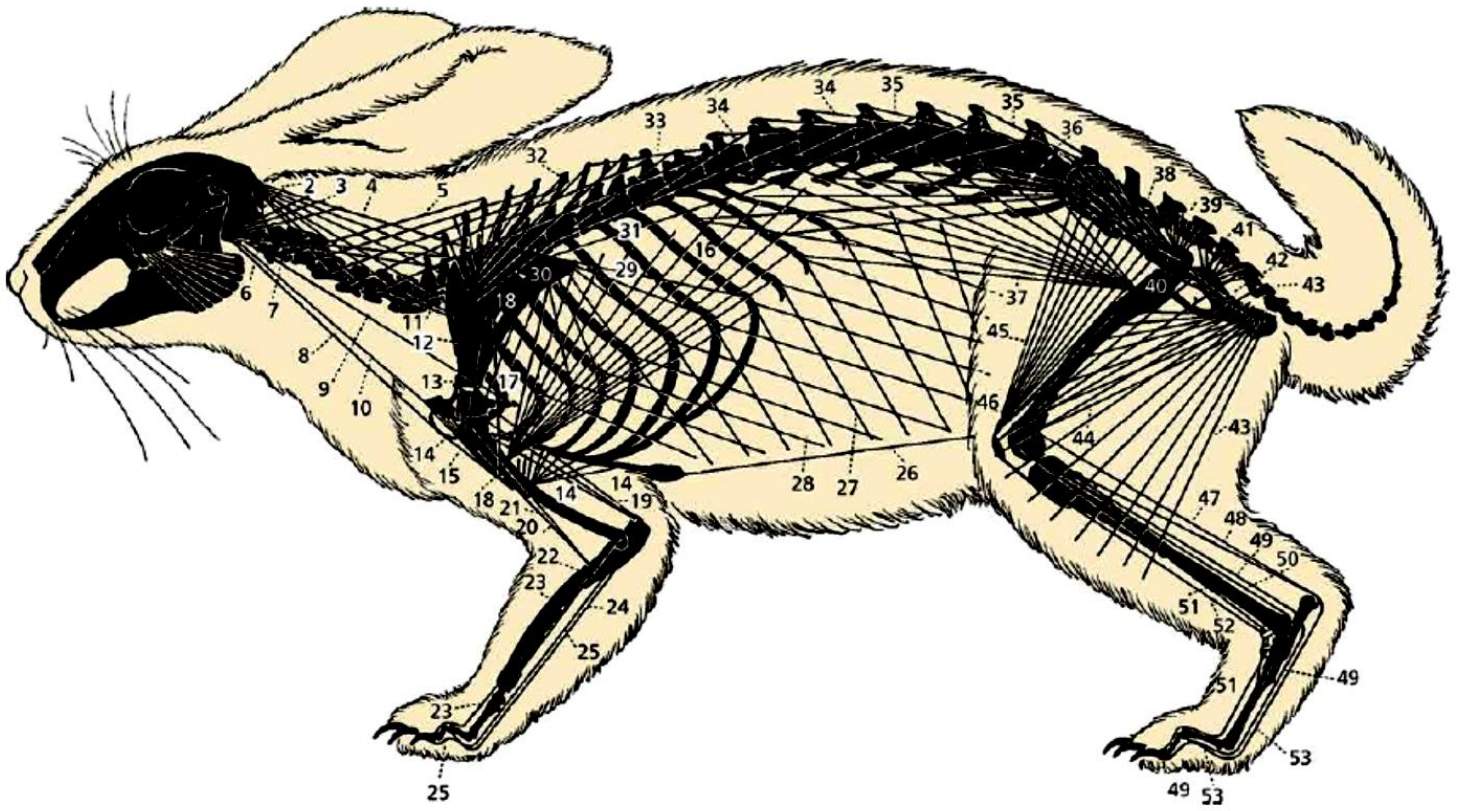


Figure 7.13 Muscle groups. Schematic representation of muscle groups in the European rabbit (*Oryctolagus cuniculus*). Notice the groups of muscles that operate the limbs and the manner in which they are positioned to work in opposition to one another.

- (1) Masseter; (2) obliquus capitis; (3) splenius capitis; (4) semispinalis capitis; (5) longissimus cervicis; (6) longissimus capitis; (7) obliquus capitis inferior; (8) basioclavicularis; (9) levator scapulae; (10) sternomastoid; (11) scalenus; (12) supraspinatus; (13) infraspinatus; (14) pectoralis; (15) cleidohumeralis; (16) latissimus dorsi; (17) subscapularis (displaced caudally); (18) deltoid; (19) triceps; (20) biceps brachii;

21) brachialis; (22) extensor carpi ulnaris; (23) extensor digitorum communis; (24) flexor digitorum sublimis; (25) flexor digitorum profundus; (26) rectus abdominis; (27) transversus abdominis; (28) external oblique; (29) serratus anterior; (30) trapezius; (31) iliocostalis; (32) longissiumusi; (33) semispinalis dorsi; (34) longissimus dorsi; (35) multifidous; (36) sacrospinalis; (37) psoas major; (38) gluteus medius; (39) pyriformis; (40) gluteus maximus; (41) abductor caudae; (42) gemellus inferior; (43) biceps femoris; (44) adductors; (45) rectus femoris; (46) vastus intermedius; (47) gastrocnemius and plantaris; (48) soleus; (49) flexor digitorum longus; (50) peroneus muscles; (51) extensor digitorum; (52) tibialis anterior; (53) Achilles' tendon.


Thank you

Adaptive Radiation in Mammals

- During Mesozoic era, the age of reptiles (dinosaurs), mammals were small, generalised and rare.
- By the end of Mesozoic or beginning of Coenozoic, the dinosaurs vanished and mammals suddenly expanded into varied evolutionary patterns.
- Early in Cretaceous period, placental mammals became distinct from marsupials.
- During Eocene and Oligocene, most of the orders of mammals originated moving into habitats and ecological niches vacated by the extinct dinosaurs.
- This evolution from a single ancestral species to a variety of forms which occupy different habitats is called adaptive radiation or divergent evolution.

ORIGIN

- The concept of adaptive radiation in evolution was developed by H.F. Osborn in 1898.
- Examples often given as evidence include

1. Darwin's finches of the Galapagos Islands,
2. varied limb structure of mammals,
3. Australian Marsupials, etc.

A. Radiation in Limb Structure of Mammals:

- Mammalian limbs are the modifications of the pentadactyl limb.
- Primitive, ancestral mammals are believed to have been short legged five fingered creatures living on the ground.
- Their limbs were not modified for any particular type of locomotion. These animals were terrestrial. These terrestrial ancestors formed the ancestors of modern mammals.

From these terrestrial mammals the different lines radiated in the following manner:

- 1. One evolutionary line radiates to form arboreal forms which have adapted limbs for life in trees (e.g., squirrels, sloths, monkeys, etc.).
- 2. Another line leads to aerial representing mammals adapted for flight (e.g., bats) Only bats occupy the position at the terminus of this line, since they are the only truely flying mammals Somewhere along this line we can place for gliding mammals such as “flying squirrel. ”
- The arboreal and aerial forms not arose independently from the terrestrial forms as shown in the diagram It is believed that the ancestral aerial forms were previously lived in trees having gliding type of locomotion which later gave rise to true flight. Hence, perhaps the gliding formed transitional type of locomotion between climbing and true flight.

- 3. Third line of radiation gave rise to cursorial forms (e.g., horses and antelopes).
- They have developed limbs suitable to rapid movements over the surface of the ground.
- Along this line also developed other mammals with less strongly modified limbs, such as wolves, foxes, hyaenas, lions.

- 4. Fourth line of radiation formed the burrowing mammals, the fossorial mammals.
- Some of the fossorial mammals, like the moles, have modified their forelimbs for digging but they are poorly adapted for locomotion on the ground.
- While others like pocket gophers and badgers are expert diggers but they have retained structures enabling them to move readily on the surface of ground.

5. Fifth line of radiation leads to the aquatic mammals:

- (i) Whales and porpoises having limbs strongly adapted for aquatic life, but they cannot move about on land.

- (ii) While seals, sea lions and walruses have also strongly modified limbs for aquatic life but they are also able to move about on land.

- (iii) The third group includes accomplished swimmers such as others and polar bears which are equally at home in water or on land.

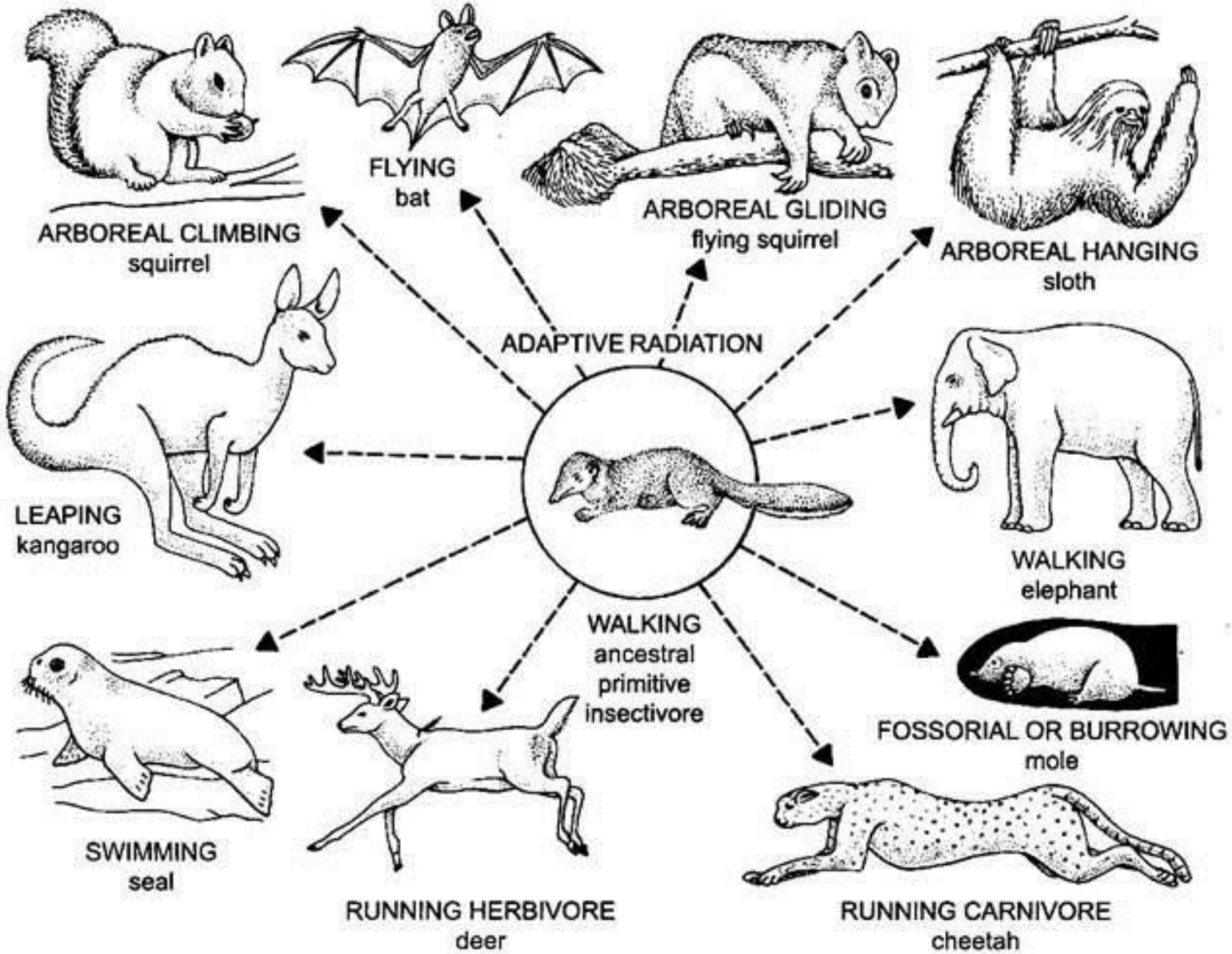


Fig. 33.10. Adaptive radiation or divergent evolution in mammals, based on locomotion.

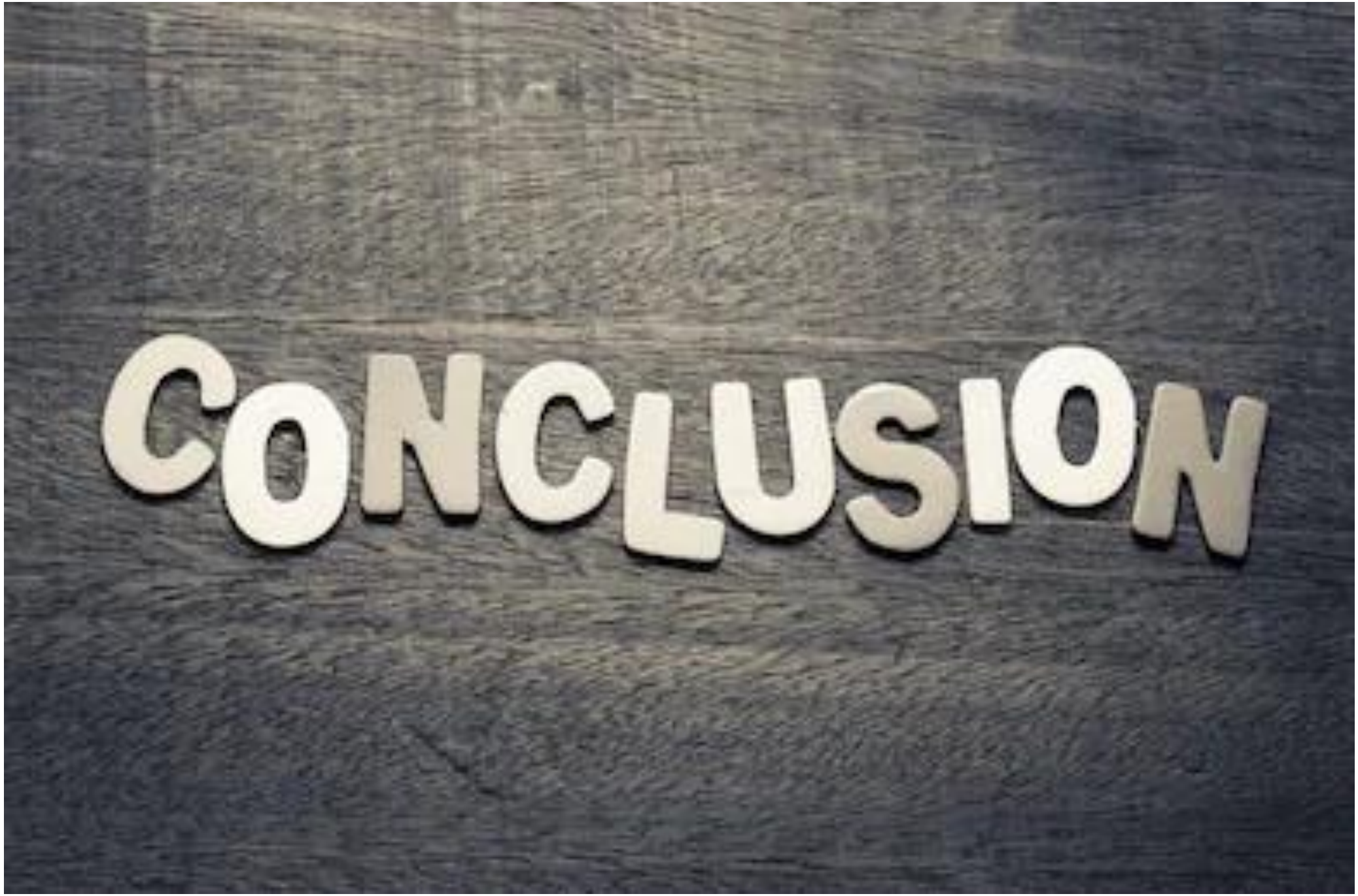
B. Tooth Radiation in Mammals:

- The mammals with few exceptions (Cetacea, ant-eaters etc.) possess heterodont dentition, i.e., the teeth in contrast to those of reptiles, are differentiated into different forms with very distinct functions.
- The different types of teeth are incisors for biting, canines for grasping, tearing or for defence or offence, premolars and molars are for grinding.
- The premolars and molars show greatest structural modification for different types of food.

- In insectivorous type (stem form in mammals), premolars and molars are low-crowned simple with few cusps, generally sharp pointed and suitable for crushing feeble prey.
- In carnivorous type, premolars and molars are high crowned, trenchant, shearing structures (carnassial). The jaws have little or no lateral movement. Cats have no grinding teeth, while dogs have more of grinders.
- In Odontoceli (e.g., toothed whales) there is no tooth differentiation and the teeth are practically alike.

- In sperm whale, Physeter, no teeth in the upper jaw, while in whalebone whales (Mystaceti) upper teeth are totally absent and their place is taken by curious baleen or whalebone which hangs from the palate.

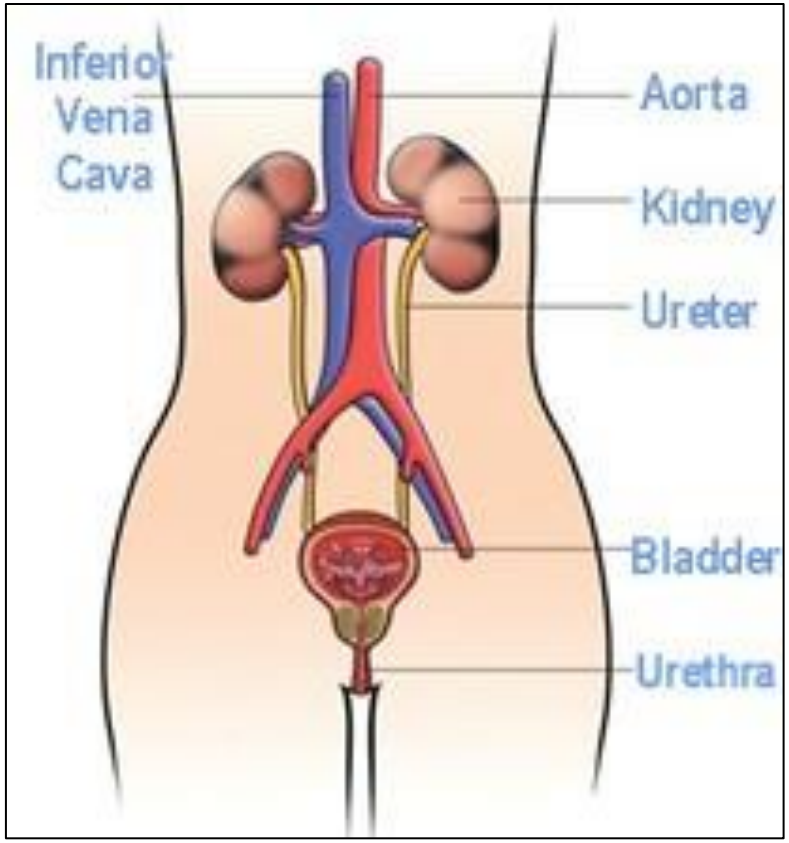
- In herbivorous types, incisors are for seizing and cutting the vegetation. In ruminants, they are absent in the upper jaw, but a horny pad is present there. Canine teeth are of little importance for herbivores, but in musk deer they are used for defence and in swine they are used for uprooting the vegetation.


CONCLUSION

Water Regulation Of Mammals

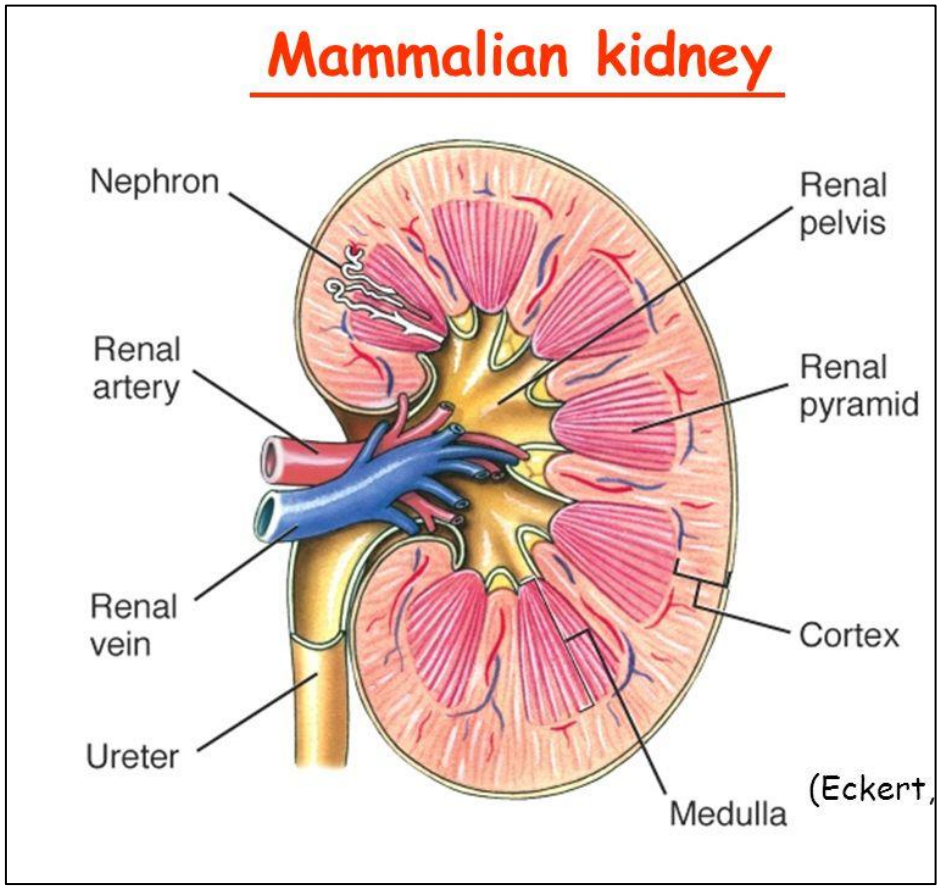
- Water is essential for survival. It constitutes 70% of the body mass of mammals, and water loss must be balanced by water gain.
- In mammals, **osmoregulation**— the maintenance of proper internal salt and water concentrations— is performed principally by the kidney.

The Mammalian Kidney



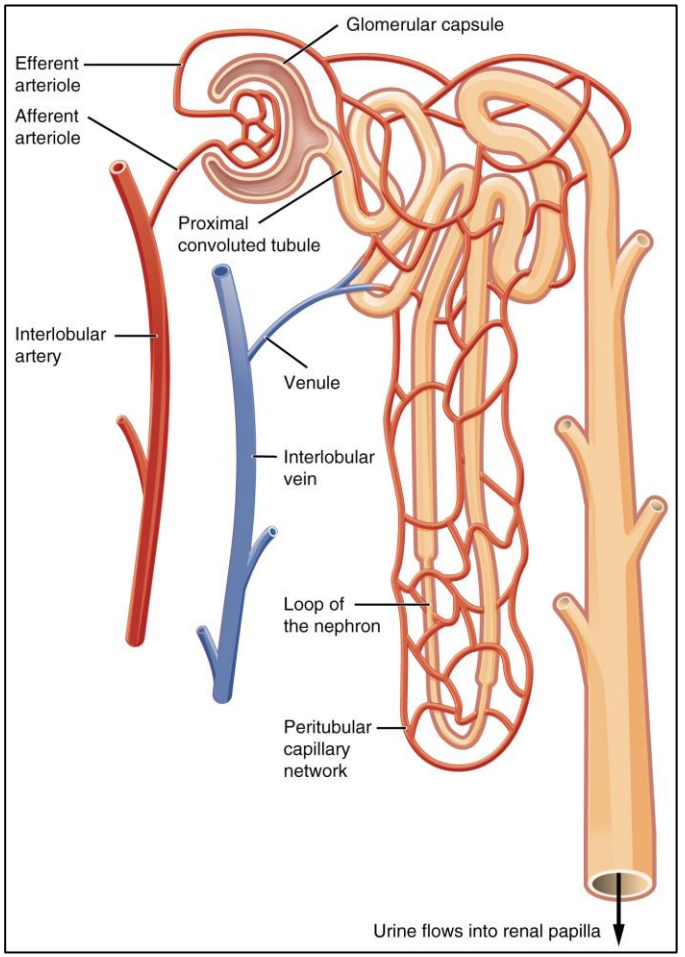
- Most of the elimination of excess water and soluble salts, urea, uric acid, creatinine, and sulfates occurs in the kidney.
- Mammalian **kidneys** are paired, bean-shaped structures located within the dorsal part of the abdominal cavity.
- The kidney in cross section displays the following areas and structures------
- The outer **cortex** contains the renal corpuscles, convoluted tubules, and blood vessels.
- Masses of cortical tissue fill in between the pyramids of medullary tissue.

- The inner **medulla** is divided into triangular wedges called **renal pyramids.**
- Their broadbases are directed toward the cortex, and narrow apices (**renal papillae**) are oriented toward the center of the kidney, opening into the **calyx** and expanded **pelvis.**



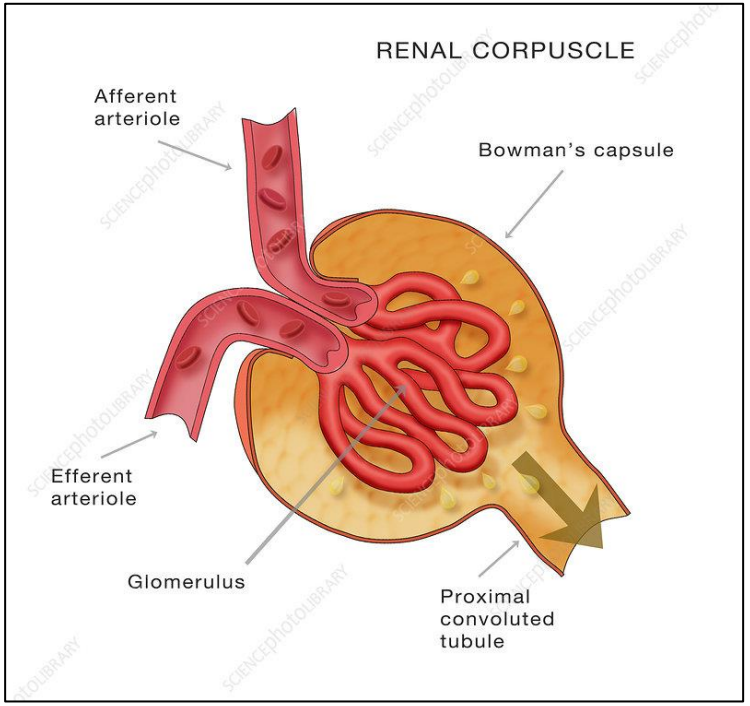
- Ducts leading into the pelvis, the **ureters,** empty into the **urinary bladder,** which functions as a storage organ for urine.
- Another duct, the **urethra,** drains the bladder and carries its contents to the outside.

- **Nephrons** (about 1.5 million in each kidney) are the functional units of the kidney and consist of a closed bulb, **Bowman's capsule** (or glomerular capsule), connected to a long coiled tube.
- Tubules of the various nephrons empty into collecting ducts that discharge into the pelvis of the kidney and then connect to the ureter.



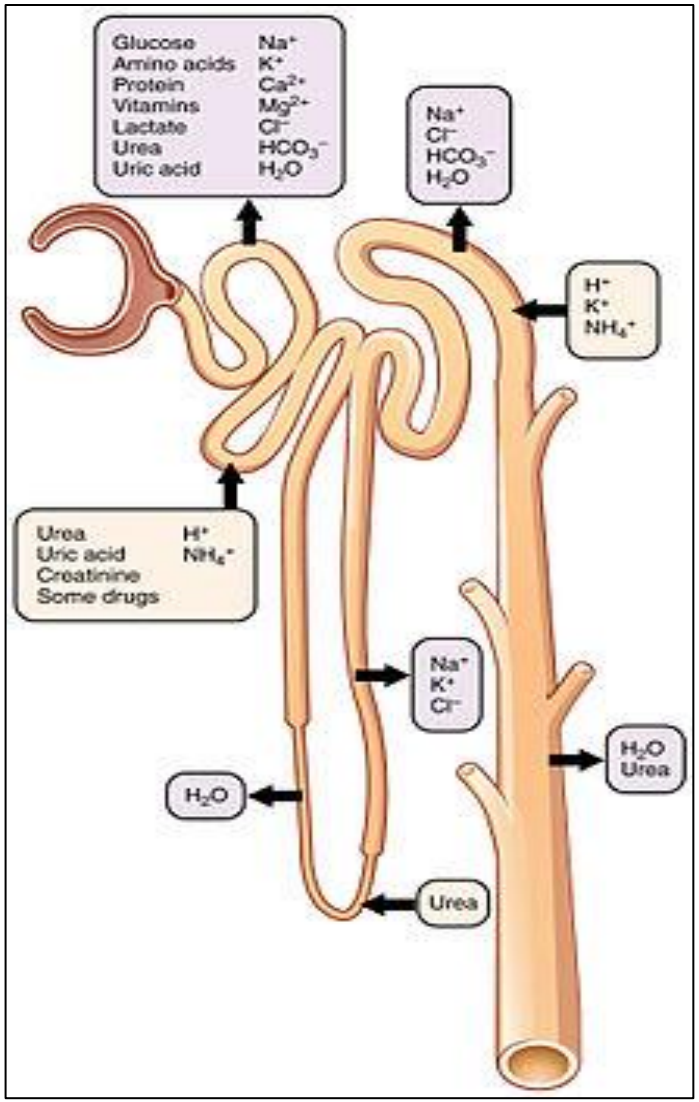
- A microscopic mass of capillaries called the **glomerulus** is enclosed within the capsule. The capsule plus the inner glomerulus is called a **renal corpuscle.**

- Blood reaches the kidney via the large renal artery, a branch of the descending aorta.
- The blood arrives at the glomeruli by afferent arterioles. The blood is collected from the glomeruli by a number of venules and leaves the kidney by way of renal veins making their way to the inferior vena cava.



- Blood vessels enter a convoluted network within the glomerular capsule, move around proximal and distal convoluted tubules and the **loop of Henle,** finally emptying into a branch of the renal vein.
- Exchange of substances takes place through active transport and osmosis almost exclusively between blood capillaries and nephrons.

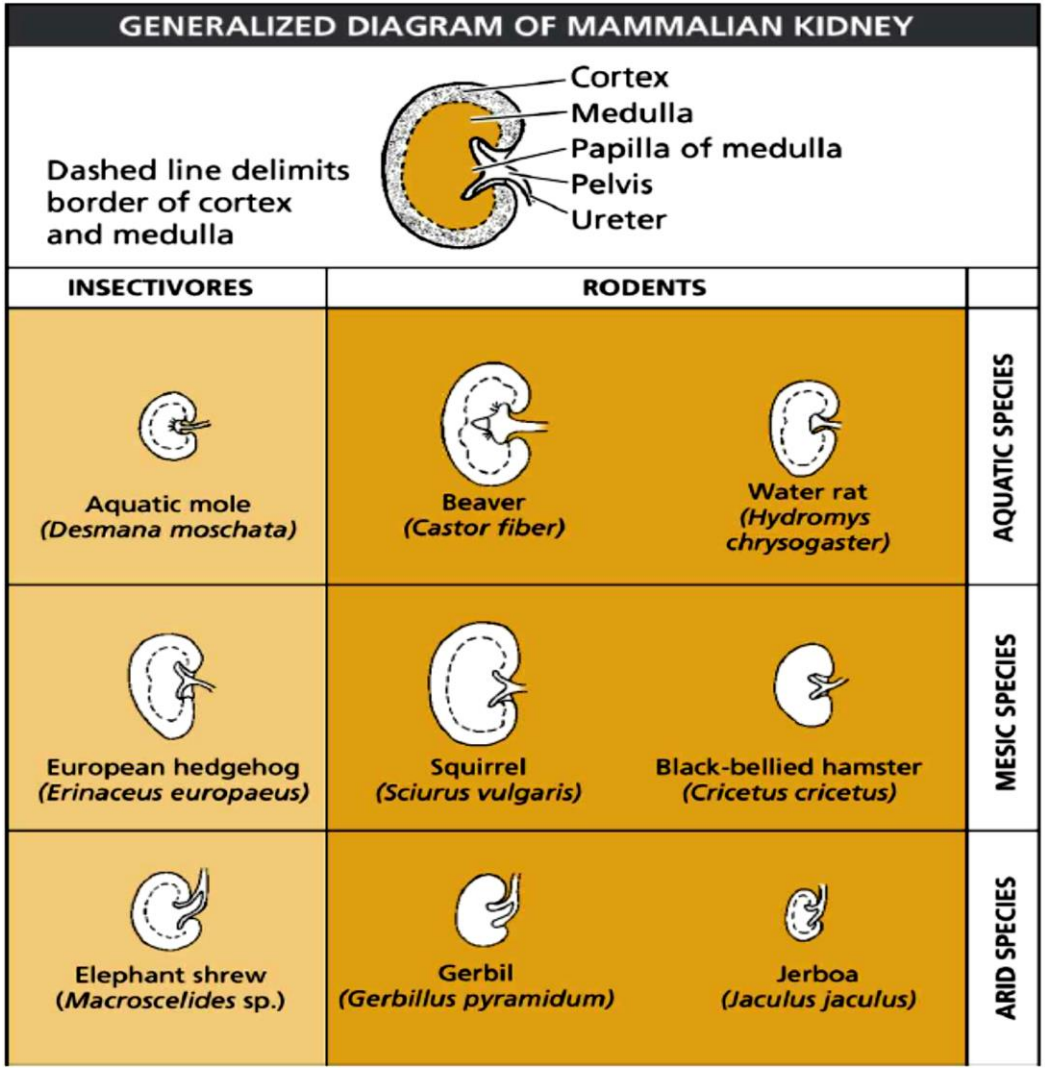
- The mammalian kidney performs many different roles including glomerular filtration, tubular reabsorption, and tubular secretion.
- For mammals residing in desert environments, the ability to concentrate urine is paramount and closely tied to the function of the kidney.
- Because of the urine concentrating ability of kidneys, mammals are able to produce urine that is hyperosmotic to that of blood plasma—up to 25 times the concentration of plasma.



- Understandably, the highest urine concentrations are found in mammals residing in desert habitats.
- The concentrating ability of the mammalian kidney in different species is closely related to the respective lengths of their loops of Henle and collecting ducts that transverse the renal medulla.
- The prominence of the medulla is commonly expressed as the relative medullary thickness (RMT), an important index of kidney adaptation.
- RMTs of mammals residing in arid areas are greater than those of mammals from more mesic environments (those with more moisture).
- The relationship between RMT and the kidney's maximum urine-concentrating capacity was first quantified by Schmidt-Nielsen and O'Dell (1961) and has proven very useful as a means of comparing kidney function in mammals.

- The anatomy of the papilla of the medulla can be compared visually for different species.
- In desert-adapted small mammals, the papilla may extend beyond the margins of the renal capsule into the ureter.
- This extension is pronounced in small desert rodents, shrews and bats, suggesting that these species possess very powerful kidneys.
- In contrast, aquatic mammals, such as beavers, aquatic moles, water rats, and muskrats, have very short loops (shallow papillae) and produce less concentrated urine.

Figure 10.21 The kidneys of selected mammals. Aquatic species show little or no development of the papilla of the medulla. Genera *Desmana* and *Hydromys* lack the papilla. Genus *Castor* has two very shallow papillae. Mesic species have papillae. The papilla is especially well developed in arid species, so much so that it often penetrates well into the ureter (e.g., Genera *Macroscelides*, *Gerbillus*, and *Jaculus*). *Adapted from R. W. Hill and G. A. Wyse (1989)*.



Urine and Feces

- Comparative studies of renal function and morphology in mammals indicate a direct relationship between the ecological distribution of a species and its ability to conserve urinary water.
- The ability to concentrate urine in mammals is associated with long loops of Henle and tubules in the kidney that enhance the countercurrent exchange function.
- Species that reside in arid habitats tend to possess kidneys better adapted for water conservation.
- Representatives are found in the Orders Diprodontia, Chiroptera, Cingulata, Rodentia, and Lagomorpha.

- Most mammals lose water by excretion in the urine and elimination in the feces.
- But the preceding groups have the ability to produce relatively dry feces and concentrated urine.
- For example, the average values for maximum urine concentration in desert heteromyids is superior to those of most mammals and comparable to those of other desert-adapted small mammals, such as dipodids from Asia and North Africa and murids from Australia and southern Africa.

- For example, the laboratory white rat can produce urine with twice the osmotic concentration that humans can achieve.
- The dromedary, and even dogs and cats, have a urine-concentrating equivalent to that of the white rat.
- As expected, the amount of water loss from feces is quite low for desert mammals.
- The feces of Merriam's kangaroo rat (*Dipodomys merriami*) are over 2.5 times as dry as those of white rats (834 versus 2,246 mg of water/g of dry feces).
- Furthermore, heteromyids commonly decrease fecal water loss by assimilating over 90% of the food they ingest.

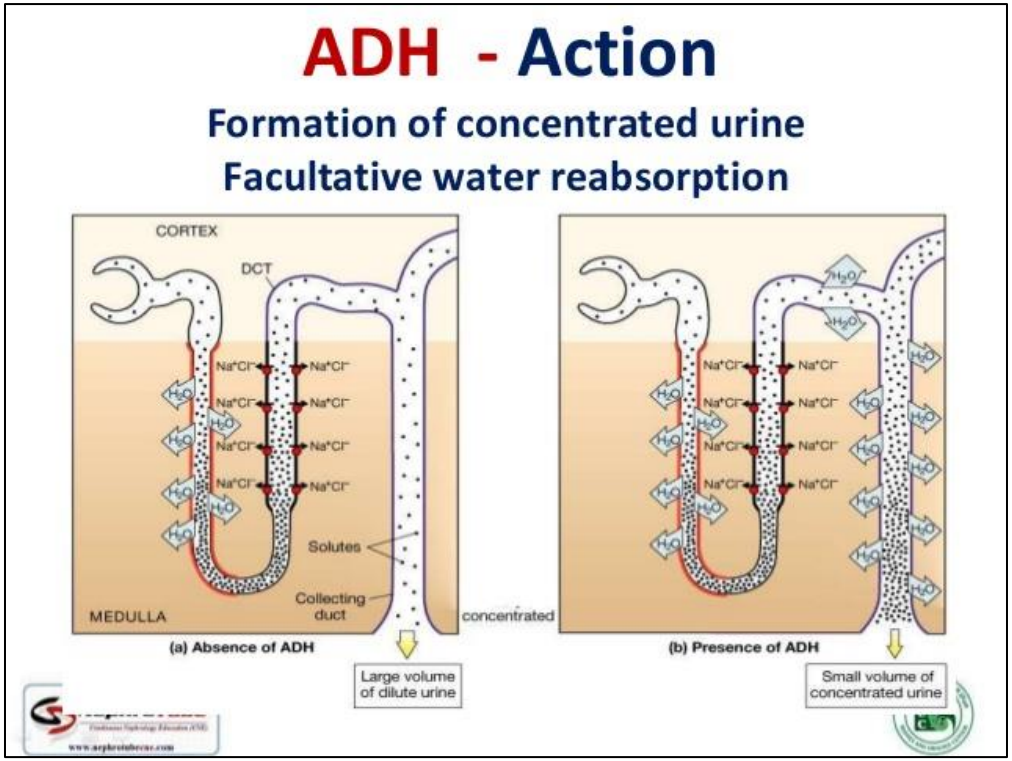
- An additional way that desert rodents economize water loss is by producing highly concentrated milk.
- The milk of *D. merriami* averages 50.4% water—a concentration comparable to that produced by seals and whales.
- Furthermore, it has been demonstrated that in desert rodents, canids, and kangaroos, mothers reclaim water by consuming the dilute urine and feces of their young.
- This behaviour may regain about one third of the water originally secreted as milk.

Diet

- Since free drinking water is not available for desert mammals, they must obtain water from other sources, such as succulent plants or the body fluids of their prey or by consuming dry food.
- This requires subsisting on **metabolic water,** which is created in the cells by the oxidation of food, especially carbohydrates.
- Some desert mammals consume succulent plants and insects for a source of water.
- Desert woodrats (*Neotoma lepida*) and cactus mice (*Peromyscus eremicus*) of southwestern North America consume large quantities of cactus (Genus *Opuntia*) as a source of both food and water.

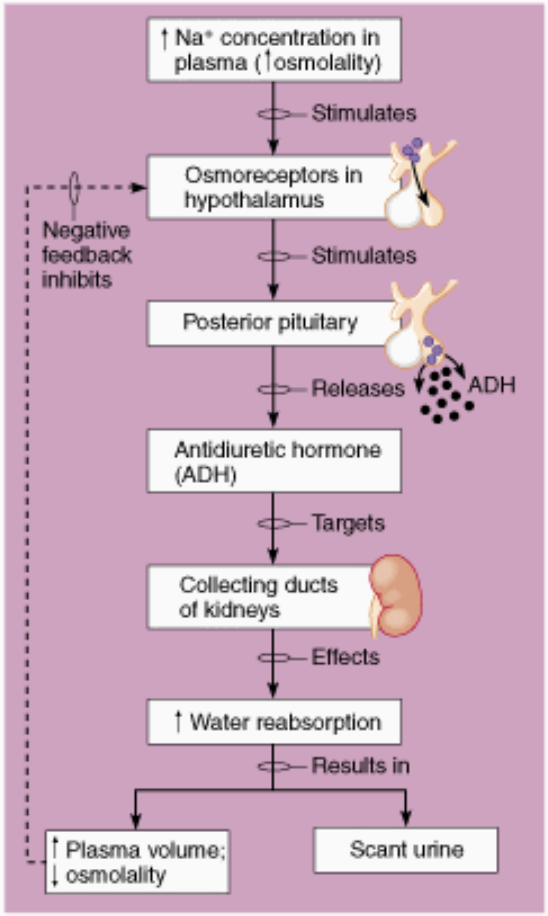
VASOPRESSIN

- The concentration of urine can vary from more dilute than plasma to many times higher than the plasma concentration.
- The concentration of urine is related to the circulating concentration of antidiuretic hormone (ADH).



- Argenine vasotocin (AVT) is the primary antidiuretic hormone of most vertebrates, but placental mammals and probably monotremes have substituted the chemically similar arginine vasopressin (AVP), while marsupials have a variety of ADHs, including lysopressin and phenypressin.

- Whatever its form, ADH is the most important hormone in the regulation of water balance in mammals.
- This small peptide is secreted by the neurohypophysis in response to increases in plasma osmolality as small as 2%.
- The effects of ADH on the renal tubule are mediated by the binding of ADH to V2 type basolateral receptors.

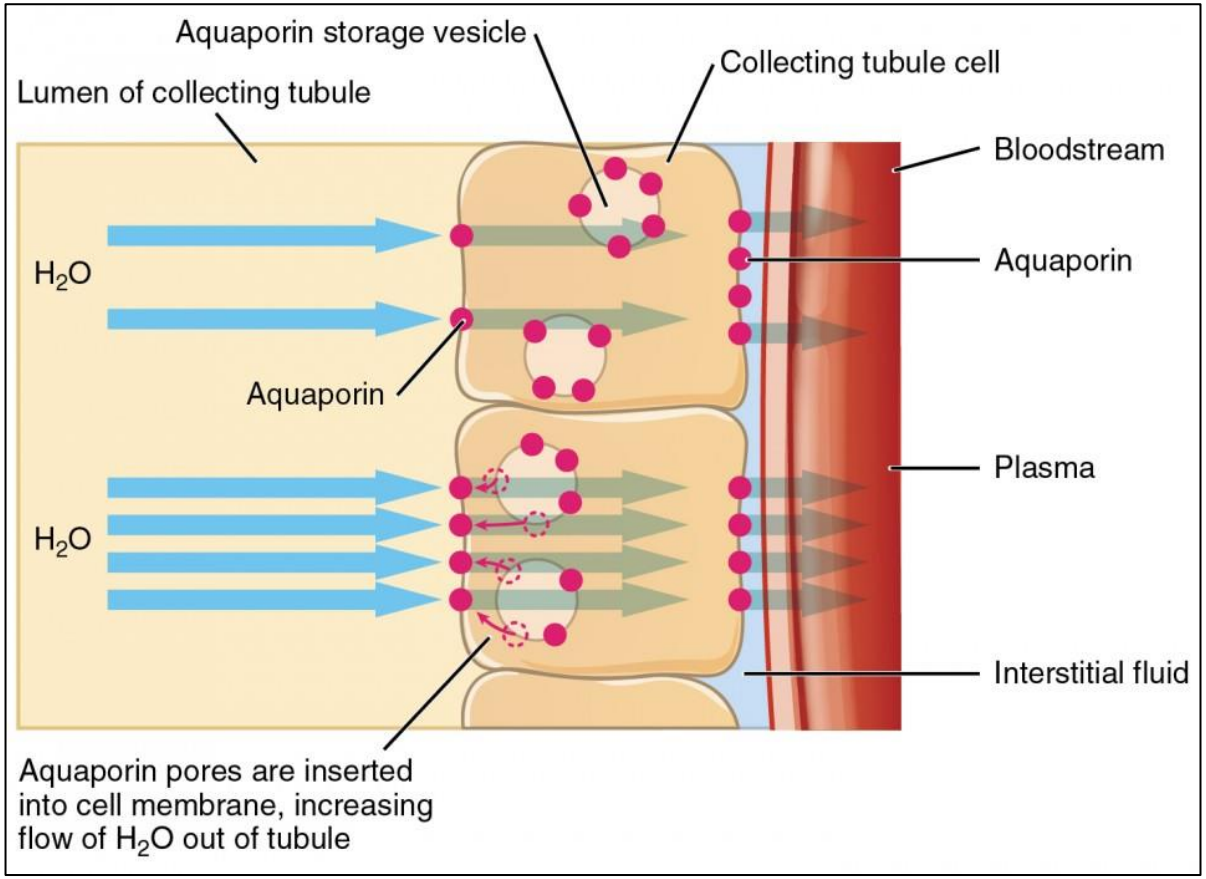


- The functional hydro-osmotic outcomes of the hormone are mediated by an increase in the osmotic water permeability of connecting cells, principal cells, and inner medullary collecting duct cells, via the activity of AQP channels.

AQUAPORIN

- Aquaporins (AQPs) are integral membrane proteins that facilitate water transport across the plasma membrane in many cells.
- The AQP family is composed of ten members; some isoforms are strict water transporters (aquaporins), while others allow the passage of water as well as small organic molecules (aquaglyceroporins).
- Prior to the discovery of aquaporin, it was assumed that water simply leaked through the lipid bilayer of cells, but some cells permit rapid water transport, too rapid to be accounted for by simple diffusion.

- Peter Agre (who won the Nobel Prize for chemistry in 2003 for the discovery of aquaporins) and coworkers were studying the Rh-antigens on red blood cells, and a 28 kD protein kept showing up in the erythrocyte membrane.
- The protein was expressed in many tissues, and was abundant in erythrocytes and kidney tubules. The molecule was identified as aquaporin and its role in water transport was later established.
- Studies carried out in aquaporin-null transgenic mice showed that several AQPs play a physiological role in transepithelial water transport; in most epithelia, they are the molecular entities that facilitate water transport.



- At least seven aquaporins (e.g. AQP-1, AQP-2, etc.) are found within the kidney.
- AQP-1 is plentiful in the apical and basolateral membranes of proximal tubules and the thin descending loops of Henle.

Type	Location	Function
Aquaporin 1	•kidney (apically) • proximal convoluted tubule • proximal straight tubule • thin descending loop of Henle	Water reabsorption
Aquaporin 2	•kidney (apically) • connecting tubule • cortical collecting duct • outer medullary collecting duct • inner medullary collecting duct	Water reabsorption in response to ADH
Aquaporin 3	•kidney (basolaterally) • connecting tubule • cortical collecting duct • outer medullary collecting duct	Water reabsorption and glycerol permeability
Aquaporin 4	•kidney (basolaterally) • inner medullary collecting duct	Water reabsorption

NITROGENOUS WASTE

- The metabolism of nitrogen-containing organic compounds (e.g. protein, nucleic acids) and the scavenging of their carbon skeletons for metabolic energy require excretion of the remaining N to prevent the accumulation of potentially toxic nitrogenous wastes (e.g. NH_4^+).
- The excretion of nitrogenous wastes is an important role of the mammalian kidney.
- Other components of organic compounds also need to be excreted to a lesser extent (e.g. protein sulphur is excreted as SO_4^{2-}), but this is a relatively minor role of excretion.

- The initial N-containing waste product from protein metabolism is ammonia, but for terrestrial amniotes its high toxicity precludes its use as the nitrogenous waste product.
- Generally, in mammals the ammonia is converted to urea, which is less toxic but also less soluble.
- In contrast, for terrestrial reptiles and birds the general, N waste product is uric acid.

Amino Acids

Nitrogenous Bases

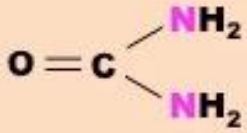
$-NH_2$
Amine groups

Most aquatic animals, including most bony fish

NH_3

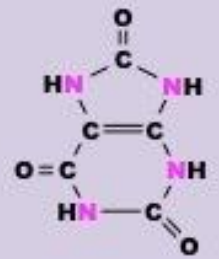
Ammonia

Mammals, amphibians, sharks, some bony fish



Urea

Birds, many reptiles, insects, snails



Uric acid

AMMONIA

- Ammonia is an unsuitable waste product for amino-acid nitrogen in mammals because it is extremely soluble in water and because it is a weak base, reacting with water to form ammonium ions (NH_4^+).
- At physiological pH, the equilibrium greatly favours ammonium (Withers 1992, 1998), so it is extremely difficult to excrete ammonia gas across the respiratory or cutaneous surface. Even at high NH_4^+ concentrations, the pNH_3 is quite low and so is the driving force for its excretion
- Because ammonia/ammonium is so toxic for most animals, including mammals (LD50 is about 5 mM of ammonium salts for mammals; Withers 1998a), it isn't possible to achieve a sufficiently high pNH_3 to excrete a significant amount of NH_3, so it must be converted to a less toxic waste product.
- Mammals are also very sensitive to inspired ammonia; 500 min of exposure to 500 ppm NH_3 is lethal to humans, and 40 min is lethal for laboratory rats at 5,000 ppm.

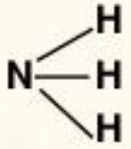
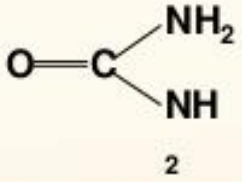
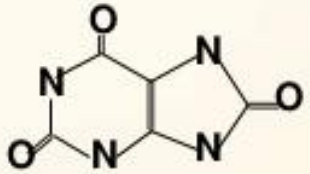
UREA

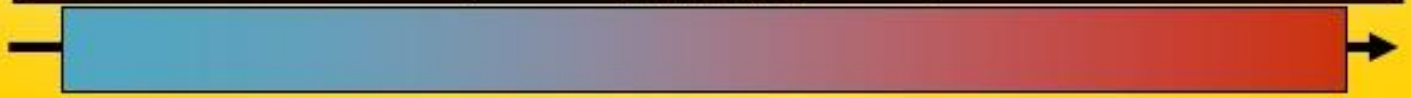
- Most N derived from amino-acid metabolism is converted by mammals to urea in their liver; urea is a less toxic (but also less soluble) nitrogenous waste product than ammonia.
- This conversion is accomplished by the urea cycle, a biochemical cycle that essentially combines two NH_4^+ with a CO_2 to form urea;

$$2NH_3 + CO_2 \rightarrow CO(NH_2)_2 + H_2O$$

- However, urea is not simply a nitrogenous waste product; it actually has a number of potentially useful roles in various animals, including mammals.
- One of these is establishment of the renal osmotic gradient for urine concentration in the renal medulla.

The use of these three forms of nitrogenous wastes follows a pattern in animals

AMMONIA	UREA	URIC ACID
NH_3	$CO(NH_2)_2$	$C_5H_4O_3N_4$
		
Highly toxic	Moderately toxic	Not very toxic
Highly soluble	Moderately soluble	Insoluble
Excreted mainly by aquatic invertebrates, osteichthyes (bony fish) and tadpoles	Excreted by chondricthyes (sharks and rays), terrestrial amphibians and mammals	Excreted by insects, most reptiles and all birds



Conclusion


Thank You!