VERTEBRATE ZOOLOGY

INTRODUCTION

By
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DISTRIBUTION OF ORGANISMS

Before understanding the details of distribution of vertebrates, let us understand distribution of living organisms. Usually the living organisms are classified as below along with some of chief characteristics. For your information virus do not fit nearly any classification of living organisms because they have a very simple, noncellular structure and cannot exist independently of other organisms.

DISTRIBUTION OF ORGANISMS

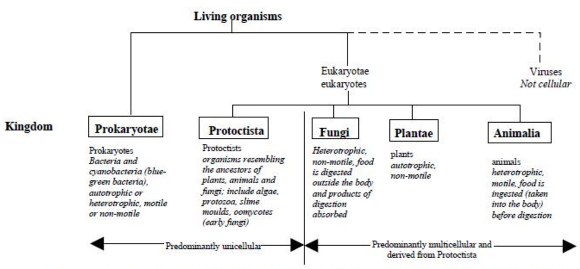
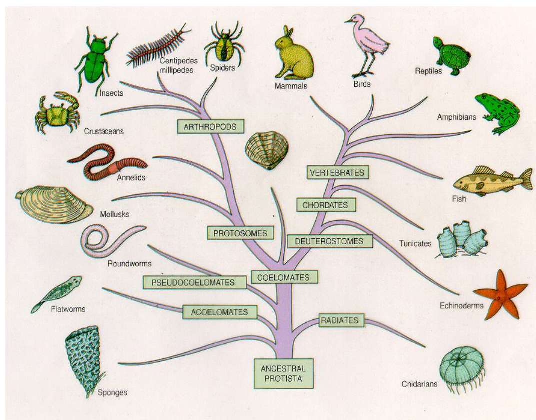
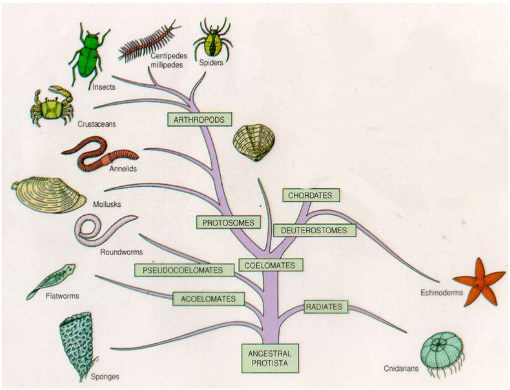


Fig. 1.2: The five kingdom classification of living organisms, according to Margulis and Schwartz. Some of the chief characteristics of the kingdoms are shown. Viruses do not fit neatly into any classification of living organisms because they have a very simple, non-cellular structure and cannot exist independently of other organisms.

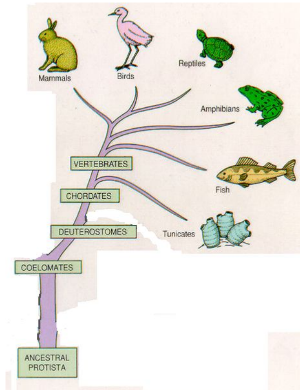
DISTRIBUTION OF ANIMALS



DISTRIBUTION OF INVERTEBRATES



DISTRIBUTION OF VERTEBRATES



CRITERIA

Animals are grouped using a variety of criteria.

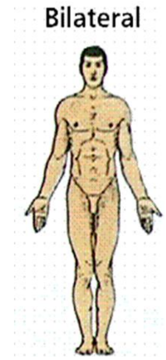
Three criteria are used to categorize animals:

1. Body plan symmetry
2. Tissue layers
3. Developmental patterns

CRITERIA

There are 3 types of body plan symmetry.

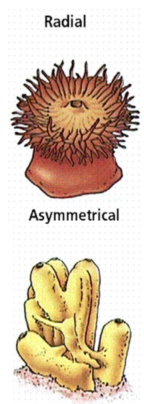
Bilateral symmetry: Animals with bilateral symmetry can be divided equally along only one plane, which splits an animal into mirror-image sides.



CRITERIA

Radial symmetry: Body arranged in circle around a central axis (usually the mouth).

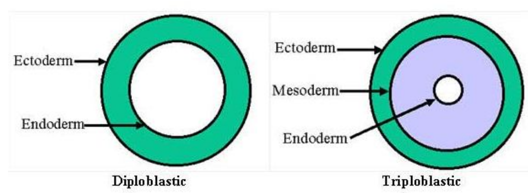
Asymmetry: Body has no general plan or central axis. It is irregular in shape.



CRITERIA

Both radial and asymmetrical animal types have ectoderm (outer layer) and endoderm (inner layer) and they are called as diploblastic animlas.

Whereas bilateral animals have mesoderm (middle layer) also. Such animals are called as triploblastic animals



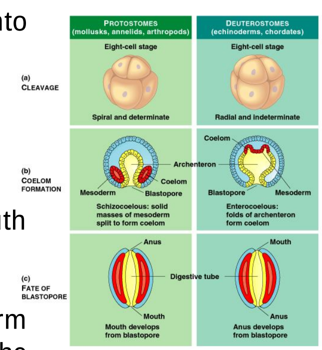
CRITERIA

Animals are divided into two major groups,

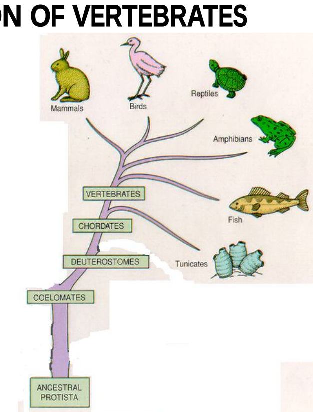
1. The Protostomes
2. The Deuterostomes.

Protostomes form mouth first, and anus second.

Deuterostomes first form the anus and then the mouth.

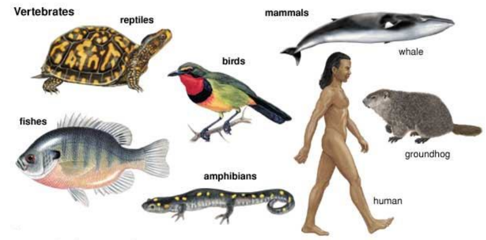


DISTRIBUTION OF VERTEBRATES



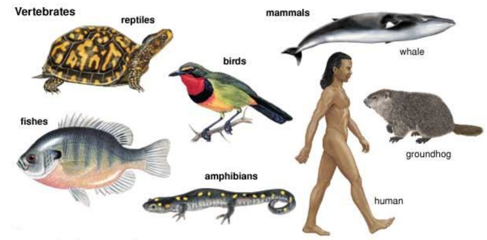
WHAT IS VERTEBRATE

Vertebrate (subphylum Vertebrata) is an animal of a large group distinguished by the possession of a backbone or spinal column, including mammals, birds, reptiles, amphibians, and fishes.

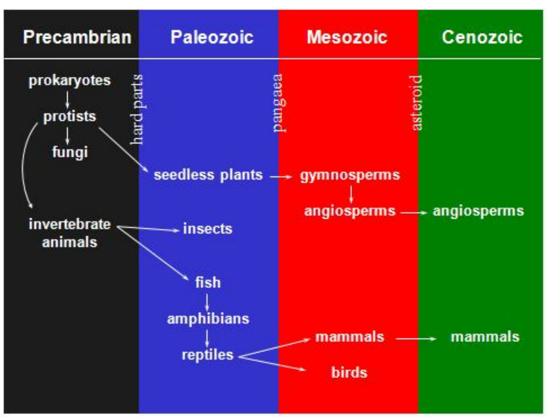


WHAT IS VERTEBRATE

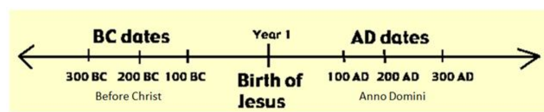
The vertebrates and Protochordates together from the second big group of animals besides the Invertebrata. vertebrates are the largest of the deuterostome



GEOLOGIC TIME SCALE



TIME SCALE



Anno Domini = In the year of lord

HUMAN TIME SCALE

Seven stages of Life:

0-5 yrs - Everything Spills

06-16 yrs - School Drills

17-25 yrs - Youth's Thrills

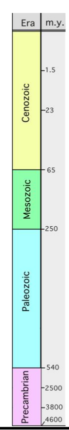
26-40 yrs - Pay Bills

41-60 yrs - Get Ill

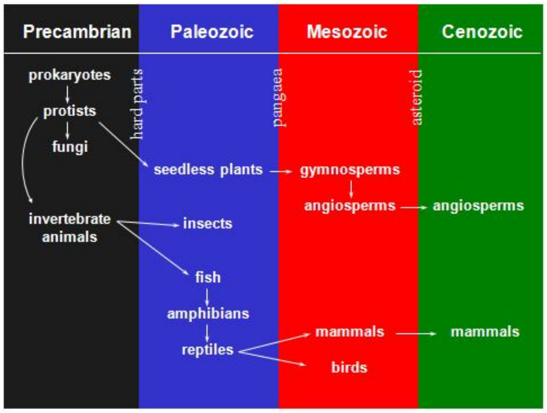
61-75 yrs - Eat Pills

76 and above = Prepare Will

GEOLOGIC TIME SCALE



GEOLOGIC TIME SCALE



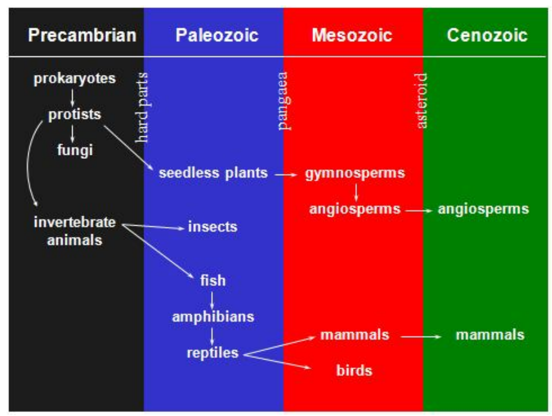
GEOLOGIC TIME SCALE

The Geologic Time Scale is the history of the Earth broken down into spans of time marked by various events. There are other markers, like the types of species and how they evolved, that distinguish one time from another on the Geologic Time Scale.

GEOLOGIC TIME SCALE DIVISIONS

There are four main time spans the generally mark the Geologic Time Scale divisions. The first, Precambrian Time, is not an actual era on the Geologic Time Scale because the lack of diversity of life, but the other three divisions are defined eras. The Paleozoic Era, Mesozoic Era, and Cenozoic Era saw many great changes.

GEOLOGIC TIME SCALE



PRECAMBRIAN TIME

(4.6 billion years ago - 540 million years ago)

The Precambrian Time Span began at the beginning of the Earth 4.6 billion years ago. For billions of years there was no life on Earth.

PRECAMBRIAN TIME

(4.6 billion years ago - 540 million years ago)

It wasn't until the end of this time period that single celled organisms came into existence.

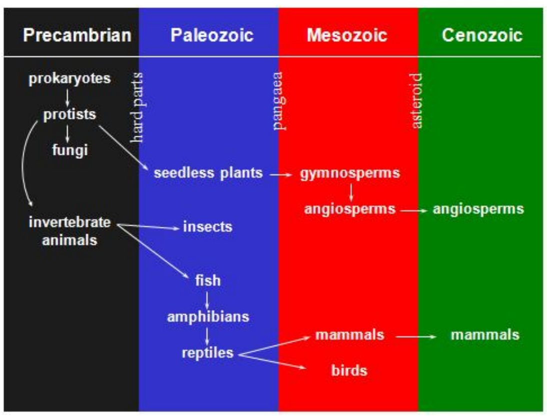
PRECAMBRIAN TIME
(4.6 billion years ago - 540 million years ago)

No one knows for sure how life on Earth began, but there are several theories like the Primoridal Soup Theory, Hydrothermal Vent Theory, and Panspermia Theory.

PRECAMBRIAN TIME
(4.6 billion years ago - 542 million years ago)

The end of this time span saw the rise of a few more complex animals in the oceans like jellyfish. There was still no life on land and the atmosphere was just beginning to accumulate the oxygen needed for higher order animals to survive. It wasn't until the next era that life really began to take off and diversify.

GEOLOGIC TIME SCALE

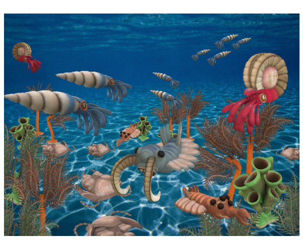


PALEOZOIC ERA
(540 million years ago - 250 million years ago)

The Paleozoic Era began with the Cambrian Explosion. This relatively rapid period of large amounts of speciation kicked off a long time span of flourishing life on earth.

PALEOZOIC ERA
(540 million years ago - 250 million years ago)

This great amounts of life in the oceans soon moved onto land. First plants made the move and then invertebrates. Not long after that, vertebrates moved to land as well. Many new species appeared and thrived.



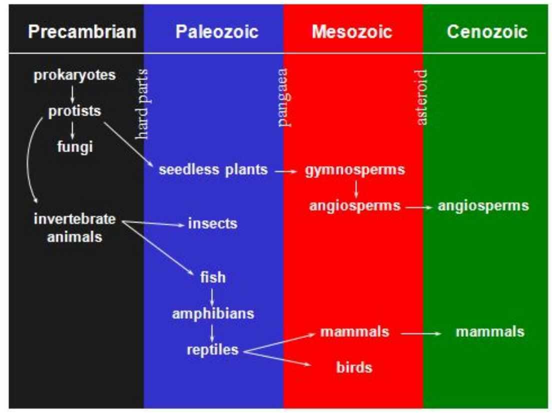
PALEOZOIC ERA
(540 million years ago - 250 million years ago)

The end of the Paleozoic Era came with the largest mass extinction in the history of life on Earth. The Permian Extinction due to glaciations (covered with ice sheets) wiped out about 95% of marine life and nearly 70% of life on land.

PALEOZOIC ERA
(540 million years ago - 250 million years ago)

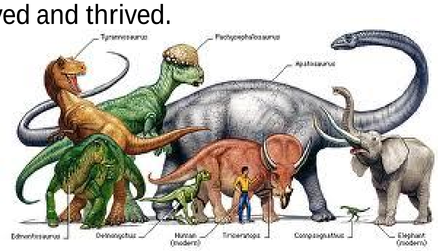
Climate changes were most likely the cause of this extinction as the continents all drifted together to form Pangaea. The mass extinction paved the way for new species to arise and a new era to begin.

GEOLOGIC TIME SCALE



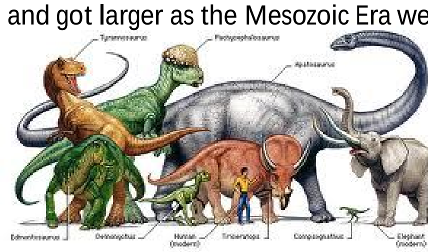
MESOZOIC ERA
(250 million years ago - 65 million years ago)

The Mesozoic Era is the next era on the Geologic Time Scale. After the Permian Extinction caused so many species to go extinct, many new species evolved and thrived.



MESOZOIC ERA
(250 million years ago - 65 million years ago)

The Mesozoic Era is also known as the "age of the dinosaurs" because dinosaurs were the dominant species for much of the era. Dinosaurs started off small and got larger as the Mesozoic Era went on.



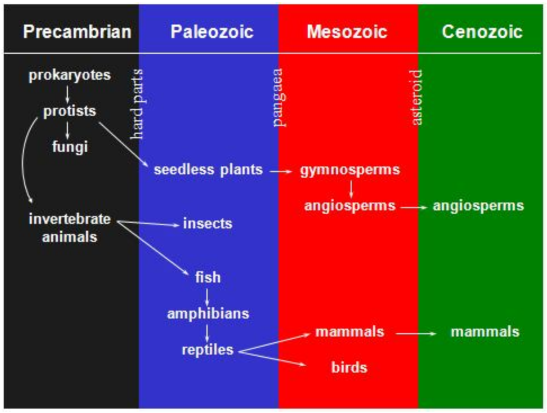
MESOZOIC ERA
(250 million years ago - 65 million years ago)

The climate during the Mesozoic Era was very humid and tropical and many lush (growing extreme in abundance), green plants were found all over the Earth. Herbivores especially thrived during this time period. Besides dinosaurs, small mammals came into existence. Birds also evolved from the dinosaurs during the Mesozoic Era.

MESOZOIC ERA
(250 million years ago - 65 million years ago)

Another mass extinction marks the end of the Mesozoic Era. All dinosaurs, and many other animals, especially herbivores, completely died off. Again, niches were needing to be filled by new species in the next era.

GEOLOGIC TIME SCALE



CENOZOIC ERA

(65 million years ago - Present)

The last and current time period on the Geologic Time Scale is the Cenozoic Period.

CENOZOIC ERA

(65 million years ago - Present)

With large dinosaurs now extinct, the smaller mammals that survived were able to grow and become dominant life on Earth. Human evolution also all happened during the Cenozoic Era.

CENOZOIC ERA

(65 million years ago - Present)

The climate has changed drastically over the relatively short amount of time in this period. It got much cooler and drier than the Mesozoic Era climate. There was an ice age where most temperate parts of the Earth was covered in glaciers. This made life have to adapt rather rapidly and increased the rate of evolution.

CENOZOIC ERA

(65 million years ago - Present)

All life on Earth evolved into their present day forms. The Cenozoic Era has not ended and most likely will not end until another mass extinction period.

EVOLUTION OF VERTEBRATES

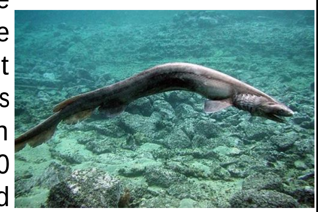
Vertebrate animals have come a long way since their tiny, translucent ancestors way back 500 million years ago. Here's a brief chronological list of the major vertebrate animal groups, ranging from fish to amphibians to mammals, with some notable extinct reptile lineages (including archosaurs (Crocodile like), dinosaurs and pterosaurs (Flying Reptiles) in between.

EVOLUTION OF VERTEBRATES
FISH AND SHARKS

Between 500 and 400 million years ago, life on earth was dominated by prehistoric fish. With their bilaterally symmetric body plans, V-shaped muscles and protected nerve chords running down the lengths of their bodies.

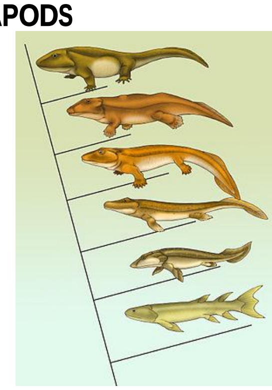
EVOLUTION OF VERTEBRATES
FISH AND SHARKS

These ocean dwellers established the template for later vertebrate evolution. The first prehistoric sharks evolved from their fish forebears about 420 million years ago, and quickly swam to the apex of the undersea food chain.



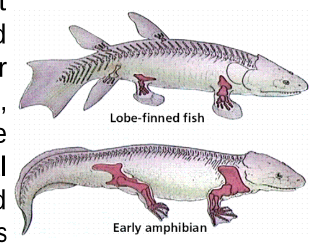
EVOLUTION OF VERTEBRATES
TETRAPODS

The proverbial "fish out of water," tetrapodes were the first vertebrates to climb out of the sea and colonize least swampy land, a key evolutionary transition that occurred somewhere between 400 and 350 million years ago.



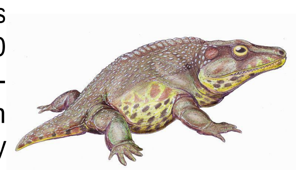
EVOLUTION OF VERTEBRATES
TETRAPODS

Crucially, the first tetrapodes descended from lobe-finned, rather than ray-finned, fish, which possessed the characteristic skeletal structure that morphed into the fingers, claws and paws of later vertebrates.



EVOLUTION OF VERTEBRATES
AMPHIBIANS

During the Carboniferous period--from about 360 to 300 million years ago--terrestrial life on earth was dominated by prehistoric amphibians.

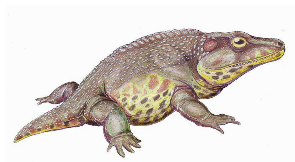


EVOLUTION OF VERTEBRATES
AMPHIBIANS

Often considered a mere way station between earlier tetrapodes and later reptiles, amphibians were crucially important in their own right.

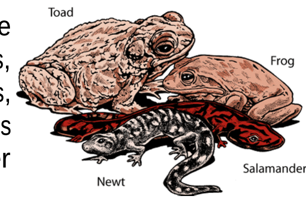
EVOLUTION OF VERTEBRATES
AMPHIBIANS

Since they were the first vertebrates to figure out a way to colonize dry land (however, these creatures still needed to lay their eggs in water, which severely limited their mobility).



EVOLUTION OF VERTEBRATES
AMPHIBIANS

Today, amphibians are represented by frogs, toads and salamanders, and their population is rapidly dwindling under environmental stress.



EVOLUTION OF VERTEBRATES
TERRESTRIAL REPTILES

About 320 million years the first true reptiles evolved from amphibians (with their scaly skin and semi-permeable eggs, reptiles were free to leave bodies of water behind and venture deep into dry land).

EVOLUTION OF VERTEBRATES
TERRESTRIAL REPTILES

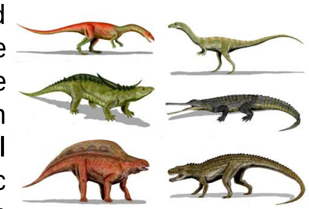
The earth's land masses were quickly populated by pelycosaurs (the primitive reptiles that preceded the dinosaurs.), archosaurs (including prehistoric crocodiles), anapsids (including prehistoric turtles).

EVOLUTION OF VERTEBRATES
TERRESTRIAL REPTILES

Then prehistoric snakes, and therapsids (the "mammal-like reptiles" that later evolved into the first mammals) came into existence.

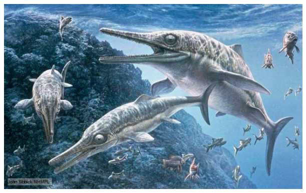
EVOLUTION OF VERTEBRATES
TERRESTRIAL REPTILES

Later on two-legged archosaurs spawned the first dinosaurs, the descendants of which ruled the planet until the end of the Mesozoic Era 175 million years later.



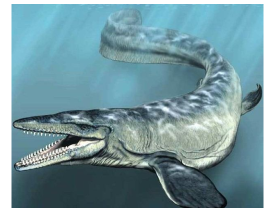
EVOLUTION OF VERTEBRATES
MARINE REPTILES

At least some of the first reptiles led partly (or mostly) aquatic lifestyles, but the true age of marine reptiles didn't begin until the appearance of the ichthyosaurs ("fish lizards").



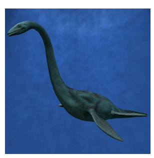
EVOLUTION OF VERTEBRATES
MARINE REPTILES

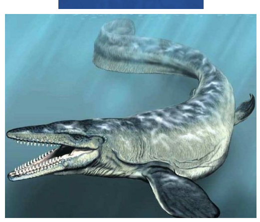
The ichthyosaurs overlapped with, and were then succeeded by, long-necked plesiosaurs and muscular pliosaurs, which themselves overlapped with, and were then succeeded by, the exceptionally sleek, vicious mosasaurs.



EVOLUTION OF VERTEBRATES
MARINE REPTILES

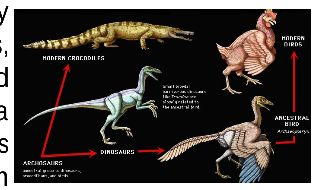
All of these marine reptiles went extinct 65 million years ago along with their terrestrial dinosaur cousins.





EVOLUTION OF VERTEBRATES
AVIAN REPTILES

Often mistakenly referred to as dinosaurs, pterosaurs ("winged lizards") were actually a distinct family of reptiles that evolved from archosaurs.



EVOLUTION OF VERTEBRATES
AVIAN REPTILES

The pterosaurs of the early Mesozoic Era were fairly small, but some truly gigantic breeds (such as the 200-pound Quetzalcoatlus).

EVOLUTION OF VERTEBRATES
BIRDS

It's difficult to pin down the exact moment when the first true prehistoric birds evolved from their dinosaur forebears; most palaeontologists point to the late Jurassic period, about 150 million years ago, on the evidence of distinctly bird-like dinosaurs like Archaeopteryx.

EVOLUTION OF VERTEBRATES
BIRDS

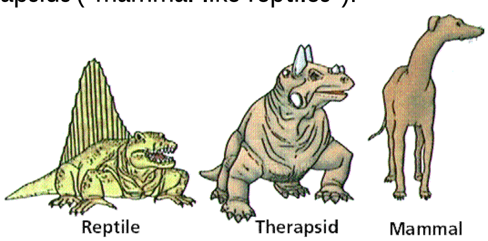
However, it's possible that birds evolved multiple times during the Mesozoic Era, most recently from the small, feathered theropods (sometimes called "dino-birds“).

EVOLUTION OF VERTEBRATES
BIRDS

By the way, following the classification system known as "cladistics,“ (a classification of animals and plants into groups based on characteristics which originated in a common evolutionary ancestor) this refer to modern birds as dinosaurs!

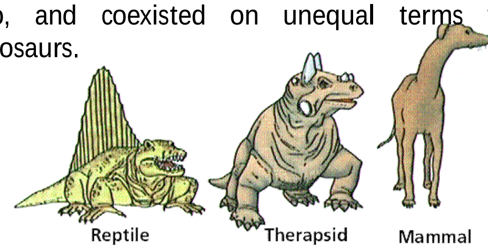
EVOLUTION OF VERTEBRATES
MESOZOIC MAMMALS

As with most such evolutionary transitions, there wasn't a bright line separating the most advanced therapsids ("mammal-like reptiles“).



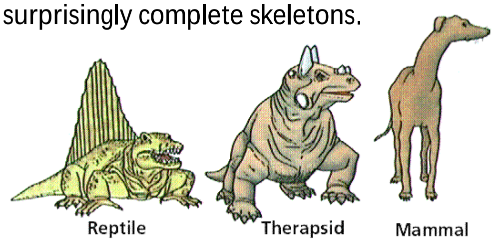
EVOLUTION OF VERTEBRATES
MESOZOIC MAMMALS

All we know for sure is that small, furry, warm-blooded, mammal-like creatures skittered across the high branches of trees about 230 million years ago, and coexisted on unequal terms with dinosaurs.



EVOLUTION OF VERTEBRATES
MESOZOIC MAMMALS

Because they were so small and fragile, most Mesozoic mammals are represented in the fossil record only by their teeth, though some species left surprisingly complete skeletons.



EVOLUTION OF VERTEBRATES
MEGAFAUNA MAMMALS

After the dinosaurs and marine reptiles vanished off from the earth 65 million years ago, the next big theme in vertebrate evolution was the rapid progression of mammals from small, timid, mouse-sized creatures to the giant megafauna.

EVOLUTION OF VERTEBRATES MEGAFAUNA MAMMALS

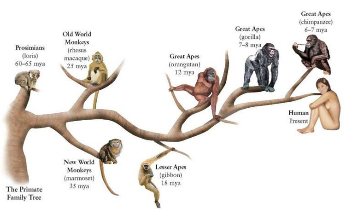
The megafauna including oversized wombats (Burrowing plant-eating Australian marsupial which resembles a small bear with short legs), rhinoceroses, camels and beavers (a large semi aquatic broad-tailed rodent).

EVOLUTION OF VERTEBRATES MEGAFAUNA MAMMALS

Among the mammals that ruled the planet in the absence of dinosaurs and mosasaurs were prehistoric cats, prehistoric dogs, prehistoric elephants, prehistoric horses and prehistoric whales, most species of which went extinct often at the hands of early humans.

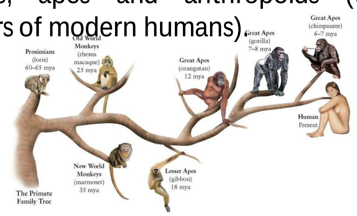
EVOLUTION OF VERTEBRATES PRIMATES

Technically, there's no good reason to separate prehistoric primates from the other mammalian megafauna that succeeded the dinosaurs, but it's natural to want to distinguish our human ancestors from the mainstream of vertebrate evolution.



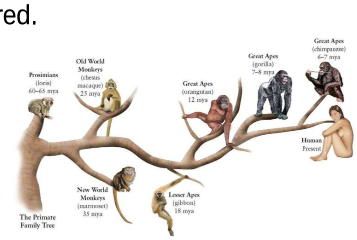
EVOLUTION OF VERTEBRATES PRIMATES

The first primates appear in the fossil record into a bewildering (unknown origin) array of lemurs (arboreal primate with a pointed snout and typically a long tail, found only in Madagascar), monkeys, apes and anthropoids (the direct ancestors of modern humans).



EVOLUTION OF VERTEBRATES PRIMATES

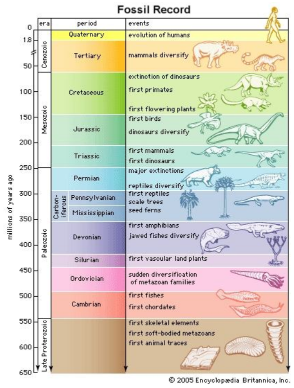
Palaeontologists are still trying to sort out the evolutionary relationships of these fossil primates, as new "missing link" species are constantly being discovered.



Thank You

THE FOSSIL RECORD

- ✓ Fossils are **remains of organisms** preserved in sediments which in the course of time have become rocks
- ✓ Direct evidences for evolution are formed by using fossils
  - Fossils tell us **past history** of organisms
  - Indirect evidences are also used – based on the living



THE FOSSIL RECORD

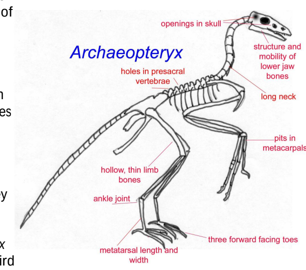
- ✓ How fossils are formed and discovered (fossilization)?
  - Usually formed from sedimentary rocks
  - When we think of fossil vertebrates, we probably picture bones and teeth, the hard parts of a body that more readily resist the destructive processes following death and burial
  - Certainly most fossil vertebrates are known from their skeletons and dentition

THE FOSSIL RECORD

- The calcium phosphate compound composing bones and teeth is a mineral usually preserved indefinitely, with little change in structure or composition
- Occasionally products of vertebrates, such as eggs, will fossilize
  - If tiny young bones are preserved inside, we can identify them and the group to which they belong
- Infrequently, fossils preserve more than just their hard parts

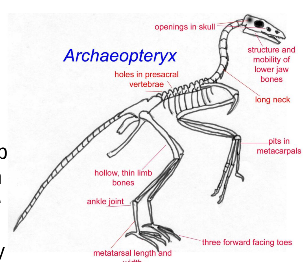
THE FOSSIL RECORD

  - If a full animal skeleton is discovered, microscopic analysis of the region occupied in life by the stomach might reveal the types of foods eaten shortly before its death
- Dung is sometimes fossilized
  - Although we might not know which animal dropped it, we can gain some notion about the types of foods eaten.
- Soft parts usually decay quickly after death and seldom fossilize.
- Occasionally soft parts leave an impression in the terrain in which they are buried
- Impressions of feathers in the rock around the skeleton of *Archaeopteryx* demonstrate that this animal was a bird
- The past behavior of now extinct animals is sometimes implied by their fossilized skeletons



THE FOSSIL RECORD

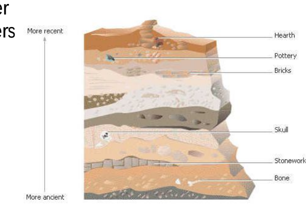
- ✓ How fossils are dated? Dating of fossils
  - To discover a fossil is not enough
  - Its position in time with regard to other species must be determined as well, because this will help to place its morphology in an evolutionary sequence
  - Techniques for dating fossils vary, and preferably several are used to verify age:



THE FOSSIL RECORD

1. **Stratigraphy** – Relative dating

- A method of placing fossils in a relative sequence to each other
- Based on the sedimentary layers - rocks could be arranged from oldest (deepest) to youngest (surface)
- Similar strata, layered one on top of another, are built in chronological order
- Each layer of rock is called a **time horizon** because it contains the remains of organisms from one slice in time – the d/t layers mark time intervals

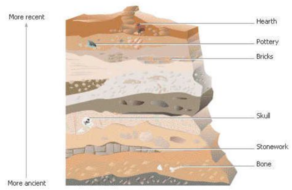


THE FOSSIL RECORD

- Any fossils contained within separate layers can be ordered from the oldest to the most recent, bottom to top
- Although this gives no absolute age, it does produce a chronological sequence of fossil species relative to each other
- By placing fossils in their stratigraphic sequence, we can determine which arose first and which later, relative to other fossils in the same overall rock exposure

✓ Since the sedimentary layers change their place due to flooding, volcanic activity, etc we can't depend in one overall rock exposure

- If we have matching and congruent (matching) sedimentary layers in d/t parts of the world, we will have reliable information for dating of fossils



THE FOSSIL RECORD

2. Radiometric dating – the widely used absolute dating technique

- Paleontologists use radiometric dating to determine more precisely the age of fossils
- In this process, they study the isotopes of minerals in the rock surrounding the fossil
- Radioactive elements decay and converted into another element through time

✓ The change takes place at constant rate

- Half life (decay constant) – the amount of time for half of a radioactive elements to decay (decompose)

Isotope		Half-life of parent (years)
Parent	Daughter	
Carbon 14	Nitrogen 14	5,730
Potassium 40	Argon 40	1.3 billion
Rubidium 87	Strontium 87	47 billion
Uranium 238 Uranium 235	Lead 206 Lead 207	4.5 billion 710 million

THE FOSSIL RECORD

✓ It is formulated by scientists

✓ Common examples include "decay" of uranium-235 to lead-207 (710 million years) and potassium-40 to argon-40 (1.3 billion years).

- Knowing the rates at which the isotopes decay, and having determined how much of the isotope has decayed in the rock sample, paleontologists can determine the age of the rock—and thus the age of the fossil preserved in the rock
- When rocks form, these radioactive isotopes are often incorporated
- If we compare the ratios of product to original and if we know the rate at which this transformation occurs, then the age of the rock and, hence, the age of fossils it holds can be calculated

Isotope		Half-life of parent (years)
Parent	Daughter	
Carbon 14	Nitrogen 14	5,730
Potassium 40	Argon 40	1.3 billion
Rubidium 87	Strontium 87	47 billion
Uranium 238 Uranium 235	Lead 206 Lead 207	4.5 billion 710 million

THE FOSSIL RECORD

✓ **Limitations of fossil record**

- All animals (& animal parts) could not be fossilized
- Mostly, only the hard parts could be fossilized
- Most protochordates couldn't be fossilized since they are soft bodied
- Sedimentary rock formation is episodic
- We can't recognize the life cycle of an organism which live at one time in one local place
- The rocks should be formed and persistent
- The sedimentary rocks which contain this information (fossil) should be exposed for the paleontologists

Isotope		Half-life of parent (years)
Parent	Daughter	
Carbon 14	Nitrogen 14	5,730
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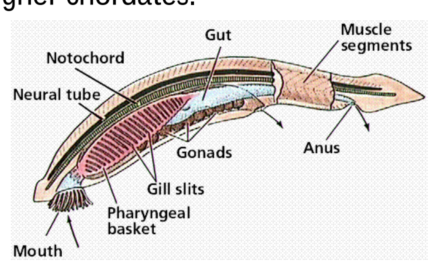
GENERAL CHARACTERS OF VERTEBRATE

The phylum vertebrata is also called as chordata is a very big phylum comprising animals which have the following characteristics which distinguish them from the Invertebrates. The distinguishing characters of vertebrates are

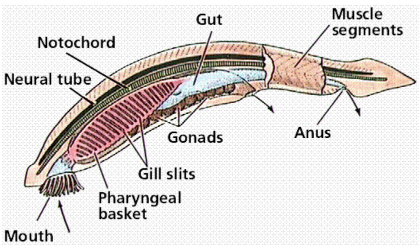
GENERAL CHARACTERS OF VERTEBRATE

Notochord: There is a dorsal median supporting rod in the body called notochord. This is replaced by the vertebral column in the higher chordates.



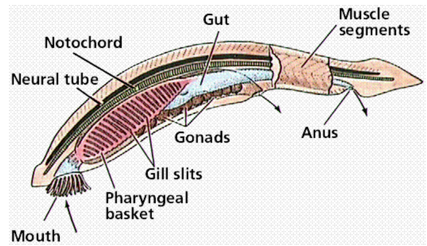
GENERAL CHARACTERS OF VERTEBRATE

This supporting chord may remain cartilaginous throughout life. In some cases the notochord develops but disappears later.



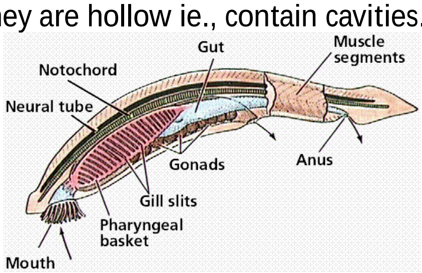
GENERAL CHARACTERS OF VERTEBRATE

So the presence of a median supporting notochord at least, during some stage in the life history of any animal is an essential characteristic of a chordate.



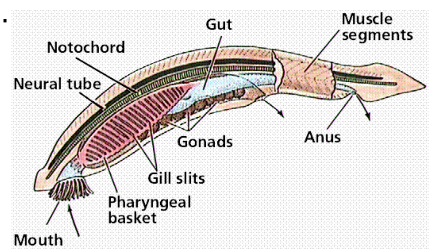
GENERAL CHARACTERS OF VERTEBRATE

Dorsal tubular nervous system: The central nervous system, namely the brain and spinal cord are place dorsally above the nototchord and they are hollow ie., contain cavities.



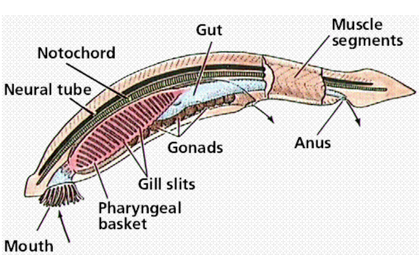
GENERAL CHARACTERS OF VERTEBRATE

The invertebrates usually have a ventral nerve cord and it is solid. Here also the presence of dorsal tubular nervous system may get obliterated (destroy) in later stages of life.



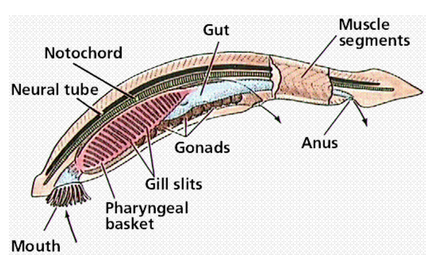
GENERAL CHARACTERS OF VERTEBRATE

But evidence of its presence at least in embryonic stages is also a chordate character.



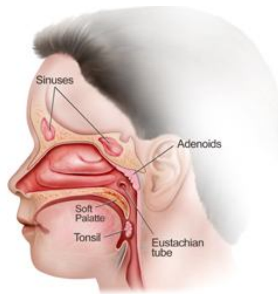
GENERAL CHARACTERS OF VERTEBRATE

Pharyngeal gill slits: All chordates have paired gill slits in the region of the pharynx.



GENERAL CHARACTERS OF VERTEBRATE

The gill slits may disappear later but at least in the embryonic stages pharyngeal gill slits are present in all chordates (In man the eustachian tubes are remnants of the gill slits in the embryo)



GENERAL CHARACTERS OF VERTEBRATE

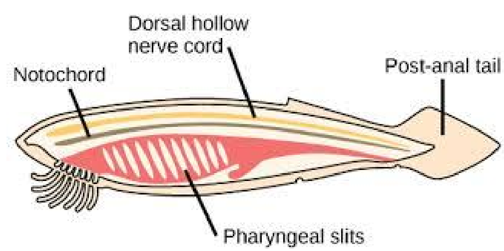
Ventral heart: Where as the heart is usually dorsally placed in the invertebrates, the chordates have a ventral heart placed a little below and behind the pharynx

GENERAL CHARACTERS OF VERTEBRATE

Hemoglobin in the corpuscles: The respiratory pigment, the iron containing hemoglobin is present in the erythrocytes (red blood corpuscles) while in the invertebrates the pigment is dissolved in the plasma

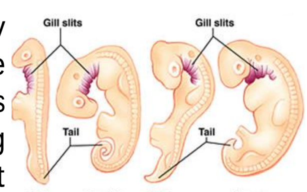
GENERAL CHARACTERS OF VERTEBRATE

Post anal tail: All chordates possess a tail with the vertebral column extending into it.



GENERAL CHARACTERS OF VERTEBRATE

The tail may be concealed internally as in man or may become lost as in the adult frog. But its presence, extending beyond the anus at least during some part of the life is a chordate character.



GENERAL CHARACTERS OF VERTEBRATE

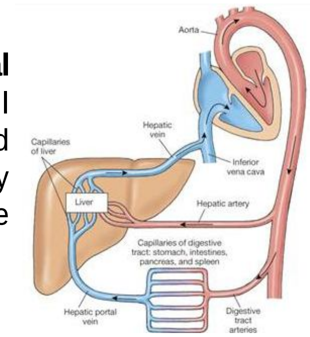
Number of limbs: No chordates has more than two pairs of limbs (a pair of forelimbs and a pair of hind limbs).

GENERAL CHARACTERS OF VERTEBRATE

The limb may be absent as in the case of snakes but it is a secondary adaptation (Invertebrates can have more limbs)

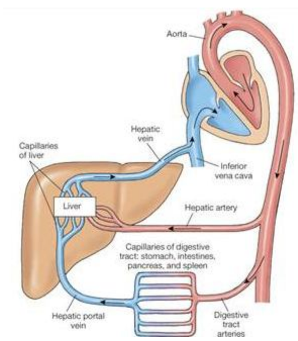
GENERAL CHARACTERS OF VERTEBRATE

Hepatic portal system: In all chordates, blood from the alimentary canal is taken to the liver.



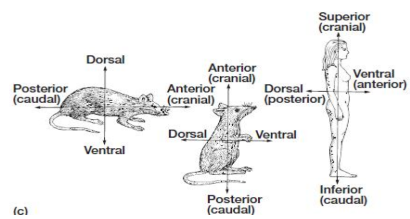
GENERAL CHARACTERS OF VERTEBRATE

This system begins in a bed of capillaries in the alimentary canal and ends in a bed of capillaries in the liver constituting the hepatic portal system. From the liver blood is later transported to the heart



SALIENT FEATURES OF CHORDATES

1. Body plan: bilateral symmetry
2. They have three axis in their body
   a. Anterio-posterior axis
   b. Dorso-ventral axis
   c. Lateral axis



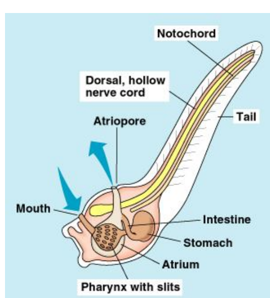
SALIENT FEATURES OF CHORDATES

Chordates have d/t body parts and structures:

Head	Pharyngeal region
Trunk	Tail
Appendages	Muscles
Skeleton	

Head: Urochordates are mostly sessile; they don't have well organized head
As you go higher the head (cephalization) is well developed

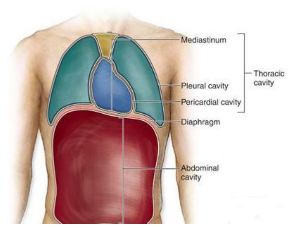
Pharyngeal region is persistent in aquatic chordates & in terrestrial chordates replaced by neck



SALIENT FEATURES OF CHORDATES

Trunk: d/t cavities are found here

1. **Abdominal cavity:** accommodates the viscera
2. **Pericardial cavity:** encloses heart (ventral)
3. **Pleural cavity:** encloses lung

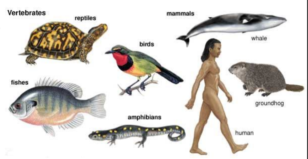


At the end of the trunk, there is an opening (anus) for waste; but for invertebrates at the extreme end

SALIENT FEATURES OF CHORDATES

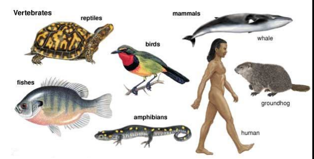
Tail: differ in function in d/t chordates

- All (most) embryos of chordates have tail; some lack tail in adults
- Adult fishes have a prominent tail
- Some adult amphibians possess tail
- Found in most adult reptiles



SALIENT FEATURES OF CHORDATES

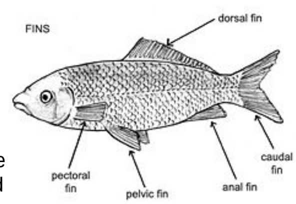
- Birds have reduced tail that can accommodate feather
- Adult mammals have tail but diminished in function
- Tail is lost in apes and humans (but, there is a sign of tail in adults as a tail bone (coccyx) – loss of tail is a secondary phenomena



SALIENT FEATURES OF CHORDATES

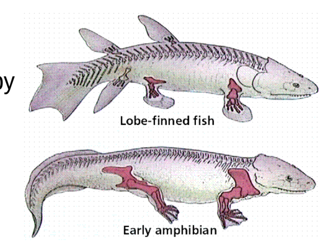
Appendages: are found as fins (in aquatic chordates) or limbs (in terrestrial chordates)

1. **Fins** – used generally for swimming; keeping balance, changing direction & controlling the motion of forward movement
   - Median fins – earlier structure
     i. Dorsal fins ii. Anal fins and iii. Caudal fins
   - Paired fins – advanced structure
     i. Pectoral fins and ii. Pelvic fins



SALIENT FEATURES OF CHORDATES

2. **Limbs -** Based on hypothesis supported by evidence
   - Fore limbs – evolved from pectoral fin
   - Hind limbs – evolved from pelvic fin



SALIENT FEATURES OF CHORDATES

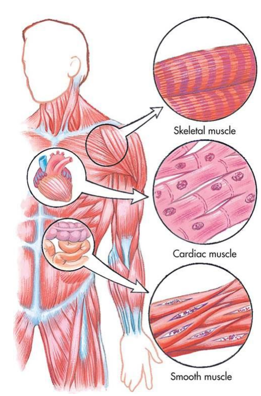
Muscles: muscle is a tissue;

- There are d/t types of tissues in the body of chordates
- $1/3^{rd}$ to ½ of the body of chordates is made up of muscles
- Contractility is the major characteristics of muscles
- Used for movement of the whole body or part of it
- Several ways for classifying muscles

SALIENT FEATURES OF CHORDATES

There are 3 types of muscles:

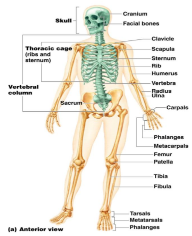
1. **Striated (skeletal) muscles** – voluntary
   Composed of long, cylindrical & multinucleate muscle fiber
1. **Non-striated (smooth) muscles** – involuntary muscles
   Uninucleate; lack cross striations
1. **Cardiac muscles** – involuntary muscles
   Heart muscles; unique striated muscles (but, uninucleate cells)



SALIENT FEATURES OF CHORDATES

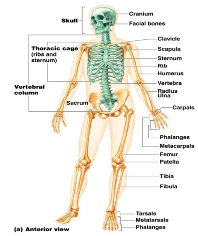
Skeleton – body support (its main function)

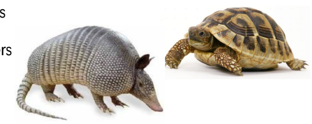
- Bone, scales and teeth constitute important storage places for calcium and other mineral salts
- Can be grouped into two: regional components
  a. Axial skeleton – found along the longitudinal axis of skeleton
  Skull, vertebral column, ribs and sternum
  b. Appendicular skeleton – found in the appendages
- Pectoral and pelvic girdles, skeleton of paired fins and limbs and skeletons of median fins
- Most chordates have endoskeleton but exoskeleton for most invertebrates
- But, some chordates have exoskeleton; e.g. Spines of Armadillos and shells of tortoises



SALIENT FEATURES OF CHORDATES

- The main composition of the skeletal material of chordates is calcium phosphate; no bone in invertebrates
- The hard parts of chordates can be grouped into four:
- Bone, cartilage, dentine and enamel – all arose from the same ancestral structure
- **Bone**: composed of collagenous fibers (proteinaceous fiber on which the $Ca_3(PO4)_2$ deposited) and high concentration of crystals of $Ca_3(PO4)_2$
- Cementing elements are water + mucopolysaccharide (to bind the crystals to the collagenous matrix)
- **Cartilage**: composed of collagenous fibers and low concentrations of $Ca_3(PO4)_2$
- Cementing materials – sulphated mucopolysaccharide

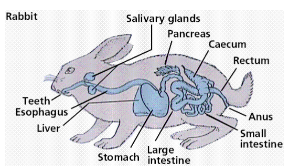


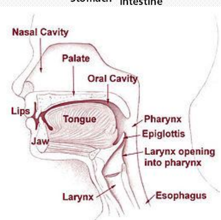


SALIENT FEATURES OF CHORDATES

Digestive system

- There are 2 openings in the digestive system of chordates without exception
- One for entry of food & another for exit of waste
- Mouth → Pharynx → Esophagus → Stomach → Intestine → Anal opening
- **Mouth** is used for the entry of food and water
- **Pharynx** is a muscular tube located in the neck, lined with mucous membrane, that connects the nose and mouth with the trachea (windpipe) and esophagus and serves as a passageway for both air and food

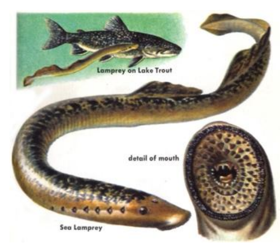




SALIENT FEATURES OF CHORDATES

Esophagus is a muscular tube that takes food from the pharynx to the stomach. Peristalsis of the esophagus propels food in one direction and ensures that food gets to the stomach even if the body is horizontal or upside down; Absent in lower chordates

Stomach - Although part of the alimentary tube, the stomach is not a tube, but rather a sac that extends from the esophagus to the small intestine. Absent in some chordates e.g. Lamprey – the only parasitic vertebrates



SALIENT FEATURES OF CHORDATES

Intestine – in almost all aquatic chordates large intestine is absent b/c its role is for reabsorbtion of water; water is not a problem in aquatic habitat.

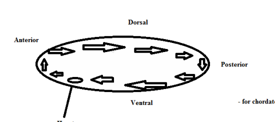
Anal opening – For digestive and excretory (urinary) wastes. But, in higher chordates the excretory & digestive wastes exit in d/t openings.

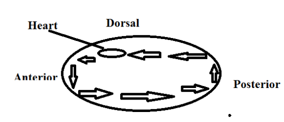
Cloaca - Digestive & excretory wastes and reproductive cells are released out through the same opening in fishes, amphibians, reptiles and birds

SALIENT FEATURES OF CHORDATES

Circulation and the heart

- The position of the heart is ventral in chordates but dorsal in invertebrates
- Blood flows dorsally backward and ventrally forward
- Blood flows dorsally forward and ventrally backward
- In both cases, blood flows first towards the head region
- Circulation of blood in chordates is closed





SALIENT FEATURES OF CHORDATES

Excretion

- The process by which the body of animals removes nitrogenous wastes
- Ammonia, which requires a large amount of water for removal, is the major nitrogenous waste in aquatic environment
- Urea & uric acid, which require relatively less amount of water for removal, are the nitrogenous wastes in terrestrial habitat
- Salts and sometimes pigments are also removed together
- Hemichordates and urochordates have specialized cell (nephrocytes) for excretion
- Cephalochordates have nephridia for excretion

SALIENT FEATURES OF CHORDATES

- All the other chordates (vertebrates) have d/t types of kidney for excretion; differ in the development of ducts and compactness

a. Archinephros
Kidney found in embryo of hagfish; this is the inferred ancestral condition of the vertebrate kidney

b. Pronephros
Functional kidney in adult hagfish and embryonic fishes and amphibians fleeting existence in embryonic reptiles, birds, and mammals

c. Mesonephros
Functional kidney of adult lampreys, fishes, and amphibians; transient function in embryonic reptiles, birds, and mammals

d. Meta nephros
Functional kidney of adult reptiles, birds, and mammals

SALIENT FEATURES OF CHORDATES

Reproduction

- Sexual reproduction is the major form
- regeneration of bodies is seen in some lower chordates
- Hermaphroditism is seen in some chordates such as urochordates and bony fishes
- When the two gametes mature at the same time, self fertilization is possible; but mostly the gonad produce either a male or female gamete (protandry or protogyny)
- Parthenogenesis is seen in some chordates such as desert lizards

SALIENT FEATURES OF CHORDATES

Reproductive pattern in vertebrates:

Oviparity

- Egg laying pattern
- A few or mostly thousands/millions of eggs may be produced
- In lamprey, fertilization & incubation are external
- Fishes are largely oviparous; mostly fertilization and incubation are external
- In birds and reptiles fertilization is internal and incubation is external

SALIENT FEATURES OF CHORDATES

Ovoviviparity

- Fertilization is internal and unnourished young is come out; it develops within the body of the female, but without placental attachment
- The nourishment is stored in the egg for most
- The embryo receives maternal protection & oxygen
- E.g. in some fishes, some amphibians, some lizards, kangaroo

SALIENT FEATURES OF CHORDATES

Viviparity

- Giving young which are already nourished; e.g. by placenta in mammals
- It is advantageous
  i. Protection: gives protection for embryo and young
  ii. Conserve energy: for laying large number of eggs, to migrate longer distances for laying eggs and for nest building
  iii. Assures fertilization: highly probable
  iv. Survival and dispersal are assured in viviparity

SALIENT FEATURES OF CHORDATES

Sexes are distinguished

- Sexual dimorphism – differences in the morphology of the two sexes; mostly males are larger than females
- Sexual dichromatism – difference in colour indicates d/t sexes; in birds and fishes males are usually brightly coloured but females are dull in colour

SALIENT FEATURES OF CHORDATES

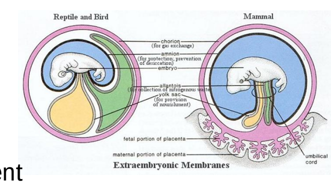
Endocrine system

- Pituitary, adrenal, thyroid, ovaries & testes, parathyroid and islets of langerhans are found in all chordates
- The difference b/n lower and higher chordates is in the organization of these glands
- Distinct in higher chordates but diffused in lower chordates
- Nervous system and endocrine system are highly related systems – the activity of one affects the other

SALIENT FEATURES OF CHORDATES

Extra-embryonic membranes

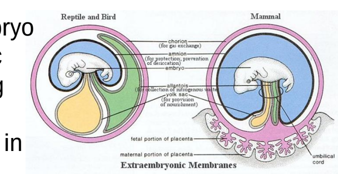
- Found exclusively in terrestrial chordates
- Four extra-embryonic membranes are present inside the leathery shell



SALIENT FEATURES OF CHORDATES

An **amnion**

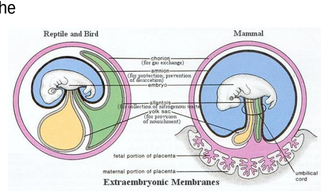
- Inner membrane surrounding the embryo forming the amniotic cavity and containing amniotic fluid
- Encloses the embryo in a fluid-filled sac – protects the embryo from desiccation; also acts as a cushion for the embryo



SALIENT FEATURES OF CHORDATES

A **chorion**

- Outer membrane surrounding the embryo that assists in gas exchange and in forming blood vessels
- Provides a special hard covering that is permeable to respiratory gases (O_2 and CO_2) while being impermeable to water vapor.



An **allantois**

- Provides a sac to store nitrogenous waste and

A **yolk sac**

- Enclosing the yolk

SALIENT FEATURES OF CHORDATES

Body temperature – source

1. **Ectotherms** – poikilotherms or cold blooded
   - Maintain their body temperature by absorbing heat from the environment
   - Can't control their body temperature
   - E.g. Agnatha, Chondrichthyes, Osteichthyes, Amphibians and Reptiles
2. **Endotherms** – homeotherms or warm blooded
   - Can maintain a constant body temperature despite changes in the temperature of the environment
   - They depend on internal sources to warm up their body
   - Exhibit structural and physiological adaptations to keep internal temperature constant
   - E.g. Birds and Mammals

SALIENT FEATURES OF CHORDATES

Integument – skin/outer body surface

The skin of vertebrates has two major layers: epidermis & dermis

a. Secretions

i. Glandular vertebrates
- Have glands on their skin to produce mucous & other secretions
- Agnatha, chondrichthyes, osteichthyes and amphibians

ii. Aglandular vertebrates
- No glands (no secretions); dry skin
- Reptiles and birds

iii. Secondarily glandular vertebrates – mammals
- No glands in their ancestors but secondarily they developed it
- There are sweat glands, sebaceous glands

SALIENT FEATURES OF CHORDATES

b. Cover of the skin
- Naked – Agnatha, Amphibians
- Dermal scales – arises from the dermal layer; chondrichthyes, osteichthyes
- Epidermal scales – arises from the epidermal layer; reptiles
- Feathers and epidermal scales – birds
- Hair - mammals

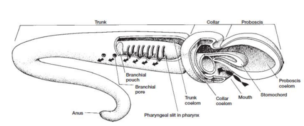
Thank You

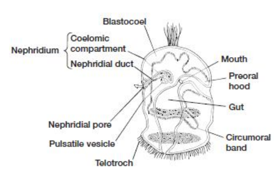
SALIENT FEATURES OF CHORDATES

Notochord
Neural Tube
Pharyngeal Gill Slits
Ventral Heart
Hemoglobin in the Corpuscles
Post Anal Tail
Four Limbs
Hepatic Portal System

SUBPHYLUM HEMICHORDATA

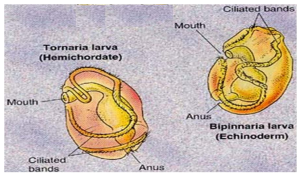
- ✓ Members of the hemichordates are marine "worms" with apparent links to chordates on the one hand and to echinoderms on the other
- ✓ They share with chordates unmistakable pharyngeal slits
- ✓ In the collar region, the epidermis and dorsal nerve cord are invaginated into a collar cord.
  - They also have dorsal partially hollow nerve cord
- ✓ Hemichordates lack a true postanal tail
- ✓ They also lack a notochord
- ✓ Although in possession of pharyngeal slits, overall hemichordates lack other homologous equivalents of other major chordate features, hence, the name *hemi- or half-chordates*
- ✓ The larvae stage is called as **tornaria larva**





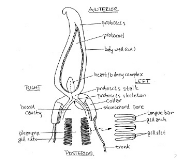
SUBPHYLUM HEMICHORDATA

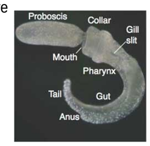
- ✓ Tornaria larva resembles the **auricularia larva or Bipinnaria larvae** of echinoderms
- ✓ Hemichordates, like both echinoderms and chordates, are deuterostomes
  - They exhibit the characteristic deuterostome patterns of embryonic cleavage and coelom formation
- ✓ Blood vascular system is closed
  - The non-contractile central sinus serve as heart; contraction is done by pericardium
  - Direction of blood flow is the same with invertebrates
  - The blood is colourless – not typical of white blood cells
  - No cells in their blood (sometimes amoebocytes)
  - No capillaries; but dorsal vessel (veins) & ventral vessel (arteries)

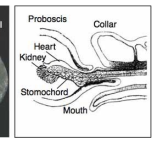


SUBPHYLUM HEMICHORDATA

- ✓ Respiration is done by gills
- ✓ Excretion is accomplished by nephrocytes
  - Excretory wastes removed from the blood by nephrocytes → proboscis gland ("glomerulus") → Proboscis coelom → Proboscis pore → out
- ✓ The nervous system is primitive – similar with invertebrates (not comparable to vertebrates)
- ✓ In the proboscis area around the proboscis pore, they possess a structure called stomochord
  - It arises in the embryo as an outpocketing from the roof of the embryonic gut anterior to the pharynx
  - In the adult, it retains a narrow connection to what becomes the buccal cavity

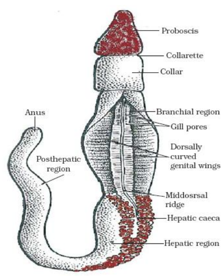






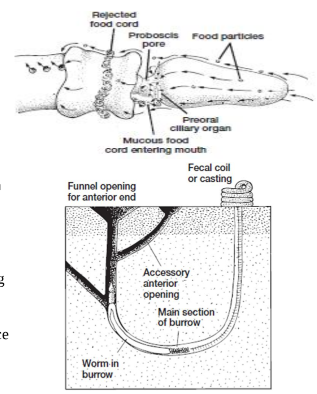
SUBPHYLUM HEMICHORDATA

- ✓ No major sense organs are available or they are poorly developed
  - But there are neurosensory cells; Photoreceptors and chemoreceptors
- ✓ Sexes are separate; no hermaphroditism
  - The sexes are indistinguishable from outside; no sexual dimorphism nor dichromatism
  - Gonads are found at the anterior part of the trunk; Mostly fertilization is external
- ✓ No sign of endocrine system
- ✓ Within the hemichordates are two taxonomic groups (classes), the **enteropneusts,** burrowing forms, and **the pterobranchs,** usually sessile forms



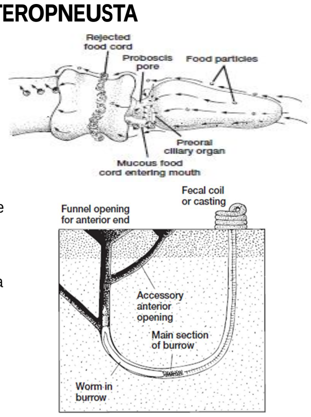
SUBPHYLUM HEMICHORDATA
CLASS ENTEROPNEUSTA

- ✓ Commonly knwn as "Acorn Worms"
- ✓ They are marine animals of both deep and shallow waters
- ✓ Most live in mucus lined burrows and have a body with three regions—**proboscis, collar & trunk –** each with its own coelom
- ✓ The proboscis, used in both locomotion and feeding
- ✓ Some species are suspension feeders, extracting tiny bits of organic material and plankton directly from the water
- ✓ In these forms, the synchronous beating of cilia on the outer surface of the proboscis sets up water currents that flow across the animal's mucous surface



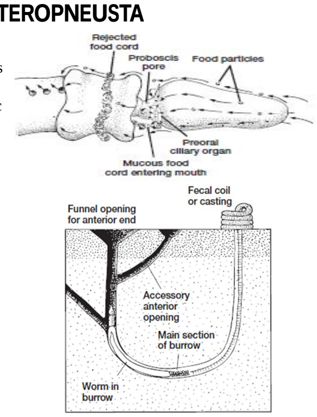
SUBPHYLUM HEMICHORDATA
CLASS ENTEROPNEUSTA

- **Suspension mucous feeding:** Direction and movement of food and mucus are indicated by arrows
  - Food material, carried along in the water current generated by surface cilia, travels across the proboscis and into the mouth where it is captured in mucus and swallowed
  - Rejected food material collects in a band around the collar and is shed



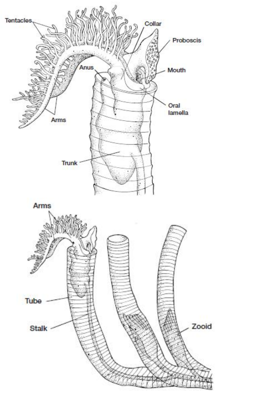
SUBPHYLUM HEMICHORDATA
CLASS ENTEROPNEUSTA

- ✓ In some species, development proceeds directly from egg to young adult
- ✓ In most, however, there is a tricoelomic tornaria larval stage in that the three body cavities include an anterior **protocoel,** a middle **mesocoel,** and a posterior **metacoel,** which become the coelom of the proboscis, collar, and trunk, respectively
- ✓ The tornaria feeds and may remain a planktonic larva for several months before undergoing metamorphosis into the benthic adult.
- ✓ The adult body is covered by a ciliated epithelium with glandular cells that produce a mucous coating
- ✓ E.g. ***Balanoglossus***



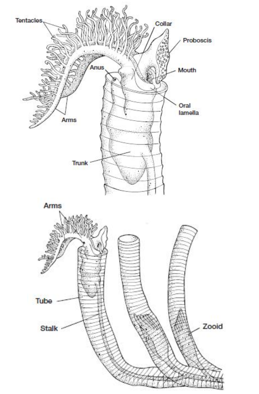
SUBPHYLUM HEMICHORDATA
CLASS PTEROBRANCHIA

- ✓ Most pterobranchs, of which there are only two genera, live in secreted tubes in oceanic waters
- ✓ These species are small and colonial and is commonly referred to as a **zooid**
  - **Proboscis**, **collar**, **and trunk** are present in each zooid, although they may be quite modified
  - The zooids within one colony are produced by asexual budding, so all are descended from a single larva
- ✓ Stomochord is usually present
- ✓ The nervous system is even simpler than that of acorn worms
  - A tubular nerve cord is absent
- ✓ E.g. ***Rhabdopleura***



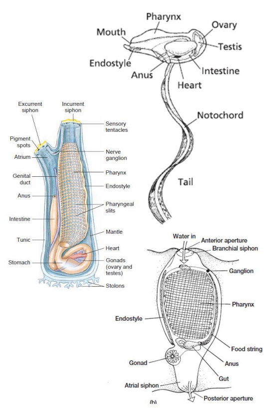
SUBPHYLUM HEMICHORDATA
CLASS PTEROBRANCHIA

- ✓ Notice that this *pterobranchia* has the same body plan as an acorn worm—proboscis, collar, trunk—but these three features are modified and the whole animal lives in a tube and when disturbed, the stalk shortens to pull a pterobranch to safety inside the tube.



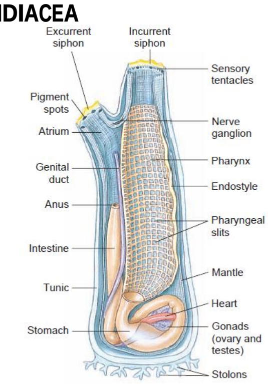
SUBPHYLUM UROCHORDATA

- ✓ At some point in their life histories, urochordates generally show all five shared derived chordate characteristics: notochord, pharyngeal slits, endostyle, tubular nerve cord, and postanal tail
- ✓ Urochordates are specialists at feeding on suspended matter, especially very tiny particulate plankton
- ✓ In most, the pharynx is expanded into a complex straining apparatus, the branchial basket
- ✓ In a few species the filtering apparatus is secreted by the epidermis and surrounds the animal
- ✓ All species are marine
- ✓ Urochordate literally means "tail back string," a reference to the notochord.
- ✓ Urochordates are divided into three major taxonomic classes



SUBPHYLUM UROCHORDATA
CLASS ASCIDIACEA

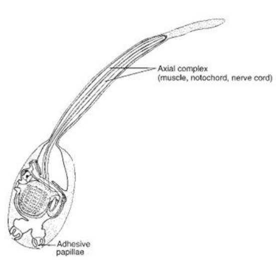
- ✓ **Ascidiacea** are sessile as adults, but have swimming larvae,
- ✓ The common name, **tunicates,** is inspired by the characteristic flexible outer body cover, the **tunic**
  - It is secreted by the underlying epidermis which characterizes the urochordates
- ✓ Commonly known as "Sea Squirts"
- ✓ Ascidians are marine animals that are often brightly colored
- ✓ Some species are solitary, others colonial
- ✓ Adults are sessile, but larvae are planktonic.



SUBPHYLUM UROCHORDATA
CLASS ASCIDIACEA

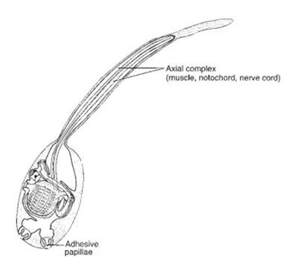
Larva:

- ✓ The larva, sometimes called the ascidian tadpole,
- ✓ Only the larval stage exhibits all five chordate characteristics simultaneously
- ✓ The small pharynx bears slits in the tadpole of colonial species
- ✓ The tubular nerve cord extends into a tail supported internally by a turgid notochord
- ✓ In solitary ascidian species, the gut does not fully differentiate in the nonfeeding larva, so an anus is not present
- ✓ In many colonial species, however, the gut may be fully differentiated, including an anus that opens into the atrial chamber, and feeding may begin within 30 minutes after settlement



SUBPHYLUM UROCHORDATA
CLASS ASCIDIACEA

- ✓ The "postanal" tail is present, although sometimes twisted or rotated about 90° to the body
- ✓ Beneath the tunic, the epidermis at the anterior end of the body forms **adhesive papillae that serve** to attach the larva to a substrate at the end of its planktonic existence
- ✓ The central nervous system forms dorsally in typical chordate fashion
- ✓ It has three subdivisions: (1) sensory vesicle and (2) visceral ganglion, both of which form a rudimentary brain, and (3) the dorsal, hollow nerve cord extending into the tail

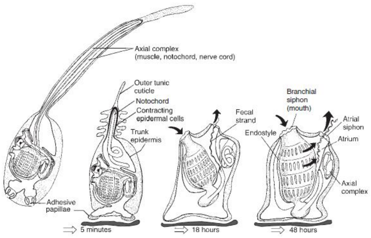


SUBPHYLUM UROCHORDATA

CLASS ASCIDIACEA

Metamorphosis:

- ✓ At the end of its short planktonic stage, the ascidian larva makes contact with the substrate of choice, usually in a dark or shaded location, adhesive papillae take hold to attach it, and metamorphosis to a young adult begins almost immediately
- ✓ Most of the chordate features that made their debut in the larva, namely, notochord, tail, and dorsal nerve tube, disappear in the forming adult

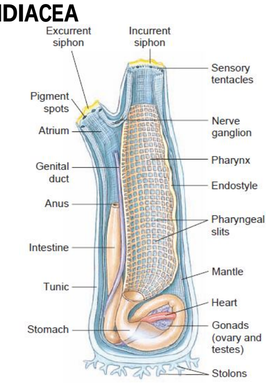


SUBPHYLUM UROCHORDATA

CLASS ASCIDIACEA

Adult

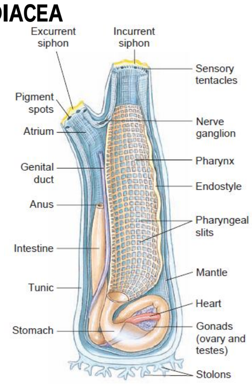
- ✓ The tunic, composed of a unique protein, **tunicin,** and a polysaccharide similar to plant cellulose, forms the body wall of an ascidian adult
- ✓ The branchial basket, a large atrial cavity around this basket, and the viscera are enclosed within the walls formed by the tunic
- ✓ The tunic attaches the base of the animal to a secure substrate
- ✓ Incurrent (branchial) and excurrent (atrial) siphons form entrance and exit portals for the stream of water that circulates through the body of the tunicate



SUBPHYLUM UROCHORDATA

CLASS ASCIDIACEA

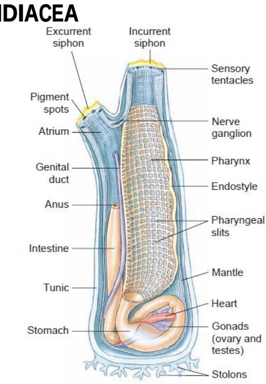
- ✓ Tiny, fingerlike sensory tentacles encircle the incurrent siphon to examine the water entering and perhaps exclude excessively large particles before water enters the branchial basket.
- ✓ The complex pharyngeal slits, the stigmata, sieve the passing water before it flows from the branchial basket into the **atrium,** the space between basket and tunic
- ✓ From here, the current exits via the excurrent siphon.
- ✓ Rows of cilia line the branchial basket



SUBPHYLUM UROCHORDATA

CLASS ASCIDIACEA

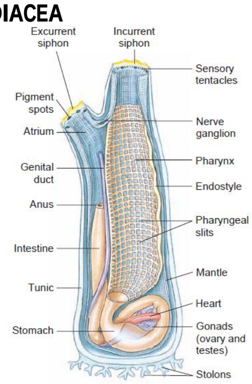
- ✓ The sea squirt's heart, located in the body near the pharynx, is tubular, with a single layer of muscle-like striated myoepithelial cells forming its wall
- ✓ The surrounding pericardial cavity is the only remnant of the coelom
- ✓ Contraction of the heart pushes blood out to the organs and tunic.
- ✓ After a few minutes, the flow reverses to return blood along the same vessels to the heart.
- ✓ Unlike the vertebrate circulatory system, there is no continuity between the heart myoepithelium and the blood vessels.
- ✓ The blood contains a fluid plasma with many kinds of specialized cells, including **amoebocytes** that resemble vertebrate lymphocytes



SUBPHYLUM UROCHORDATA

CLASS ASCIDIACEA

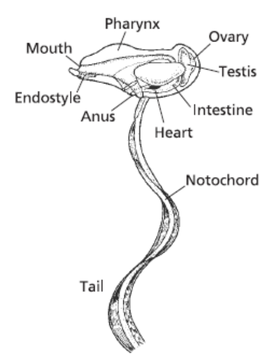
- ✓ They are phagocytic, and some accumulate waste materials
- ✓ No specialized excretory organ has been found in tunicates
- ✓ All ascidians are hermaphrodites; both sexes occur in the same individual (monoecious), although self-fertilization is rare.
- ✓ Solitary ascidians reproduce only sexually, while colonial ascidians reproduce sexually and asexually
- ✓ Asexual reproduction involves budding
- ✓ The rootlike stolons at the base of the body may fragment into pieces that produce more individuals, or buds may arise along blood vessels or viscera
- ✓ E.g. ***Ascidia,***



SUBPHYLUM UROCHORDATA

CLASS LARVACEA (APPENDICULARIA)

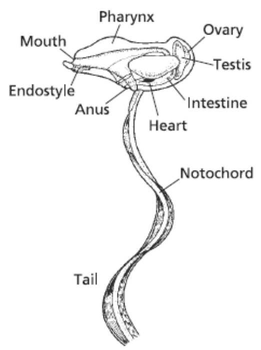
- ✓ Members of the worldwide class Larvacea are tiny marine animals that reach only a few millimeters in length and reside within the planktonic community
- ✓ Larvacea received their name because the adults retain larval characteristics similar in some ways to the ascidian tadpole with its tail and trunk
- ✓ The implication was that adult larvaceans derived from the larval stages of ascidians
- ✓ In fact, more recent phylogenetic analyses now suggest otherwise – larvaceans and ascidians are equally ancient
- ✓ Because the larvacean lives within the gelatinous matrix it constructs, this matrix is termed a "house"



SUBPHYLUM UROCHORDATA

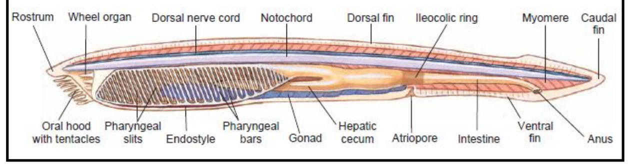
CLASS LARVACEA (APPENDICULARIA)

- ✓ All species, except one, are monoecious, and most of these are **protandrous;** (Not comparable)
- ✓ Maturation is so rapid that within 24 to 48 hours of fertilization
- ✓ Their rapid reproduction and special feeding apparatus give larvaceans a competitive advantage over other aquatic suspension feeders
- ✓ Larvaceans are especially adept at gathering ultraplankton, very minute, bacteria-sized organisms
- ✓ The trunk of the larvacean holds its major body organs
- ✓ The blood, which is mostly devoid of cells, circulates through a system of simple sinuses driven by the pumping action of a single heart
- ✓ The tail is thin and flat
- ✓ A tubular nerve cord is present



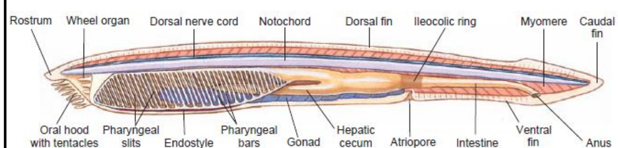
SUBPHYLUM CEPHALOCHORDATA

- ✓ In 1836 William Yarrell recognized the special nature of these animals and named them **Amphioxus** (meaning pointed at both ends)
- ✓ Amphioxus is a familiar common name with "lancelet" as another
- ✓ Living cephalochordates occur worldwide in warm temperate and tropical seas
- ✓ They are built upon the characteristic chordate pattern that includes pharyngeal slits, tubular dorsal nerve cord, notochord, and post anal tail or caudal fin
- ✓ They have two exit openings for waste materials
- ✓ i. **Anus**: for digestive waste ii. **Atriopore**: for discharge of excretory waste & reproductive gametes
- ✓ These animals are anatomically simple; suspension (ciliary) feeders on microorganisms and phytoplankton



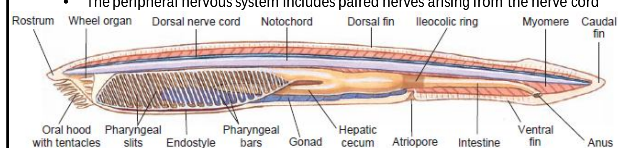
SUBPHYLUM CEPHALOCHORDATA

- ✓ Microscopic food particles are captured on mucous sheets as water flows through gill slits in the ciliated pharynx; the mucus is produced by endostyle
- ✓ Oral hood → Pharynx → Mid gut → Hind gut → Anus
- ✓ Show basic chordate features both in the larva and adult stages
- ✓ Circulation is closed within vessels
  - The blood of amphioxus is colourless due to lack of any respiratory pigment
- ✓ Its main function seems to be the transportation of food and excretory products rather than O_2 and CO_2 for gaseous exchange
- ✓ No blood cells
- ✓ Special respiratory organs are lacking
- ✓ It is probable that most gaseous exchange occurs through superficial areas



SUBPHYLUM CEPHALOCHORDATA

- ✓ Excretion is accomplished by a pair of nephridia
  - In Branchiostoma, the nephridia developes from the ectodermal cells and have no relation with mesoderm.
  - Thus, they are different from the kidney of vertebrates which are mesodermal in origin
  - They closely resemble the protonephridia of flatworms or polychaete annelids, thus providing a good example of parallel evolution
- ✓ Nervous system is very much simplified, a well developed brain, as found in higher chordates is absent
  - The central nervous system of Branchiostoma includes a hollow dorsal neural tube or nerve cord lying mid-dorsally just above the notochord – poor/no cephalization
  - It has no ganglia
  - The peripheral nervous system includes paired nerves arising from the nerve cord



VIDEO

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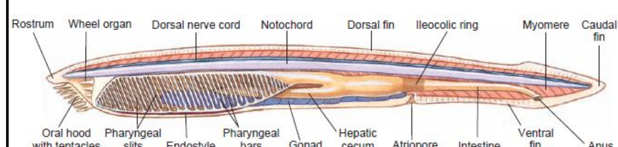
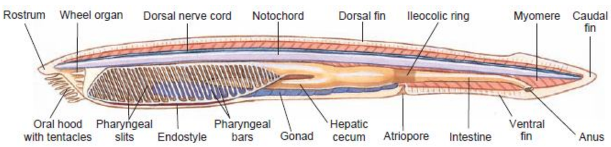
SUBPHYLUM CEPHALOCHORDATA

- ✓ Sexes are separate; but the male & female individuals look identical
  - The adult has 26 to 27 pairs of similar gonads
  - The mature sperm is one of the smallest among chordates, is about 18μm in length
  - The ovary contains ova which are large and somewhat rounded cells each 0.1mm in diameter and having a large nucleus
  - Gonoducts are absent
  - Fertilization and development take place externally in sea water
  - The cephalochordate larval stage is planktonic, lasting from 75 to over 200 days



SUBPHYLUM CEPHALOCHORDATA

- ✓ Some primitive feature
  - Ciliary feeding; no heart; no respiratory pigments
  - No cephalization; jaws are absent
  - The absence of paired fins
  - Gonads do not have ducts
- ✓ Some advanced features
  - Exhibit full chordate features
  - The presence of separate openings
  - The presence of median fins



ORIGIN OF CHORDATES - THEORIES

It is believed that Chordates have originated from invertebrates. It is difficult to determine from which invertebrate group the chordates were developed. Chordate ancestors were soft bodied animals. Hence they were not preserved as Fossils.

ORIGIN OF CHORDATES - THEORIES

Many biology theories were put forward to explain the Origin of Chordates.

1. Coelenterate theory
2. Annelid theory
3. Echinoderm -Hemichordate theory

COELENTERATE THEORY

According to this theory chordates were developed from coelenterates. Radial symmetry coelenteron, cnidoblasts etc, were 1st and advanced characters were developed to give rise to chordates. This theory infers that chordates might have acquired higher characters independently. It is not correct and hence this theory is not acceptable.

ANNELID THEORY

This theory suggests that the chordates have evolved from an annelid stock. The annelids show bilateral symmetry, head, lateral Coelome, complete digestive tract, closed circulatory system, hemoglobin, etc., like chordates. The resemblance is enhanced if, an annelid is turned upside down.

ANNELID THEORY

But the mouth would be dorsal which is unlike that of chordates. Metamerism and appendages of annelids differ in nature from those of the chordates. Bilateral symmetry, head and complete digestive tract occur in other non-chordate phyla also. Coelome is schizocoelic in annelids and enterocoelic in lower chordates

ANNELID THEORY

Haemoglobin is dissolved in the plasma in annelids but it is present in the red blood corpuscles in chordates. Annelid nerve cord is double, and, ventral in contrast to single, hollow, dorsal nerve cord of chordates. Some striking differences exist between the annelids and the chordates in their embryology. Hence it is difficult to accept this theory.

ECHINODERM -HEMICHORDATE THEORY

This theory infers origin of chordates, hemichordates and echinoderms from a common ancestor. This theory is based on the following evidences.

1. Embryological evidence
2. Serogical evidence

EMBRYOLOGICAL EVIDENCE

Both echinoderms and chordates have enterocoelic coelome. There is resemblance between the bipinnaria larva of certain echinoderms and the tonaria larva of hemichordates. In echinoderms chordates the central nervous system develops from a dorsal strip of ectoderm.

SEROGICAL EVIDENCE

A close similarity exists between the proteins of the body-fluid of chordates and echinoderms. Hence the chordates are more related to echinoderms.

ECHINODERM -HEMICHORDATE THEORY

The radial symmetry of adult echinoderms will disprove their relationship with the bilaterally symmetrical chordates. In echinoderms radial symmetry is secondarily developed from a basically bilateral symmetry. Both the primitive and the early echinoderm larvae show bilateral symmetry.

Thank You

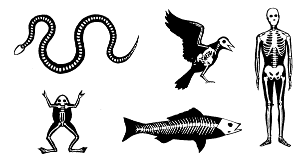
VERTEBRATE ZOOLOGY

THE VERTEBRATES

By
Dr. K. S. Goudar

VERTEBRATE

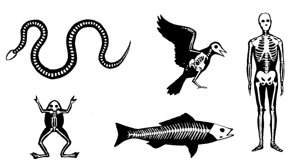
- ✓ Vertebrates belong to the subphylum Vertebrata of the phylum Chordata
- ✓ Their names is derived from the presence of serially arranged *'Vertebrae'* (L., *vertebratus, jointed),* which comprise a major part of their axial endoskeleton, the vertebral column or the backbone



The internal skeletons of some vertebrates.

VERTEBRATE

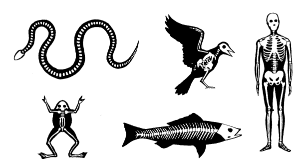
- ✓ Another feature, that all vertebrates share as a common diagnostic character, is the elaboration of anterior skeletal elements into a *'cranium' or skull' which houses* various sense organs and a complex brain
- ✓ This gives another name, the 'Craniata', which is sometimes used for the group



The internal skeletons of some vertebrates.

VERTEBRATE

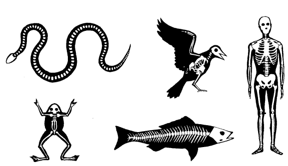
- ✓ A vertebrate may be defined as a special kind of chordate animal that has a cartilaginous or bony endoskeleton consisting of a cranium, housing a brain and a vertebral column through which the nerve cord passes
- ✓ Vertebrates occupy marine, freshwater, terrestrial, and aerial environments, and exhibit a vast array of lifestyles



The internal skeletons of some vertebrates.

VERTEBRATE

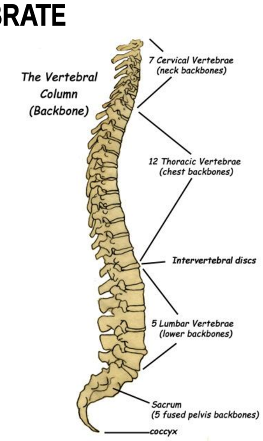
- ✓ Like tunicates and amphioxus, vertebrates are proper chordates and possess at some time during their lives all five defining chordate characteristics: notochord, pharyngeal slits, tubular and dorsal nerve tube, and postanal tail
- ✓ Their success may be due to their great variety of innovations as well
- ✓ Two of these innovations—the vertebral column and the cranium—provide names for this major taxon.



The internal skeletons of some vertebrates.

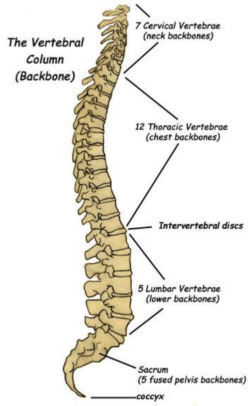
VERTEBRATE

- ✓ The **vertebral column** (spinal column or backbone) is made of individual bones called **vertebrae**
- ✓ The names of vertebrae indicate their location along the length of the spinal column
  - There are cervical, thoracic, lumbar, sacral, and caudal vertebrae
  - The **cervical vertebrae** are those within the neck



VERTEBRATE

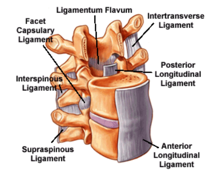
- The **thoracic vertebrae** articulate (form joints) with the ribs on the posterior side of the trunk.
- The **lumbar vertebrae**, the largest and strongest bones of the spine, are found in the small of the back
- The **sacral vertebrae** permits the articulation of the two hip bones: the **sacroiliac joints**
- The **caudal vertebrae** is the tail vertebrae

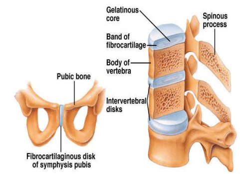


VERTEBRATE

✓ All of the vertebrae articulate with one another in sequence, connected by ligaments, to form a flexible backbone that supports the trunk and head

✓ They also form the **vertebral canal**, a continuous tunnel within the bones that contains the spinal cord and protects it from mechanical injury





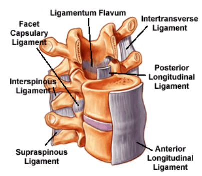
VERTEBRATE

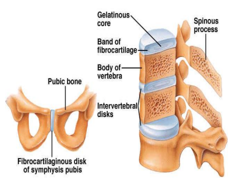
✓ The supporting part of a vertebra is its body; the bodies of adjacent vertebrae are separated by **discs** of fibrous cartilage

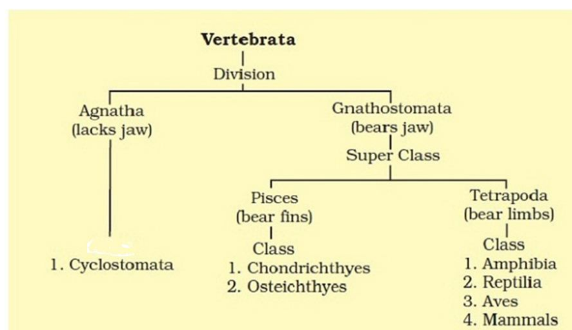
✓ These discs cushion and absorb shock and permit some movement between vertebrae (**symphysis joints**)

✓ Most living forms of vertebrates also possess paired appendages and limb girdles

✓ The subphylum vertebrata is divided into different classes:



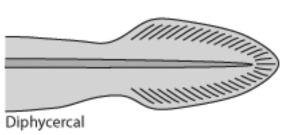


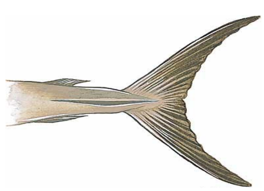


TYPES OF FINS

✓ Diphycercal: Having or designating a tail fin in which the vertebral column extends to the tip, with symmetrical upper and lower parts, as in the lungfishes.

✓ Homocercal: Characterized by a tail fin having two symmetrical lobes extending from the end of the vertebral column, as in most bony fishes.

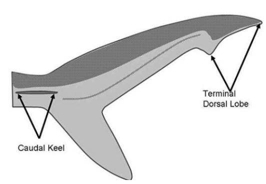


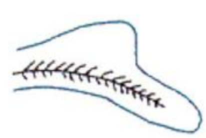


TYPES OF FINS

✓ Heterocercal: A tail fin in which the upper lobe is larger than the lower and the vertebral column extends into the upper lobe, as in sharks.

✓ Hypocercal: A tail in which the lower lobe is more pronounced or larger than the upper lobe.





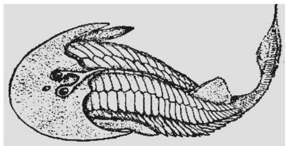
VERTEBRATE - AGNATHA

- ✓ The first vertebrate animals
- ✓ Jawless vertebrates
- ✓ Divided into 2 subclasses

i. Subclass Monorhina

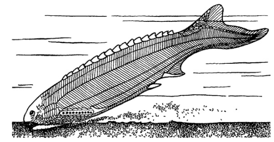
- ✓ Possess a single, large, median nostril on top of head b/n eyes
- ✓ Divided into 3 orders

  a. Order Osteostraci
  - Had bony shells
  - Possess heterocercal tail (caudal fin)

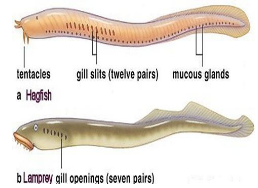


VERTEBRATE - AGNATHA

b. Order Anaspida
- Head naked or covered by a complex of small plates; Arrangement of scales was complicated; Possess hypocercal tail



c. Order Cyclostomata
- Possess cyclic mouth
- Further divided into 2 suborders
- Myxinoidea (Hagfishes) and Pteromyzontia (Lampreys)

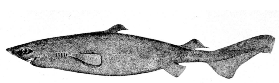


VERTEBRATE - AGNATHA

ii. Subclass Diplorhina
- ✓ Two separate nasal openings,
- ✓ Divided into 2 orders

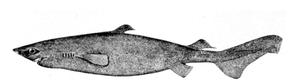
  a. Order Heterostraci
  - Body was large; Head was encased in a shield
  - Possess hypocercal tail

  b. Order Coelolepida
  - Their lateral eyes were widely apart
  - Their tail was hypocercal or heterocercal



VERTEBRATE - AGNATHA

- ✓ All the extinct groups are collectively known as **ostracoderms** (Shell skinned)
  - The earliest known vertebrates were jawless primitive fishlike animals collectively known as the **ostracoderms**
  - They resembled the present day cyclostomes, together constitute jawless vertebrates, the *Agnatha*



Thank You

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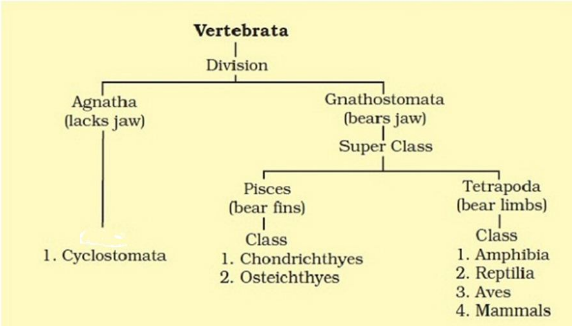
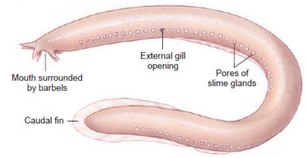


HAGFISHES

- Hagfishes are an entirely marine group (deep sea form), mud-burrowing, scavengers that feeds on annelids, molluscs, crustaceans, and dead or dying fishes
- Thus they are not parasitic like lampreys but are scavengers and predators.
- There are about 70 species of hagfishes, of which the best known in North America are the Atlantic hagfish, and the Pacific hagfish,



VIDEO

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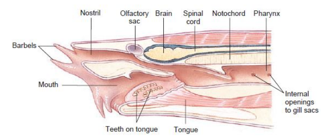
HAGFISHES

- Although almost completely blind, hagfishes are quickly attracted to food, especially dead or dying fishes, by their keenly developed senses of smell and touch
- A hagfish enters a dead or dying animal through an orifice or by digging into the body
- Using two toothed, keratinized plates on its tongue that fold together in a pincer like action, the hagfish rasps bits of flesh from its prey



HAGFISHES

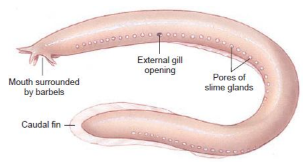
- For extra leverage, the hagfish often ties a knot in its tail, then passes the knot forward along its body until it is pressed securely against the side of its prey
  - Hagfishes can knot their bodies to escape capture or give them force to tear off food
- Hagfishes possess a single, wide nostril placed terminally, at the anterior end of the head
- Hagfishes are renowned for their ability to generate enormous quantities of slime

HAGFISHES

- If disturbed or roughly handled, a hagfish exudes a milky fluid from special glands positioned along its body
- On contact with seawater, the fluid forms a slime so slippery that the animal is almost impossible to grasp
- Unlike any other vertebrate, the body fluids of hagfishes are in osmotic equilibrium with seawater, as are most marine invertebrates
  - Body fluid of hagfishes is also unique

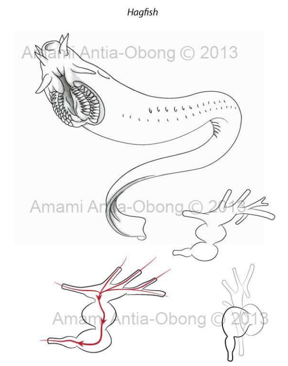
HAGFISHES

- In other vertebrates, seawater is roughly two-thirds saltier than body fluid
- Water moves osmotically out of their body along this gradient so that marine vertebrates must regulate their salt and water levels constantly to stay in balance with the surrounding environment
- By contrast, the salt concentrations in hagfish tissues are similar to surrounding seawater, there is no net flow of water in or out of the hagfish body.



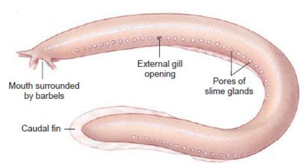
HAGFISHES

- In having high salt concentrations, hagfishes are physiologically like marine invertebrates
- Hagfishes have several other anatomical and physiological peculiarities, including a low-pressure circulatory system served by three accessory hearts in addition to the main heart positioned behind the gills



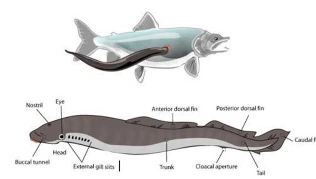
HAGFISHES

- Ovaries and testes occur in the same individual, but only one is functional; so hagfishes are not practicing hermaphrodites.
- No larval stage has ever been found, so development from yolk-filled eggs is thought to be direct; that is, without metamorphosis



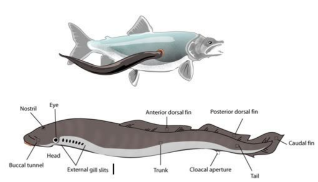
LAMPREYS

- Paired fins are absent
  - Two unequal median dorsal fins, first and second, are located near the posterior end
  - Around the tail there is a caudal fin, the upper lobe of which is continuous with the second dorsal fin
  - In some lampreys, the female possesses an anal fin, but in males, it is reduced to a copulatory papilla – sexual dimorphism
- On each lateral side of the head is a large prominent eye
  - The two eyes lack eyelids and are covered by a transparent area of skin



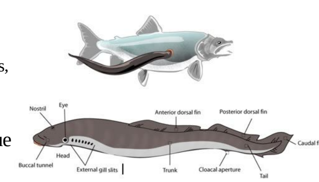
LAMPREYS

- **Skin** is soft smooth, slimy and consists of many layers of cells
  - Epidermis has many unicellular mucous glands producing slime
  - Dermis is composed of collagen and elastin fibers,
  - Star-shaped chromatophores are able to migrate, changing the skin colour dark or pale
  - A layer of subcutaneous tissue contains blood vessels, fat and connective tissue
  - Pigment cells are present in dermis.



LAMPREYS

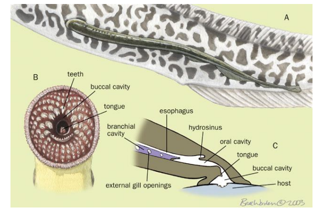
- **Musculature** and **locomotion**
  - Locomotion is by means of powerful short segmental muscles of trunk and tail arranged in E-shaped myotomes, similar to that of fishes
  - Muscle fibers are striated
- Their skeleton contains no true bone but includes notochord and cartilage
  - It resembles the notochord of amphioxus both in structure & function



VIDEO

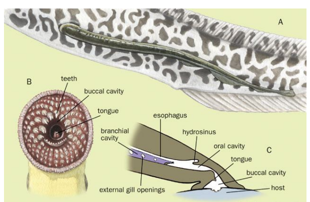
LAMPREYS

- **Digestive system** and **feeding:**
  - Mouth → Pharyngeal region – digestive tube → Esophagus → Intestine → Cloaca
  - Possess "rasping teeth" for piercing the host or scraping flesh – parasitic/ predators
  - Mouth can be closed or opened by the forward and backward piston-like movement of the *tongue*
  - Buccal cavity communicates behind with two tubes, a dorsal esophagus and a ventral respiratory pharynx
  - The latter is a blind pouch, which bears 7 internal gill slits on each side



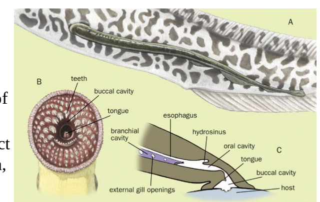
LAMPREYS

- A valve like structure, the velum, prevents the passage of food into the respiratory tube
- There is no distinct stomach
- Their intestine is straight
- Anterior part of intestine is dilated, representing the stomach
- Posteriorly, the esophagus opens by a valve into the straight intestine which terminates at the cloaca
- Inside the intestine is a longitudinal fold to increase surface area for absorption of food – analogous to villi of higher vertebrates



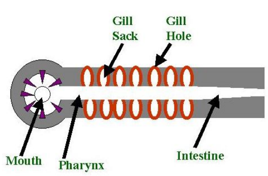
LAMPREYS

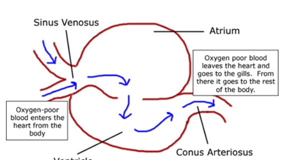
- Digestive glands are well developed
  - A pair of buccal or salivary glands opening below the tongue secrete an anticoagulant
  - A bilobed voluminous liver surrounds the anterior part of the intestine
  - A gall bladder and a bile duct although present in the larva, are absent in the adult
  - Zymogen cells, which are found in the anterior part of intestine, secrete pancreatic enzymes



LAMPREYS

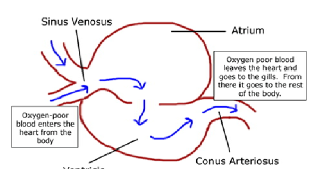
- **Respiration** is accomplished by gills which are usually 7 pairs
- **Circulatory system:**
  - The heart is located ventrally just behind the last gill pouch, enclosed in a thick-walled pericardium supported by a cartilaginous plate
  - The heart is "S" shaped
    - It is made up of four chambers – one sinus venosus, one auricle, one ventricle and one conus arteriosus
    - Blood from various parts of the body returns to a small sinus where it first goes into a thin-walled auricle and then into a thick-walled ventricle





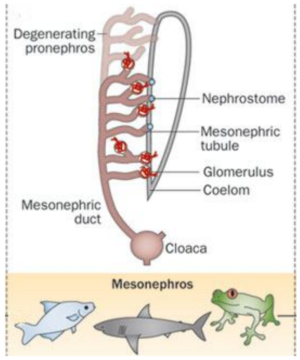
LAMPREYS

- A lymphatic system is also' present
- Blood contains both red blood corpuscles with haemoglobin and white blood corpuscles
  - Red blood corpuscles are nucleated and circular in outline
  - But white blood corpuscles are similar to lymphocytes
- Blood forming tissues are present in the spiral valve, kidney & spinal cord
- Well developed than protochordates



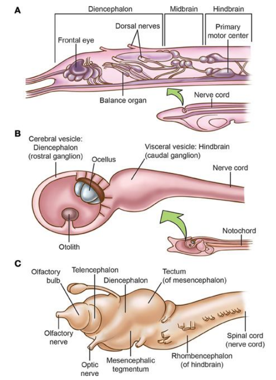
LAMPREYS

- **Excretory system (urogenital system)**
  - Kidneys are of the mesonephric type
    - Tubules (nephrones) → Mesonephric duct → Urinogenital sinus → Papilla → Cloaca
  - Tubules are used to conserve salt
  - Each tubule partially encloses a specialized cluster of capillaries known as glomerulus – removes excess water



LAMPREYS

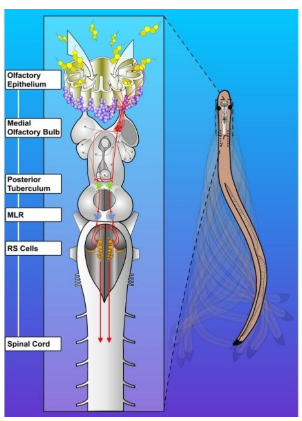
- **Nervous system** and **sense organs**
  - More developed than protochordates
  - The brain of the adult lamprey is very primitive
    - In forebrain two large olfactory lobes are found – responsible for smell
    - Midbrain has a pair of large optic lobes - responsible for sight
    - Hindbrain includes a small transverse rudimentary cerebellum and a fairly well-developed medulla oblongata - responsible for hearing & balance



A: Amphioxus, B: Tunicate
C: The lamprey

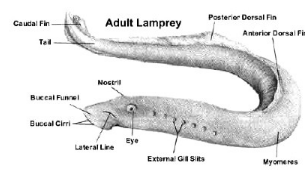
LAMPREYS

- Ten pairs of cranial nerves are present – cranial nerves 1st seen in this group
- Spinal cord is flat and peculiar as no blood vessel is present within it.
- There are 2 nerves roots which arise from spinal cord: dorsal (sensory) and ventral (motor)
  - Do not join in lampreys
  - In hagfishes, fishes & amphibians meet outside the vertebral column
  - In all amniotes meet inside the vertebral column
  - The dorsal and ventral roots of spinal nerves remain separate



LAMPREYS

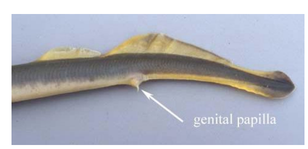
- Sympathetic nervous system is poorly defined
- All the nerve fibers of lampreys are non-myelinated, because of which, rate of conduction of nerve impulses is very slow
- **Sense organs:**
  - They have single, dorsal & median nostril
  - The two lateral eyes are primitive
  - There are taste buds in the pharynx
  - In salt water, lampreys can produce electric fields to detect the prey
  - Integumentary photoreceptors showing photosensitivity are also found in the integument of lampreys



VIDEO

LAMPREYS

- **Endocrine system** is more developed
  - Pituitary, thyroid and adrenal glands the 3 prominent glands in lampreys
- **Reproductive system**
  - Sexes are separate (dioecious)
    - Some sort of sexual dimorphism
  - ✓ Females have large anal fins and males have genital papillae
  - There is no genital duct
  - Mature eggs or sperm escape from gonad into coelom, pass through genital pores into the urinogenital sinus, and leave the body through the urinogenital opening into water



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LAMPREYS

- In spring or early summer, lampreys become sexually mature and migrate into a neighbouring freshwater stream or river for breeding
- When they reach fresh water habitat, with their buccal funnels, the males move pebbles from a sandy bottom and form a nest in the form of a shallow rounded depression
  - Then initiate each other for copulation
- When a female attaches to a stone in the nest, a male winds his tail around her and eggs and sperm are discharged

LAMPREYS

- More than one pair may spawn in the same nest
- The adults die after spawning
- Fertilization is external, taking place in water
- A large female sea lamprey lays up to 236,000 eggs
- The eggs hatch in about 3 weeks into minute transparent larvae called **ammocoetes**
  - At first, they are about 7 mm in length and stay in the nest
- When about 15 mm long, they quit the nest and burrow in mud and sand in quiet water.

DIFFERENCES BETWEEN HAGFISHES AND LAMPREY

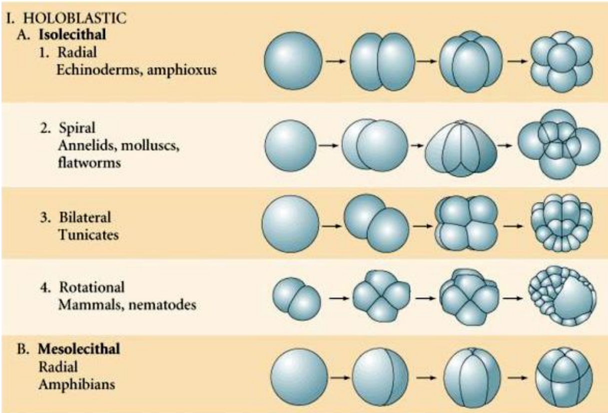
Characters	Lampreys	Hagfishes
Habitat	Marine as well as freshwater	Exclusively marine, burrowing in sand
Feeding	Rasp away flesh and suck out blood of host fishes.	Primarily scavengers, burrowing into dead or morbid fish for flesh consumption
Breeding	Anadromous, i.e., ascend fresh water rivers and streams for spawning	Spawn on ocean floor
Knot tying activity	Not found	For feeding and defense body draws a knot and squeezes out

DIFFERENCES BETWEEN HAGFISHES AND LAMPREY

Characters	Lampreys	Hagfishes
Skin	Less slimy	Exceedingly slimy
Nostril	High on head	Terminal
Paired eyes	Large and functional	Degenerate, coveted by thick skin
Mouth	Ventral	Terminal
Tongue	Less developed with larger teeth	Strongly developed with smaller teeth
Salivary glands	Present secreting an anticoagulant	Absent
Kidneys	Advanced mesonephros	Pronephros anterior, mesonephros posterior
Brain	Better developed	Poorly developed
Cranial nerves	10 pairs present	8 pairs present

DIFFERENCES BETWEEN HAGFISHES AND LAMPREY

Characters	Lampreys	Hagfishes
Spinal nerve roots	Dorsal and Ventral roots separate	Roots united
Semicircular canals	Two	Single
Sexes	Separate	United
Eggs	Small, naked, without shell	Large, enclosed in a horny shell
Cleavage of embryo	Holoblastic	Meroblastic
Development	Indirect with a larval stage (ammocoete) arid metamorphosis	Direct, without larva and metamorphosis



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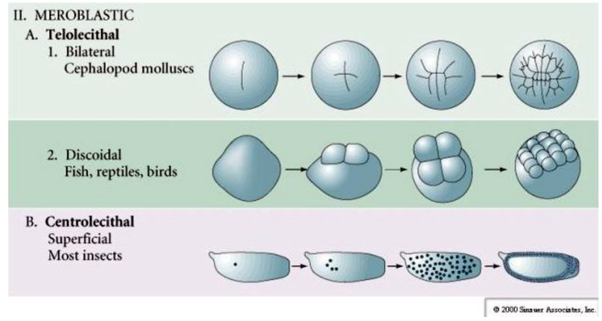

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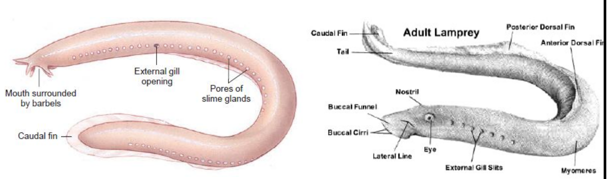

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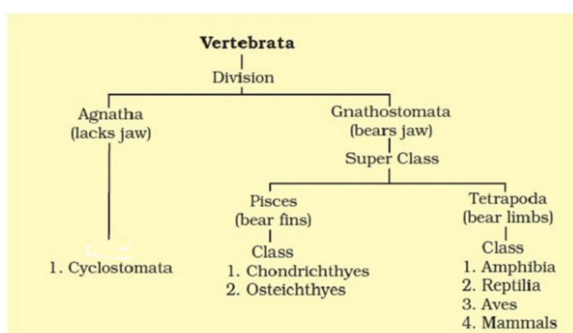
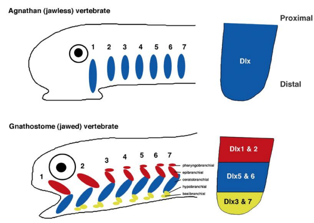


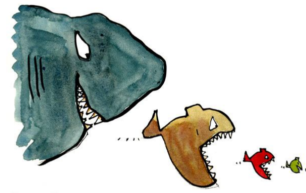
GNATHOSTOMES
JAWED VERTEBRATES

- Perhaps the greatest of all advances in vertebrate history was the development of jaws and the consequent revolution in the mode of life of early fishes
- The development of hinged jaws from the most anterior pair of primitive pharyngeal arches was one of the most important events in vertebrate evolution
- Jaws arose from one of the anterior pair of gill arches.



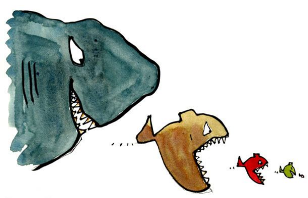
GNATHOSTOMES
JAWED VERTEBRATES

- Jaws permitted the capture and ingestion of a much wider array of food than was available to the jawless ostracoderms, and they also permitted the development of predatory lifestyles
- Fish with jaws could selectively capture more food and occupy more niches than ostracoderms and, thus, were more likely to survive and leave offspring
- They could venture into new habitats in search of food, breeding sites, and retreats



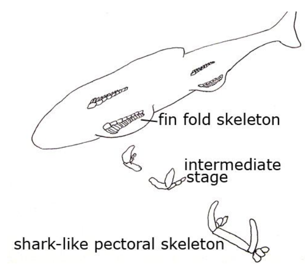
GNATHOSTOMES
JAWED VERTEBRATES

- Jaws, which also could be used for defensive purposes, could have aided these primitive fish in both intraspecific and interspecific combat
- Thus, hinged jaws made possible a revolution in the method of feeding and hence in the entire mode of life of early fishes
- The term **gnathostome** includes all of the jawed fishes and the tetrapods



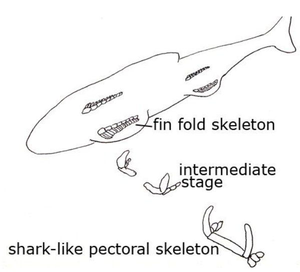
ORIGIN OF PAIRED FINS

- A second major development in the evolution of vertebrates was the evolution of paired appendages
- As early fishes became more active, they would have experienced instability while in motion
- Presumably, just such conditions favored any body projection that resisted roll (rotation around the body axis), pitch (tilting up or down), or yaw (swinging from side to side) and led to the evolution of the first paired fins (pectoral and pelvic)



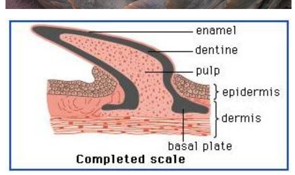
ORIGIN OF PAIRED FINS

- Pectoral fins, which project laterally from the sides of the body, are used for balancing and turning, whereas pelvic fins serve as stabilizers
- The associated girdles stabilized the fins, served as sites for muscle attachment, and transmitted propulsive forces to the body
- The origin of paired fins has long been debated and even today remains unresolved.



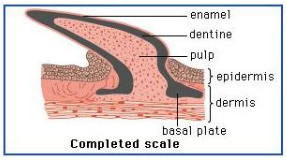
SCALES OF FISHES

- In many vertebrates, the exoskeletal covering of body is made of two types of scales: epidermal and dermal
- Epidermal scales are cornified derivatives of the Malpighian layer of epidermis
  - They are well developed in terrestrial vertebrates such as reptiles, birds and mammals
- Dermal scales are mesenchymal in origin and especially developed in the fishes.
  - They are small, thin, cornified, calcareous or bony plates which fit closely together or overlap



SCALES OF FISHES

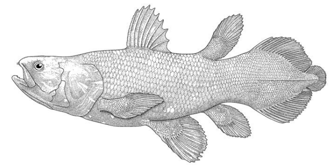
- Scales vary in size and shape in different species
- The body of all fishes except members of family Siluridae and a few bottom dwellers is covered by scales
- Exoskeleton in the form of plates and scales which consist of three distinct layers
  - The innermost layer of *Pulp*, the intermediate one is *Dentine* and outer layer is of *Enamel*



TYPES OF SCALES

1. Cosmoid scales

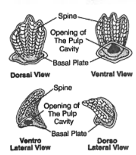
- These do not occur in living fishes; *Latimeria* – an exception
- These were characteristic of certain ostracoderms and placoderms,
- These consisted of 4 distinct layers : an outermost thin enamel-like *ganoine*, thick dentine-like *cosmine*, *spongy bone* and innermost *compact bone*



TYPES OF SCALES

2. Placoid scales

- These are characteristic of elasmobranch fishes only
- Each placoid scale consists of a backwardly directed spine arising from a rounded or rhomboidal basal plate embedded in dermis
- Spine is made of enamel-like and basal plate of dentine-like bony material
- A pulp cavity inside spine opens through basal plate.

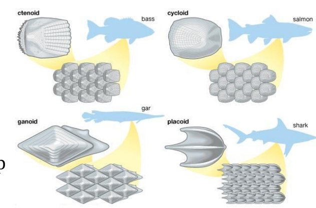


Placoid scale

TYPES OF SCALES

3. Ganoid scales

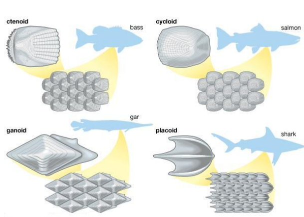
- Thick, usually rhomboid or diamond-shaped plates closely fitted side by side, like tiles, providing a bony armour to the fish
- In some cases they may overlap



TYPES OF SCALES

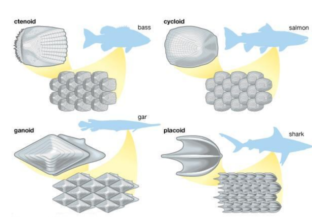
4. Cycloid scales

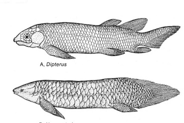
- Cycloid scales are thin flexible translucent plates, rather circular in outline, thicker in the centre and marked with several concentric lines of growth which can be used for determining the age of the fish
- They are composed of a thin upper layer of bone and a lower layer of fibrous connective tissue



TYPES OF SCALES

- They overlap each other, each scale embedded in a small pocket of dermis
- Cycloid scales are found in lung fishes,

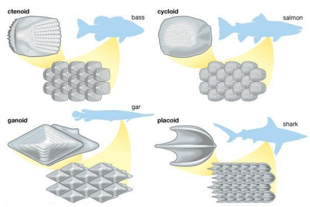




TYPES OF SCALES

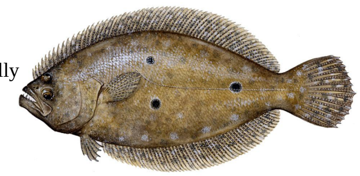
5. Ctenoid scales

- These are characteristic of modern higher teleosteans such as perch, sunfish, etc
- In form, structure and arrangement they are similar to cycloid scales
- They are more firmly attached and their exposed free hind parts which are not overlapped, bear numerous small comblike teeth or spines



TYPES OF SCALES

- Intermediate types between cycloid and ctenoid scales also occur
- Certain fishes, such as flounders, may bear both types, ctenoid scales dorsally and cycloid ventrally



TYPES OF TEETH (DENTITION)

a. Attachment of teeth on the jawbone

i. Acrodont – Teeth are attached to the outer surface of the jawbone e.g. most lizards, lungfishes

ii. Pleurodont – Teeth are attached to the inner side of the jawbone e.g. Chondrichthyes, Teleosts, Lizards Amphibians

iii. Thecodont – Teeth are set into sockets in the jawbone e.g. Mammals

(a) Acrodont (b) Pleurodont (c) Thecodont

TYPES OF TEETH (DENTITION)

b. Replacement of teeth

i. Polyphyodont – Series of loss of teeth

- Ability to continually replace teeth throughout the animal's lifetime
- E.g. Fishes, amphibians, reptiles

ii. Diphyodont – Develop 2 sets/generations of teeth

- 1st set (generation) – milk (deciduous) teeth and 2nd set (generation) – permanent (adult) teeth e.g. mammals

iii. Monophyodont – having only one set of teeth without replacement during the animal's lifetime

e.g. Lungfishes, Tuatara

TYPES OF TEETH (DENTITION)

c. Shape and size (appearance)

i. Homodont – Having teeth similar in shape & size e.g. Teleosts, most amphibians, most reptiles

ii. Heterodont – Having teeth which are different in size shape; differentiated for various functions e.g. mammals

iii. Edentates – Toothless vertebrates (if present, highly reduced)

e.g. birds, toads

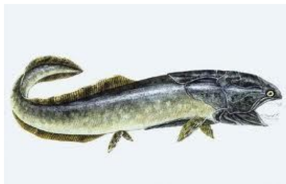
PLACODERMS

- Their body was covered by hard plate – the group name
- The first jawed vertebrates (gnathostomes)
- Some 450 million years ago, as the ostracoderms were disappearing, a host of more efficient and jawed fishes appeared
- Placodermi were earliest jawed vertebrates of fossil record
- They probably lived both in fresh water as well as seas
- Some primitive agnathan ostracoderms were probably the ancestors of placoderms
  - But their fossil record does not show any connecting link between the jawless and the jawed fishes
- Most placoderms possess paired fins
  - In an aquatic environment, development of strong mobile fins was coincident with the evolution of jaws, for swimming faster
- There are 2 known orders/groups

PLACODERMS

i. Order Arthrodiriformes

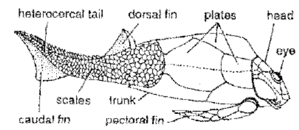
- Earliest placoderms
- Resembled ostracoderms in appearance and habitat
- Heavy bony armour shields of head and trunk meeting in a movable joint (Gr., *arthros. joint)*.
- Powerful gaping jaws with sharp shearing blades
- Violently predaceous.
- Large in size, up to 9m



PLACODERMS

ii. Order Antiarchiformes

- Bottom-dwellers and mud-feeders in fresh water.
- Pectoral fins long
- Small armoured placoderms, mostly <1m



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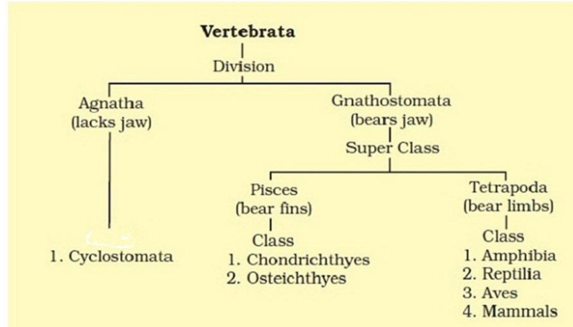
VERTEBRATE ZOOLOGY

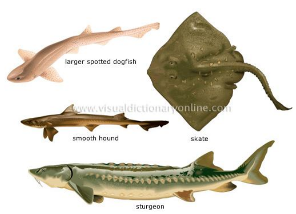
ADVANCED FISHES- CHONDRICHTHES AND OSTEICHTHYES

By
Dr. K. S. Goudar



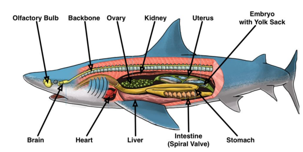
CLASS CHONDRICHTHYES
(CARTILAGINOUS FISHES)

➢General Characters
- Mostly marine and predators
- Body fusiform or spindle shaped
- Fins both median and paired, all supported by fin rays
  - Pelvic fins bear claspers in male
  - Tail heterocercal
- Skin tough containing minute placoid scales and mucous glands



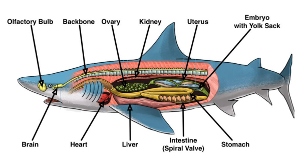
CLASS CHONDRICHTHYES
(CARTILAGINOUS FISHES)

- Endoskeleton entirely cartilaginous,- without true bones (Gr., *chondros, cartilage* + *ichthys*, fish)
  - Notochord is persistent; but reduced
  - Vertebrae complete and separate
  - Pectoral and pelvic girdles present
- Mouth ventral. Jaws present
  - Teeth are modified placoid scales



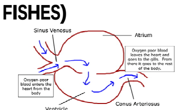
CLASS CHONDRICHTHYES
(CARTILAGINOUS FISHES)

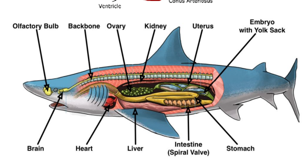
- Digestive system with J-shaped stomach
  - Intestine with spiral valve
  - Often with large oil-filled liver for buoyancy
- Respiration by means of five to seven pairs of gills leading to exposed gill slits in elasmobranchs
  - 4 pairs of gills covered by an operculum in chimaeras; No air bladder and lungs.



CLASS CHONDRICHTHYES
(CARTILAGINOUS FISHES)

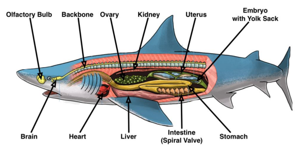
- Heart with sinus venosus, atrium, ventricle, and conus arteriosus
- Both renal and hepatic portal systems present
- Temperature variable (poikilothermous).
- Mesonephric kidney
  - Blood isosmotic or slightly hyperosmotic to seawater
  - High concentrations of urea and trimethylamine oxide in blood Kidneys opisthonephric





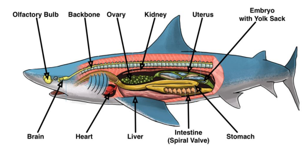
CLASS CHONDRICHTHYES
(CARTILAGINOUS FISHES)

- Cloaca present.
- Brain of two olfactory lobes, two cerebral hemispheres, two optic lobes, cerebellum, medulla oblongata
  - 10 pairs of cranial nerves
  - Three pairs of semicircular canals; senses of smell, vibration reception (lateral-line system), vision, and electroreception well-developed
  - Olfactory sacs do not. open into pharynx.



CLASS CHONDRICHTHYES
(CARTILAGINOUS FISHES)

- Sexes are separate; Gonads paired; Gonoducts; open into cloaca; Fertilization internal.
  - Oviparous or ovoviviparous or viviparous
  - Eggs large, yolky
  - Development direct, without metamorphosis
  - Separate urogenital and anal openings in chimaeras



CLASS CHONDRICHTHYES
(CARTILAGINOUS FISHES)

Classification

1. Subclass Elasmobranchii

- Placoid scales usually present
- Five to seven gill arches and gill slits in separate clefts along pharynx
- Upper jaw not fused to cranium.

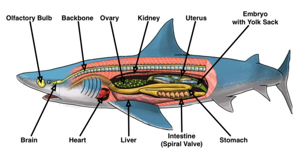
Divided into many orders

Order Pleuroacanthodii – Spiny sharks

Order Cladoselachii - Primitive sharks

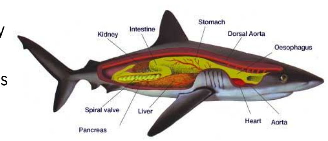
Order Selachii – Living sharks

Order Batoidea – Skate fishes



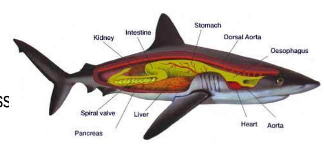
SHARK

- Distributed in all parts of the world (especially in tropical seas and oceans)
  - Although most sharks are by nature timid and cautious, some of them are dangerous to humans
  - There are numerous authenticated cases of shark attacks by great white sharks, (reaching 6 m); mako sharks; tiger sharks; bull sharks; and hammerhead sharks,



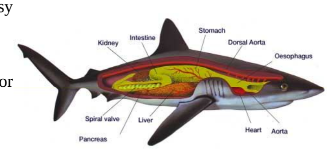
SHARK

- More shark casualties have been reported from tropical and temperate waters of the Australian region than from any other
- During World War II there were several reports of mass shark attacks on victims of ship sinking in tropical waters
- Dogfish sharks are extensively studied nearly all over the world.



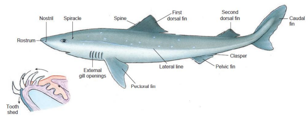
SHARK

- Dogfish is chosen for study for several reasons:
  - Its skeleton is not bony but cartilaginous, so that it is easy to dissect
  - It is neither too big nor too small but of a suitable size for dissection,
  - It is not a popular article of diet
  - Its not highly specialized and can represent a generalized fish
  - Some of its anatomical features are found in the embryos of higher vertebrates.



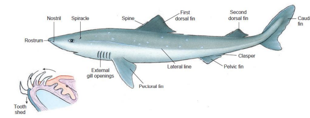
SHARK

- Although to most people sharks have a sinister (evil) appearance and fearsome reputation, they are at the same time among the most gracefully streamlined of all fishes
  - The body of a dogfish shark is fusiform (spindle-shaped); divided into head, trunk and tail
  - Mouth is ventral and crescentic in shape
  - Possess polyphyodont and homodont. Lower jaw shows new teeth development inside the jaw



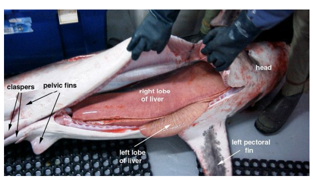
SHARK

- The asymmetrical heterocercal tail,
- There are paired pectoral and pelvic fins, one or two median dorsal fins and a median caudal fin
  - The paired fins are used for keeping balance & movement
  - A median anal fin is present in most sharks
- In males, the medial part of the pelvic fin is modified to form a clasper, which is used in copulation



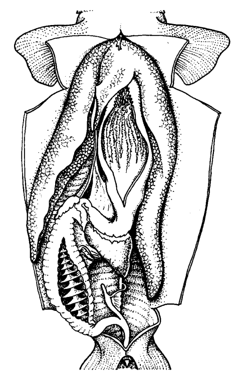
SHARK

- The tough, leathery skin is covered with toothlike, dermal placoid scales arranged to reduce the turbulence of water
- Have no air/gas/swim bladder, but possess large liver (accounts 25% of the body)
  - The liver is largely made up of oil (its density is 0.95) and density of marine water is 1.03; liver facilitates buoyancy
- Most of these contribute to the fast swimming of sharks
  - Sharks are the fastest aquatic swimmers



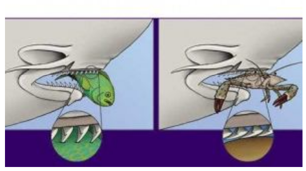
SHARK

- **Digestive System**
- Sharks found at the top of the pyramid; can eat all vertebrates but not eaten by any vertebrates
- The digestive system includes the alimentary canal or gut through which the food passes and the glands that open into it
- Alimentary **canal** begins at mouth and terminates in cloaca
- It is longer than the body and includes buccal cavity, pharynx, oesophagus, stomach and intestine
- Mouth → Pharynx → Esophagus → Stomach → Intestine → Cloaca



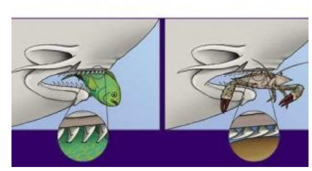
SHARK

- **Mouth –** is wide crescentic opening on the ventral side of head
- It is bounded by folds of integument sometimes called upper and lower lips.
- Buccal cavity – mouth opens into a spacious dorso-ventrally flattened mouth cavity, lined by mucous membrane and bordered by the jaws
- Teeth are not attached to the jaw cartilages, but are simply embedded in the skin like other placoid scales



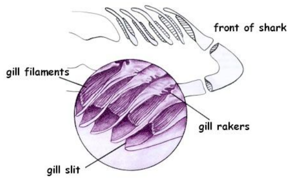
SHARK

- They are all similar in shape (homodont), sharply pointed and directed backwards
- They are arranged in several rows
- If lost or destroyed they are replaced by others several times in life time (polyphyodont)
- Teeth serve to grasp the prey which is usually swallowed whole
- On the floor of the buccal cavity lies the so-called 'tongue'. It is merely a thick, flat, non-muscular, non-glandular



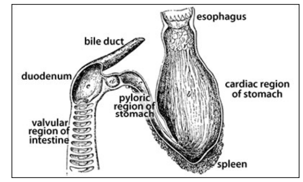
SHARK

- **Pharynx –** posteriorly the buccal cavity merges insensibly with the larger cavity of pharynx
- Water & food are separated in the pharynx, with the gill rakers preventing the food from passing out through the gill slits
- Mucous lining of pharyngeal wall contains numerous dermal denticles (a small tooth-shaped scale with a projecting spine, typical of cartilaginous fish)



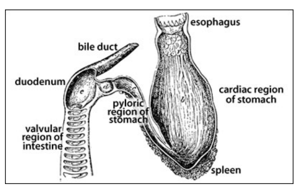
SHARK

- **Oesophagus** – pharyngeal cavity narrows down posteriorly into a short but wide tube, with thick muscular wall
- Its mucous lining is thrown into longitudinal folds.
- **Stomach** – the oesophagus passes backwards into the abdominal cavity to open into a large muscular and U-shaped stomach
- The oesophageal opening into stomach is guarded by an oesophageal valve



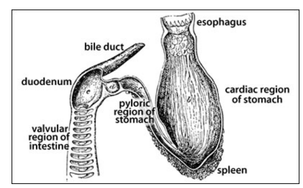
SHARK

- Production of pepsin & HCl is d/t from higher vertebrates
- At the end of stomach is present a strong circular muscle band, called *pyloric valve*, guarding its opening into a small but thick-walled muscular chamber, the *bursa entiana*
- **Intestine** – bursa entiana is followed' by intestine.
- It is a straight wide tube, receives the bile and pancreatic ducts



SHARK

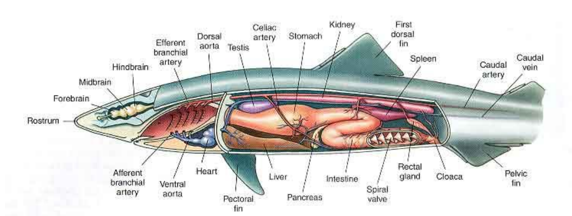
- The inner mucous lining of intestine becomes folded anticlockwise into a longitudinal turns or folds called spiral valve
- The last part of intestine is called rectum
- A small finger-like caecal or rectal gland of unknown function opens dorsally into the rectum.



SHARK

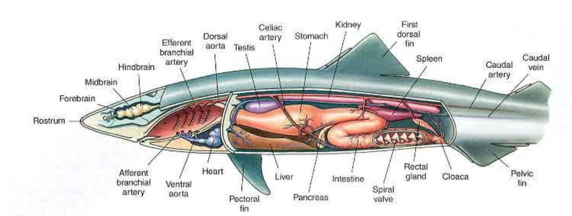
Glands of alimentary canal

- **Liver –** liver of dogfish is a massive yellowish bilobed gland
- The two lobes extend backwards freely into abdominal cavity, but they are united anteriorly
- The gall bladder, in which bile is collected, lies embedded in the right lobe of liver



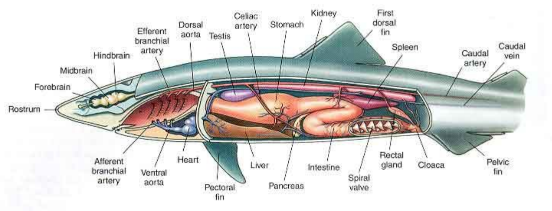
SHARK

- A narrow bile duct, leaves the gall bladder, and opens into the anterior end of the intestine
- Bile duct also receives branches from the lobes of liver
- Liver secretes bile, stores glycogen and fat, and destroys worn out erythrocytes of blood



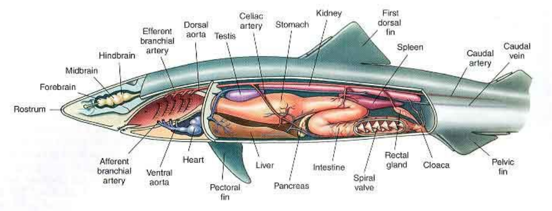
SHARK

- **Pancreas** – it is a compact, whitish or pale bilobed gland
- The small pancreatic duct traverses the entire length of the gland to open into the intestine just opposite the opening of the bile duct



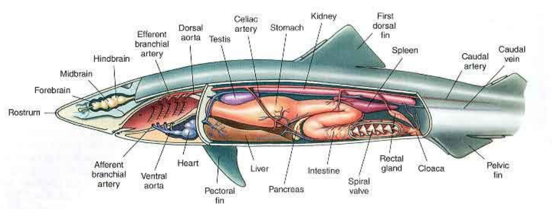
SHARK

- **Caecal or rectal gland** – it is a small finger-like body attached by its duct to the dorsal side of rectum into which it opens
- It is highly vascular and composed of lymphoid tissue but discharges a fluid in the intestinal lumen.



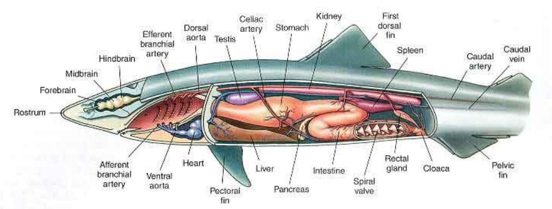
SHARK

- **Spleen** – it is a large gland closely attached to the stomach
- But it has no physiological relation with alimentary canal and functionally associated with circulatory system
- It is a lymphoid organ which produces lymphocytes.



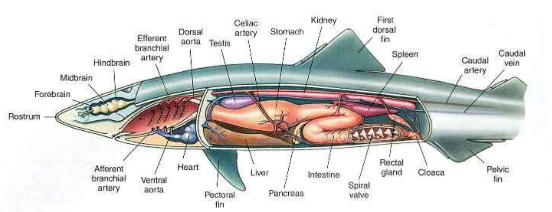
SHARK

- Food is swallowed without mastication
- No digestion occurs in buccal cavity which lacks salivary glands
- The gastric juice in stomach contains pepsin and hydrochloric acid
- It digests protein but cannot chitin



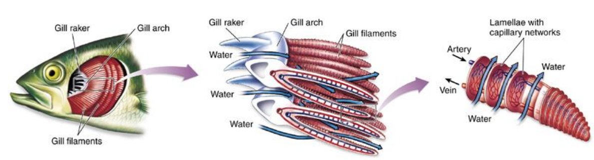
SHARK

- Bile makes the semi-digested food alkaline in intestine while pancreas secretes trypsin, amylase and lipase for digestion of proteins, starches and fats, respectively
- Spiral valve in intestine serves to retard the passage of food and affords a large surface for absorption of the products of digestion



SHARK

- **Respiratory System**
- They depend wholly upon oxygen dissolved in sea water for respiration; thus, respiration is carried on entirely by vascular gills
- Their respiratory organs consist of 5 pairs of exposed (naked) gill slits
- During respiration, water taken into the mouth, passes through internal gill slits bathing gill lamellae and passes out of the external gill slits.



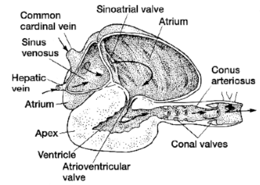
SHARK

Blood Vascular System

- The circulatory system comprises 4 parts : (i) Heart (ii) arteries, (iii) veins and (iv) blood

Heart

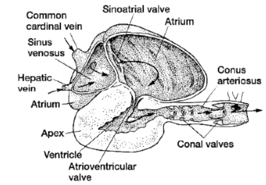
- As in cyclostomes and other fishes, heart of *Scoliodon* receives venous blood only which it pumps into gills for aeration
- Such a heart is called a venous or branchial heart
- The heart is situated mid-ventrally in head beneath the pharynx



(a) Shark heart

SHARK

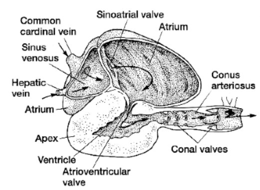
- It lies within the pericardial cavity in a two-layered membranous pericardium.
- It is a reddish-brown, muscular and S-shaped tube differentiated into a series of 4 chambers: Sinus venosus → Auricle, → Ventricle → Conus arteriosus, arranged in tandem formation
- Of these only two, the auricle and ventricle, are considered to be true chambers so that heart is only two-chambered in fishes



(a) Shark heart

SHARK

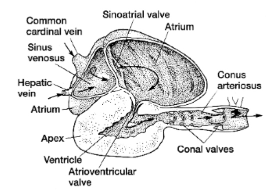
- Sinus venosus is highly contractile and the beating of the heart originates from this part of the heart
- A pair of membranous valves prevent backward flow of blood from auricle to sinus venosus
- Two pocket like valves prevent backward flow of blood from ventricle to auricle
- Cavity of conus arteriosus contains two transverse rows of semi-lunar valves to block the or backward flow of blood into ventricle.



(a) Shark heart

SHARK

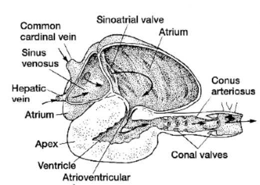
- Sinus venosus and auricle constitute the receiving chambers of the heart.
- Whereas, ventricle and conus arteriosus constitute the forwarding' part of the heart.
- Heart of Scoliodon receives only deoxygenated or venous blood (venous heart)
- In a complete circuit of body, the blood passes through heart only once (single circulation)
- Heart works like a muscular pump for pumping its venous blood to the gills for gas exchange



(a) Shark heart

SHARK

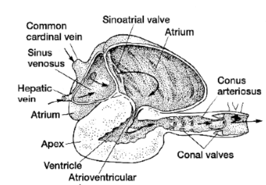
- To achieve this, different parts of the heart rhythmically contract at regular intervals and in a definite succession, first sinus venosus, then auricle, then ventricle and finally the conus arteriosus
- Each contraction, called systole, is followed by a relaxation, called diastole.
- Different valves of the heart serve to prevent the backward flow of blood into preceding chambers through the apertures that they guide



(a) Shark heart

SHARK

- The walls of the heart are supplied oxygenated blood through special coronary arteries
- Blood of Scoliodon consists of colorless plasma and corpuscles suspended in it.
- Corpuscles are of two types
- RBC (erythrocytes) are oval and nucleated bodies and contain respiratory pigment, haemoglobin and
- WBC (leucocytes) are ameboid cells resembling with lymphocytes of other vertebrates



(a) Shark heart

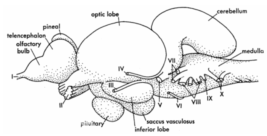
SHARK

Nervous System

- The nervous system of *Scoliodon* consists of three parts
- 1. Central nervous system. It includes brain, and spinal cord
- 2. Peripheral nervous system. It includes cranial and spinal nerves.
- 3. Autonomic nervous system.

Brain

- Brain of dogfish is more advanced than that of the sea lamprey
- It lies enclosed within the chondrocranium and is made of the same three basic parts of the vertebrate brain-forebrain, midbrain and hindbrain



SHARK

Forebrain – Consists of cerebrum and diencephalon.

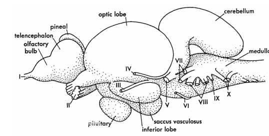
- Olfactory lobe is situated in the forebrain

Midbrain

- Optic lobe is situated in the midbrain
- III and IV cranial nerves arise from midbrain.

Hindbrain

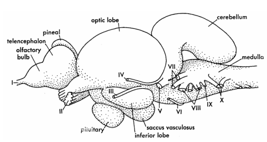
- It comprises two parts, cerebellum and medulla oblongata.
- V, VI, VII, VIII, IX and X cranial nerves arise from medulla
- Hindbrain controls swimming movements



SHARK

Cranial nerves

- Brain gives off 10 pairs of cranial nerves which are identified by their serial Roman numbers as well as names
- Besides, an additional pair of anterior terminal nerves is present numbered as "O" because they were discovered long after the others were already numbered
- The serial numbers, names, origin and distribution of cranial nerves in *Scoliodon* are almost similar to those of higher vertebrates; All are paired



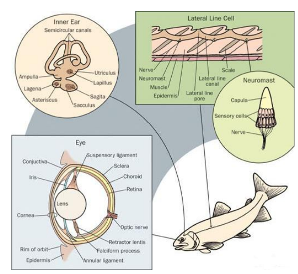
SHARK

Sense Organs

- The main receptor or sense organs of dogfish include (i) Olfactory organs, (ii) Eyes, (iii) Ears, (iv) Neuromasts or lateral line organs, and (v) Ampullae of Lorenzini.

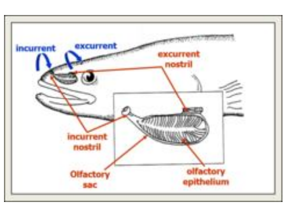
Olfactory organs

- Play a great role in the behaviour of fishes (vertebrates in general) – chemoreception is used for:
- Procurement of food
- Recognition of sex
- Discrimination b/n individuals of the same species or d/t species
- Defense against predators



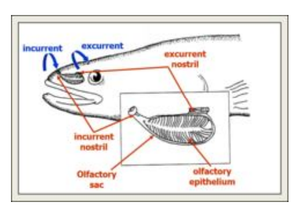
SHARK

- Parental behaviour
- Migration and orientation, etc
- Olfactory organs include a pair of nasal or olfactory sacs situated ventrally in the snout one on either side
- They are characteristically large in elasmobranchs correlated with a highly developed sense or smell for perception of chemical substances dissolved in water
- Each olfactory sac is a large, oval, ectodermal blind pouch covered by a thin membrane and housed inside the thin cartilaginous olfactory capsule of the skull



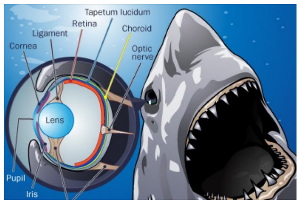
SHARK

- No connection b/n nostrils & alimentary canal (buccal cavity)
- They are ventral and anterior to the mouth
- Sharks are well equipped for their predatory life
- They track their prey using highly sensitive senses in an orderly sequence.
- Sharks may initially detect prey from a kilometer or more away with their large olfactory organs, capable of detecting chemicals as low as 1 part per 10 billion



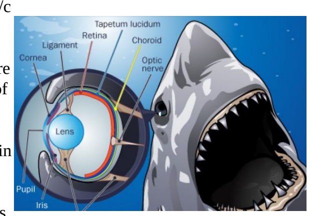
SHARK

- **Eyes**
- Scoliodon has a pair of large and well developed eyes or photoreceptors
- These are housed in socket like depressions, the orbits, one on either side of cranium
- The eye ball is elliptical in shape; The lateral eyes are lidless
- The eye ball remains attached to the inner wall of orbit by 6 eye muscles and a cartilaginous stalk
- Eye with 3 concentric circles – 3 layers are found



SHARK

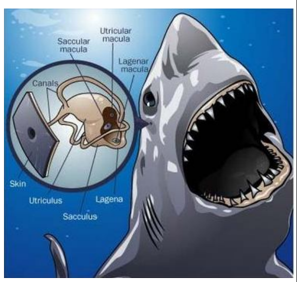
- **Sclerotic** – Outer, cartilaginous layer Cornea – exposed, transparent in w/c light comes into the eyeball
- **Choroid** – Internal layer Blood vessels & nerves (mostly cranial) are found. Iris and pupil control entry of light into the retina
- **Retina** – hind layer. Rods & cones (the light sensitive cells); no cones in sharks
- Eyes in sharks are large but far separated, so that binocular vision is not possible



SHARK

Internal ears

- In dogfish there are no external or middle ears
- Only an internal ear is present called membranous labyrinth.
- It is a delicate membranous sac found embedded in the cartilaginous olfactory capsule, one on either posterio-lateral side of cranium
- Each labyrinth consists of 3 semicircular canals filled with the fluid known as endolymph and 2 sacs (utriculus and sacculus)
- In this fluid there are particles of CaCO3 known as otoliths - hard cartilaginous parts (may be used to determine the age of the animals like scales)



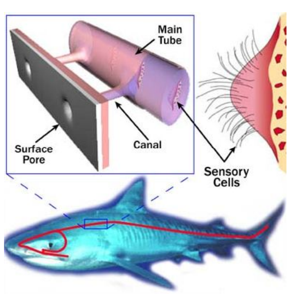
SHARK

- The main function of utriculus & sacculus is to maintain posture- static equilibrium- (the position of the body, mainly the head, relative to the earth's surface i.e. with respect to gravity
- The main function of semicircular canals is to maintain dynamic equilibrium (the maintenance of the body's position in response to sudden movements such as rotation, acceleration & deceleration
- There is no evidence on the hearing of sharks.

SHARK

Neuromast or lateral line system

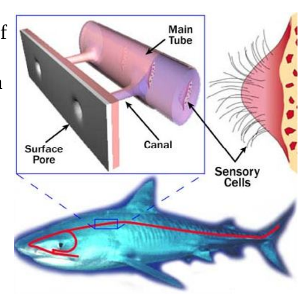
- It is a system of sense organs concerned with life in water
- Besides fishes, it is also found in cyclostomes and aquatic stages of Amphibia
- In dogfish it includes
  (1) Lateral lines,
  (2) Neuromast organs, and
  (3) Pit organs



SHARK

Lateral lines - A faint lateral line runs along either lateral side of trunk and tail

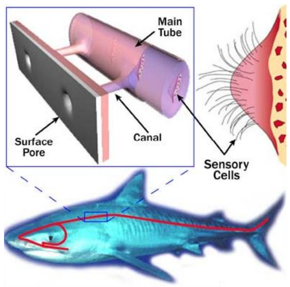
- It contains below the surface a slender mucus-filled canal sunk into dermis
- It opens to the surface by minute pores at intervals through a series of vertically running tubes
- The two lateral line canals are continued anteriorly into a system of canals



SHARK

Neuromast organs - These are little groups of receptor and supporting cells found in the lateral line canals

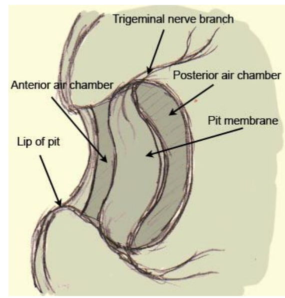
- Receptor or sensory cells bear tiny stiff sensory hairs which project into the canal.
- Neuromast organs are *rheoreceptors* or current receptors
- They can perceive vibrations of very low frequency and detect disturbances in water such as caused by the movements of other fishes



SHARK

Pit organs – Small ectodermal pits are found scattered on the dorsal and lateral surfaces of head of dogfish

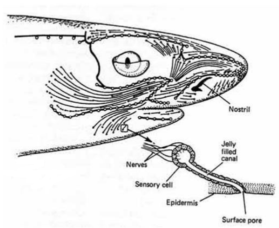
- Each pit organ consists of sensory hair cells with supporting cells and innervated by nerve fibers of VII cranial nerve
- Pit organs are regarded to be isolated individual neuromasts or rheoreceptors
- They are especially abundant in rays



SHARK

Ampullae of Lorenzini - electroreceptors

- Located primarily on their head
- Sensitive to minute electrical currents in the water
- Sense weak electrical currents associated with the functioning of nerves & muscles in living animals.
- Sharks may use electroreception to find prey buried in the sand



SHARK

Endocrine System

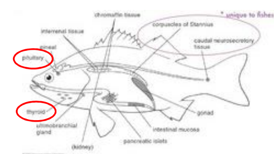
- Very little change from the plan of mammals

i. Pituitary gland

- a. Anterior pituitary is evident in sharks & responsible for the production of TSH, growth hormone
- b. No evidence of posterior pituitary – produces vasopressin (ADH) & oxytocin

ii. Thyroid gland – prominent

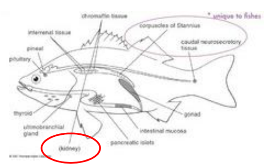
- Produces thyroid hormone that is responsible for regulation of metabolic rate, growth & development



SHARK

iii. Adrenal glands/ tissues in sharks

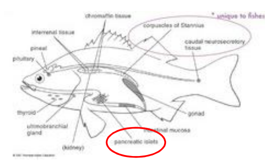
- Have two parts
- a. Inner portion (adrenal medulla) – supra renal tissues- produce adrenaline (epinephrine) & noradrenalin (norepinephrine)
- b. Outer portion (adrenal cortex) – Inter renal tissues- produces corticoides such as aldosterone & cortisone
- No evidence for the presence of parathyroid gland



SHARK

iv. Islets of Langerhans – evident in sharks

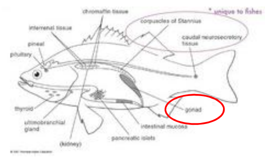
- a. Beta cells – produce insulin which is responsible for reducing blood glucose
- b. Alpha cells – produce glucagon which increase glucose concentration in the blood by initiating the conversion of glycogen to glucose



SHARK

v. Gonads – produce steroids

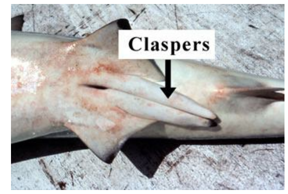
- Ovaries & testes of most vertebrates produce 3 types of steroid hormones: estrogens, progesterone & androgens
- Interstitial cells of testes produce testosterone which is responsible for primary & secondary sexual characteristics in males
- Theca cells of the follicles around the ovaries produce estrogen which is responsible for primary & secondary sexual characteristics in females
- Corpus luteum produces progesterone



SHARK

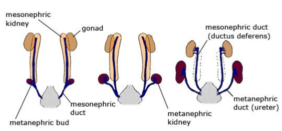
Urogenital System

- The excretory and reproductive systems are so closely related to each other in vertebrates that they are considered together under the name of "urinogenital system"
- In *Scoliodon*, the two sexes are separate
- Sexual dimorphism occurs as in male dogfish, the medial portions of pelvic fins are modified into claspers for transfer of spermatozoa during copulation



SHARK

- Urea is the major nitrogenous waste
- Normally urea is toxic in the blood, but sharks tolerate high concentration of urea in the blood by adaptive mechanism (d/t from any other animal)
- There is a section in tubules which regulates concentration of urea & salt in blood (it keeps the blood isotonic to the environment – not to lose water

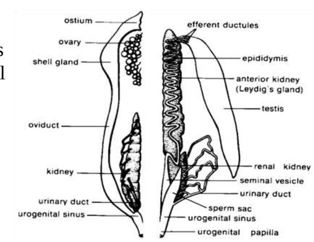


SHARK

i. Male urinogenital system

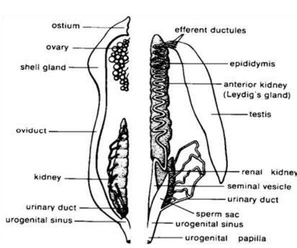
a. Excretory organs

- Excretory organs of male dogfish are a pair of long, flattened mesonephric kidneys
- They are attached to the dorsal abdominal wall
- They extend nearly the whole length of the body cavity
- Each kidney is differentiated into distinct anterior and posterior parts
- The anterior part is greatly reduced, non-excretory, narrower and genital in function, hence called epididymis



SHARK

- The posterior part is greatly developed, excretory, thicker and forms the functional adult kidney, called opisthonephros
- Each opisthonephros is formed by several coiled, glandular uriniferous tubules with Bowman's capsules enclosing glomeruli
- The tubules have a special urea-absorbing segment in them
- All the collecting tubules open into a thin-walled common kidney duct or ureter

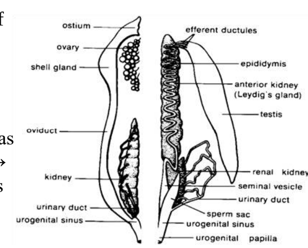


SHARK

- Posteriorly both the ureters open into a wide median urinogenital sinus, which itself opens into cloaca through its aperture placed at the tip of a short urinogenital papilla

b. Reproductive organs

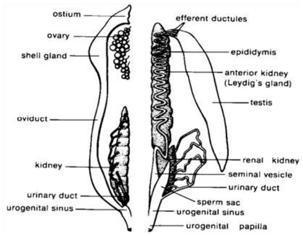
- Testes → Vasa efferentia → Vas deferens → Seminal vesicle → Urinogenital sinus → Claspers
- Spermatozoa developed from germ cells in seminiferous tubules of the testis are carried to the vas deferens
- In the seminal vesicle the spermatozoa are stored



SHARK

ii. Female urinogenital system
a. Excretory organs

- In female dogfish also, the kidneys show the same differentiation into anterior non-excretory and posterior excretory portions
- But there is no connection between kidneys and genital organs
- Unlike male, the two ureters of female dogfish unite into a common median ureter opening behind into the large median urinary sinus



SHARK

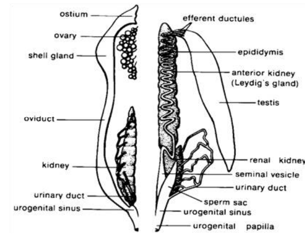
- The sinus in turn opens into cloaca at the tip of a short urinary papilla

b. Reproductive organs

- Ovaries → Oviducts → Shell gland → Uterus → Female tube → Cloaca

Reproduction

- Sexes are separate; there is sexual dimorphism; the gonads are usually paired and with ducts



SHARK

a. Copulation

- Reproduction occurs almost throughout the year
- During copulation, the male twines round the female
- Spermatozoa are transferred through the agency of grooved erected claspers of male, one or both of which are inserted into the cloaca of female

SHARK

b. Fertilization

- As in all the elasmobranchs, fertilization in dogfish is internal
- It takes place in the narrow anterior parts of oviducts in front of the shell glands

c. Development

- Some dogfishes ovoviviparous
- Their eggs develop inside uteri so that they give birth to living young 3 to 7 embryos may develop in each uterus depending upon the species

SHARK

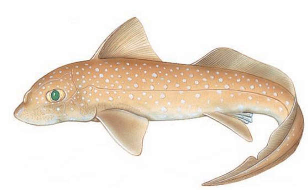
- Some sharks lay large, yolky eggs immediately after fertilization; these species are termed oviparous
- Embryos are nourished from the yolk for a long period—6 to 9 months in some, as much as 2 years in one species—before hatching as miniature replicas of adults.
- Many sharks, however, retain embryos in their reproductive tract for prolonged periods.
- Many are **ovoviviparous** species, which retain developing young in the uterus while they are nourished by contents of their yolk sac until born
- Still other species have true **viviparous** reproduction
- In these, embryos receive nourishment from the maternal bloodstream through a placenta, or from nutritive secretions, “uterine milk,” produced by the mother
- The gestation period is 6 months to 2 years
- Arrogance in sharks is innate

CLASS CHONDRICHTHYES

(CARTILAGINOUS FISHES)

2. Subclass Holocephali

- Members of the small subclass Holocephali, distinguished by such suggestive names as ratfish, rabbitfish, spookfish, and ghostfish, are remnants of a line that diverged from the shark lineage at least 360 million years ago
- Today there are only about 33 species

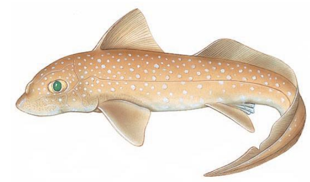


CLASS CHONDRICHTHYES
(CARTILAGINOUS FISHES)

- Anatomically these fishes have several features linking them to elasmobranchs, but they possess a suite of unique characters, too
- Instead of a toothed mouth, their jaws bear large flat plates
- The upper jaw is completely fused to the cranium
- Their food includes seaweed, molluscs, echinoderms, crustaceans, and fishes—a surprisingly mixed diet for such a specialized grinding dentition

CLASS CHONDRICHTHYES
(CARTILAGINOUS FISHES)

- Chimaeras are not commercial species and are seldom caught
- Despite their strange shape, they are beautifully colored with a pearly iridescence
- Male has a frontal or cephalic clasper in addition to usual pelvic claspers.
- All are oviparous and lay a single egg at a time. have large eyes



VIDEO

69

Cone cells are present in sharks

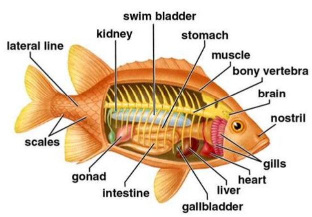
Binocular vision is possible

Thank you

CLASS OSTEICHTHYES
(BONY FISHES)

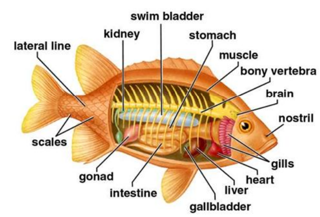
General Characters

- Inhabit all sorts of water—fresh, brackish or salt; warm or cold.
- Body spindle-shaped and streamlined
- Fins both median and paired, supported by fin rays of cartilage or bone
  - Tail is usually homocercal,



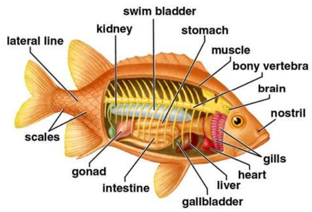
CLASS OSTEICHTHYES
(BONY FISHES)

- Skin with many mucous glands, usually with embedded dermal scales of 3 types; Ganoid, Cycloid or Ctenoid.
  - Some without scales
  - No placoid scales.
- Endoskeleton chiefly of bone (Gr., *osteon*, bone + *ichthyes, fish)*
  - Cartilage in sturgeons (fishes valued for their flesh) and some others
  - Notochord replaced by distinct vertebrae.



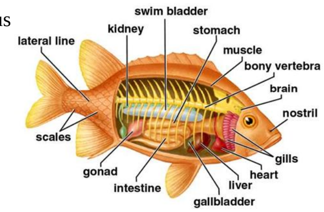
CLASS OSTEICHTHYES
(BONY FISHES)

- Pelvic girdle usually small and simple or absent
- Claspers absent
- Mouth usually terminal
- Jaws usually with teeth
- Respiration by 4 pairs of gills on bony gill arches, covered by a common operculum on either side.
- An air (swim) bladder often present with or without duct connected to pharynx
  - Lung-like in some bony fishes (Dipnoi)
- No cloaca; but anus



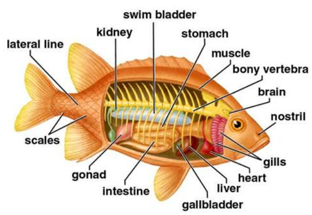
CLASS OSTEICHTHYES
(BONY FISHES)

- Ventral heart 2-chambered (1 auricle + 1 ventricle). Sinus venosus and conus arteriosus present
  - Erythrocytes oval, nucleated
  - Temperature variable (poikilothermous)
- Adult kidneys mesonephric
- Brain with very small olfactory lobes, small cerebrum and well developed optic lobes and cerebellum.
  - Cranial nerves 10 pairs

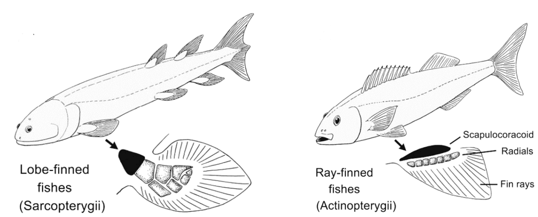


CLASS OSTEICHTHYES
(BONY FISHES)

- Well developed lateral line system
- Internal ear with 3 semicircular canals
- Sexes separate
  - Gonads paired
  - Fertilization usually external
  - Mostly oviparous, rarely ovoviviparous or viviparous
  - Eggs minute to12 mm
  - Development direct



CLASS OSTEICHTHYES
(BONY FISHES)

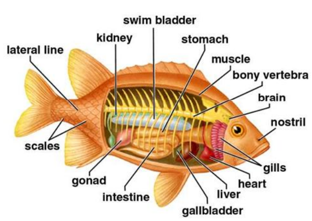


CLASS OSTEICHTHYES
(BONY FISHES)

Classification of bony fishes

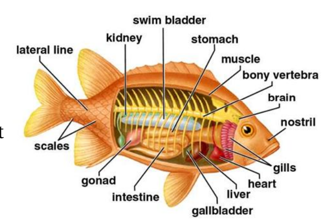
i. Subclass Sarcopterygii (Gr. sarkos, flesh, pteryx, fin, wing)

- Lobe-finned (fleshy-finned) fishes
- Skeleton ossified
- Single gill opening covered by operculum
- Paired fins with sturdy internal skeleton and musculature within appendage



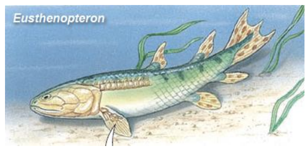
CLASS OSTEICHTHYES
(BONY FISHES)

- Paired fins are lobed, with a fleshy, bony central axis covered by scales
- Diphycercal tail
- Intestine with spiral valve
- Usually with lungs
- Atrium and ventricle at least partly divided
- Teeth with enamel covering
- Olfactory sacs usually connected to mouth cavity by internal
- Divided into several groups



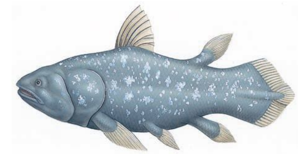
CLASS OSTEICHTHYES
(BONY FISHES)

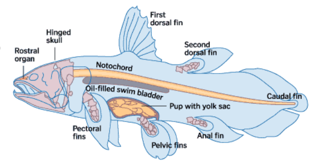
Rhipidistians
- The ancestor of tetrapods is found within a group of extinct sarcopterygian fishes called rhipidistians,
- Rhipidistians, such as *Eusthenopteron* were cylindrical, large-headed fishes with fleshy fins, and presumably lungs



CLASS OSTEICHTHYES
(BONY FISHES)

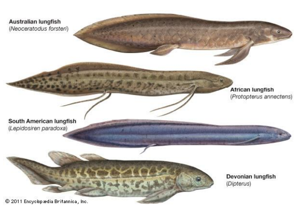
Coelacanths
- Most of them were marine
- In living coelacanths, the swim bladder does not serve in respiration but is filled with fat
- Size ranges from 0.75 to slightly over 2 meters
- The scales have hollow tubercles, overlap each other to form a strong, thick protective covering
- The first dorsal fin is unlobed and caudal fin has distinct 3 lobes.





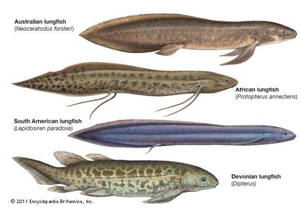
CLASS OSTEICHTHYES
(BONY FISHES)

Dipnoi (Lung fishes)
- Earlier lungfishes were marine but modern forms occupy fresh water
- Three surviving genera occur in continental streams and swamps
- *Protopterus* – African lungfish
- *Lepidosirem* – South American lungfish
- *Neoceratodus* – Australian lungfish



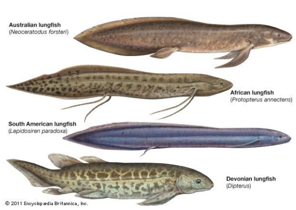
CLASS OSTEICHTHYES
(BONY FISHES)

- With paired lungs, can breathe during periods when oxygen levels in the water fall during dry seasons
- They breath both atmospheric oxygen and dissolved oxygen
- Their lungs are modified swim bladder
- Modern lungfishes have a skeleton composed mostly of cartilage, and exhibit a prominent notochord



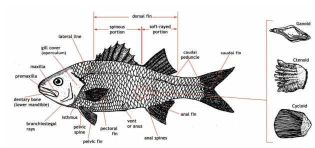
CLASS OSTEICHTHYES
(BONY FISHES)

- Double circulation for the first time developed in this group
- Lungfishes are mostly cartilaginous
- They have specialized crushing tooth plates to feed effectively upon shell fish.
- Their tadpole like larva has external gills as accessory respiratory structure



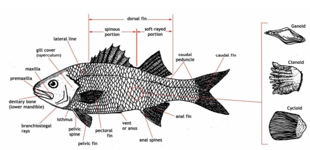
CLASS OSTEICHTHYES
(BONY FISHES)

ii. Subclass Actinopterygii
(Gr., *actis, ray* + *pteryx, fin)*
- Commonly known as "ray-finned" fishes because of their distinctive fins, which are internally supported by numerous slender, endoskeletal rays
- Muscles that control fin movements are located within the body wall, in contrast to the muscles of sarcopterygians that are located outside the body wall along the projecting fin



CLASS OSTEICHTHYES
(BONY FISHES)

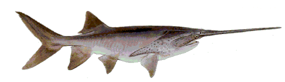
- Paired fins thin, broad, without fleshy basal lobes, and supported by dermal fin rays
- Olfactory sacs not connected to mouth cavity
- Divided into several groups
- **chondrosteans, holosteans,** and **teleosts,**



CLASS OSTEICHTHYES
(BONY FISHES)

a. Chondrostei (Gr., chondros, cartilage + osteon, bone)

- Mouth opening large
- Scales usually ganoid
- Tail fin heterocercal
- Primitive ray-finned fish
- Example is Paddle fishes – naked skin; possess typical elongated rostrum & heterocercal tail



CLASS OSTEICHTHYES
(BONY FISHES)

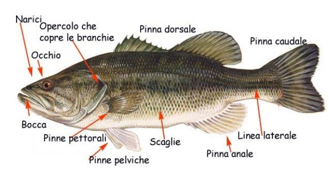
b. Holostei (Gr., holos, entire + osteon, bone)

- Mouth opening small
- Ganoid or cycloid scales
- Tail fin heterocercal
- Intermediate ray-finned fish, transitional between Chondrostei and Teleostei
- There are two surviving genera of early holosteans
- *Lepisosteus* (Garpike) – possess beak-like elongated jaws
- *Amia* (Bowfins) – possess bone like dorsal fins

CLASS OSTEICHTHYES
(BONY FISHES)

c. Teleostei (Gr., teleos, perfect+ osteon, bone)

- The modern bony fishes
- The most diverse & abundant (successful) vertebrates
- There are almost 30,000 described species, representing about 96% of all living fishes or about half of all vertebrates
- In addition, it has been estimated that there are an additional 5,000 to 10,000 undescribed species



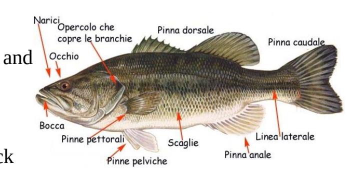
CLASS OSTEICHTHYES
(BONY FISHES)

- Teleosts range in size from 7 mm adult minnows to 17 m oarfish and 900 kg
- They exist in a variety of forms, mostly spindle shaped
- They share similar structure and function with cartilaginous fishes despite a lot of differences
- Evolved in Mesozoic era

CHARACTERISTIC FEATURES OF TELEOSTS

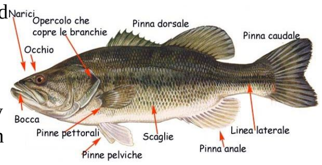
a. Head:

- Head extends from tip of snout to hind edge of operculum
- Snout is depressed, short and not pointed
- Mouth is subterminal
- It is a large transverse aperture, bounded by thick and fleshy lips
- Snout bears dorsally a pair of small nostrils, they are peculiar as they do not communicate to the buccal cavity.



CHARACTERISTIC FEATURES OF TELEOSTS

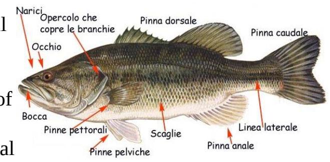
- The lateral eyes on head are without eyelids but protected by a transparent protective membrane
- Behind the eye, on either side is a large movable bony gill cover or operculum with free posterior and ventral margins
- Beneath each - operculum lie four comb-like gills in a branchial chamber



CHARACTERISTIC FEATURES OF TELEOSTS

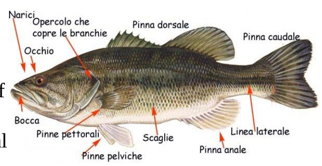
b. Trunk:

- It is the thick middle part of body. and oval in cross section
- Back of operculum upto tail constitute the trunk with lateral line
- On the back of the middle of trunk is a single large somewhat rhomboidal dorsal fin
- Just behind operculum are a pair of larger ventro-lateral pectoral fins, followed behind by a pair of smaller ventral pelvic fins



CHARACTERISTIC FEATURES OF TELEOSTS

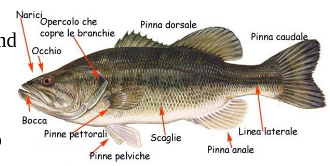
- On either side of trunk extending from the back of operculum upto tail there is a dark line on the mid ventral portion of the body called, lateral line
- On the back of the middle of trunk is a single large somewhat rhomboidal dorsal fin
- Mid-ventrally at the posterior end of trunk lie in a series three small apertures: anterior anus, middle genital and posterior urinary



CHARACTERISTIC FEATURES OF TELEOSTS

c. Tail:

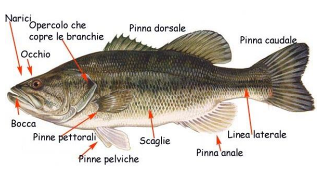
- It comprises about one-third posterior part of body
- It is laterally compressed and narrower behind
- At the end of the tail is a median homocercai caudal fin deeply notched into two similar lobes
- On the ventral side of tail is a median anal fin lying just posterior to urinary aperture.
- The tail makes the principal locomotor organ.



CHARACTERISTIC FEATURES OF TELEOSTS

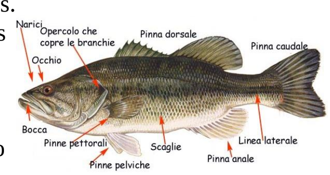
Body wall

- Trunk and tail are covered by thin, rounded, overlapping dermal cycloid scales
- The concentric or ring-like markings on scales called circulii are used to determine the age of fish
- The skin comprises of two parts: outer epidermis and inner dermis
- The dermis is made up of connective tissue, blood vessels, nerves and smooth muscle fibers.



CHARACTERISTIC FEATURES OF TELEOSTS

- Scales are found embedded in the dermis.
- The epidermis of fishes contains large mucous cells or Becker's cells and chromatocytes
- Chromatocytes are also found in dermis
- Two type of sensory cells viz., granular sensory cells and club cells are also present

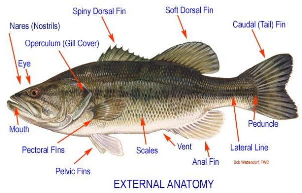


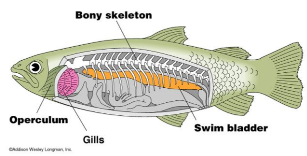
CHARACTERISTIC FEATURES OF TELEOSTS

Skeleton

a. Exo and endoskeleton

- Scales and finrays constitute the exoskeleton of Labeo rohita
- Scales are cycloid type, thin overlapping bony plates, partly covered by skin
- Exposed part of scales bear pigment cells
- They are of two types- spines (single ray) and soft rays (segmented rays)
- Bony endoskeleton is found in *Labeo*





Thank You

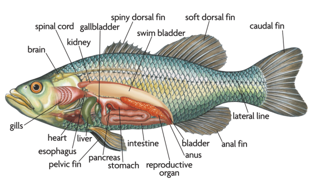
CLASS OSTEICHTHYES
(BONY FISHES)

Digestive System

Digestive system comprises the alimentary canal and the associated digestive glands

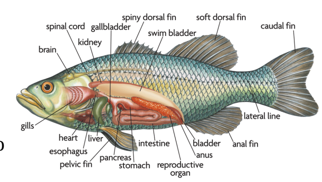
a. Alimentary canal

- Alimentary canal starts from the mouth and terminates in the anal opening
- The subterminal mouth, bounded by fleshy lips, opens into a broad, dorso-ventrally compressed buccal cavity.
- Teeth and a distinct tongue are lacking in rohu.



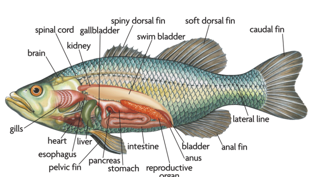
CLASS OSTEICHTHYES
(BONY FISHES)

- Pharynx is also dorso-ventrally compressed and differentiated into a broad anterior respiratory part and a narrow posterior masticatory part
- Anterior part is perforated laterally by four pairs of internal gill slits leading into branchial chambers
- From branchial arches project into pharyngeal cavity small spiny gill rakers, to prevent passage of food through gill slits



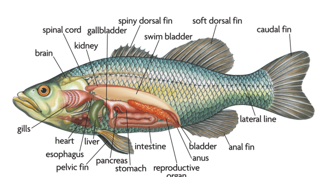
CLASS OSTEICHTHYES
(BONY FISHES)

- Pharynx leads posteriorly into a short, narrow tubular **oesophagus**
- Its mucous lining forms prominent longitudinal folds
- A pneumatic duct from air bladder of fish opens dorsally into oesophagus.
- Labeo and many other teleost fishes do not have **stomach** like higher vertebrates which is difficult to understand
- Oesophagus opens behind straight into an elongated, swollen, thick-walled **intestinal bulb**



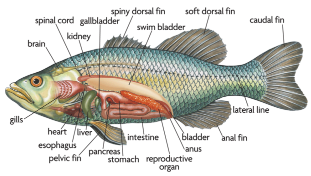
CLASS OSTEICHTHYES
(BONY FISHES)

- Opening between the two is guarded by an **oesophageal valve** to prevent regurgitation of food
- The intestinal bulb has an anterior broader cardiac part into which open dorsally the pancreatic and bile ducts, and a posterior narrower pyloric part without pyloric caeca so common in other teleost fishes
- Gastric glands are lacking



CLASS OSTEICHTHYES
(BONY FISHES)

- Intestinal bulb is followed by a thin-walled, narrow and extremely elongated (about 8 metres long) **intestine**
- It is a much coiled tube of practically uniform diameter
- Intestine is longer in Labeo because of its herbivorous habit but it tends to be shorter in carnivorous fishes.
- The rectum which follows is nearly 1 metre long, slightly wider and thin-walled
- Rectal gland is lacking

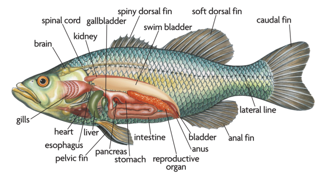


CLASS OSTEICHTHYES
(BONY FISHES)

- Rectum opens to the exterior by anus mid-ventrally just in front of the anal fin
- It functions for the muscular expulsion of the faecal material

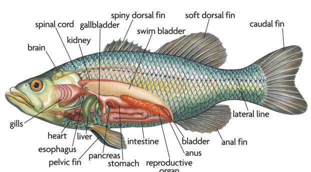
Digestive glands

- Digestive glands of *Labeo* are liver and pancreas
- Liver is a large, dark brown gland



CLASS OSTEICHTHYES
(BONY FISHES)

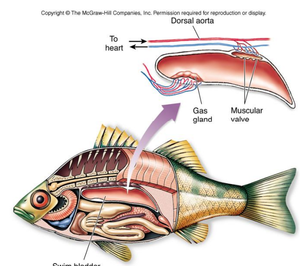
- A thin-walled elongated sac-like gall bladder, 8 cm long and 2.5 cm broad, lies dorsally between right liver lobe and intestinal bulb
- Pancreas is rather diffused, found scattered in liver, spleen and intestinal mesentery



CLASS OSTEICHTHYES
(BONY FISHES)

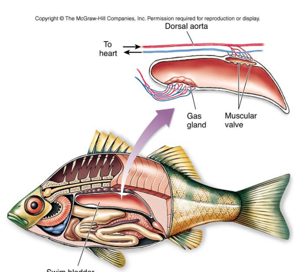
Air Bladder - it may constitute 4-11% of the volume of the body

- Air bladder is also called the swim bladder
- It lies in the body cavity, but outside coelom, above the intestinal bulb and ventral to the vertebral column.
- It is an elongated white, thin-walled sac filled with a gas



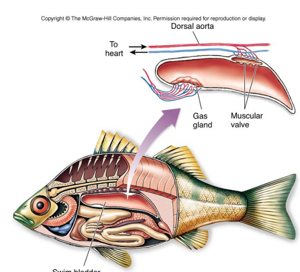
CLASS OSTEICHTHYES
(BONY FISHES)

- The air bladder is connected to the roof of esophagus by a slender pneumatic duct and such a fish is called **physostomous**
- They inhale air at the water surface & push it through the pneumatic duct into the swim bladder using a force supplied by the buccal cavity
- Examples of such bony fishes: **Catfishes, Salmon, eels** etc



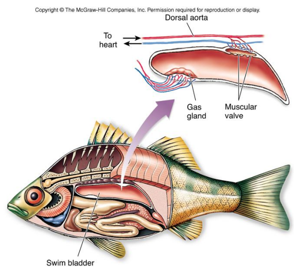
CLASS OSTEICHTHYES
(BONY FISHES)

- The other type of swim bladder is known as **physoclistous**, which is a closed type of swim bladder
- It lacks pneumatic duct
- The source of gas is normally from the blood contained in a network of capillaries found in the lining of the swim bladder
- Most teleosts have this type of swim bladder
- Air bladder has several functions:



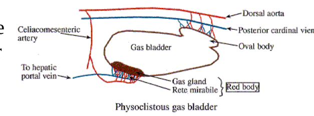
CLASS OSTEICHTHYES
(BONY FISHES)

- Air bladder functions like a hydrostatic organ
- It regulates specific gravity of body by secretion or absorption of gas in the air bladder
- To keep position in water; helpful for searching food
- The inner lining of the swim bladder is highly vascularized, forming red bodies



CLASS OSTEICHTHYES
(BONY FISHES)

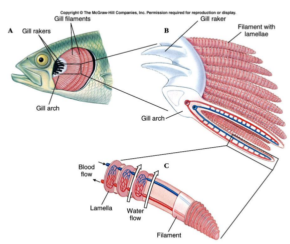
- The red bodies are located in the anterior chamber has extraordinary power of isolating oxygen, carbon dioxide and nitrogen from the blood and to fill this chamber with these secreted gases
- Besides acting as hydrostatic organ it also performs a variety of other functions like- gas secretion, respiratory function, sensory function auditory function and sound production etc.



CLASS OSTEICHTHYES
(BONY FISHES)

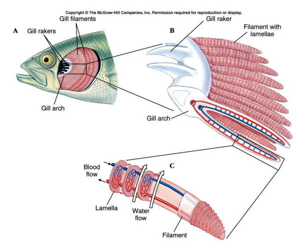
Respiratory System

- Respiration of *Labeo* is aquatic, the fish depending on 0_2 dissolved in water.
- The respiration is performed by four pairs of gills located in gill chambers.
- Teleosts respire by using 4 pairs of opercular gills
- Gill arches have supportive function
- Gill arch has teeth-like processes, the gill rakers, have protective function (do not permit food particles to enter the gill)



CLASS OSTEICHTHYES
(BONY FISHES)

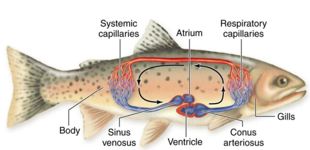
- Possess hemibranch type of gills – because gill lamellae are found in one side only
- Efficiency of taking in H_2O with O_2 is increased b/c of the presence of operculum – opening & closing of the operculum facilitates the entry of H_2O with O_2



CLASS OSTEICHTHYES
(BONY FISHES)

Circulatory System

- The blood vascular system and physiology of circulation are practically the same as in the dogfish shark; there is only minor difference
- In teleosts bulbous arteriosus is present instead of conus arteriosus of sharks
- Conus arteriosus is muscular & helps ventricle to pump blood effectively

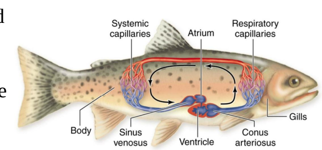


CLASS OSTEICHTHYES
(BONY FISHES)

- Bulbus arteriosus is elastic & non-muscular; do not participate in pumping blood (only ventricle is involved)
- In teleosts the spleen is very distinct, partitioned and large but diffused in sharks

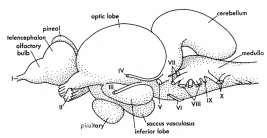
Nervous System

- The nervous and sensory systems of a bony fish are very similar to those of a dogfish



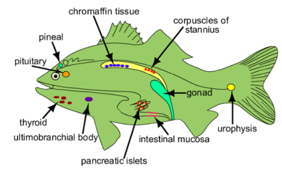
CLASS OSTEICHTHYES
(BONY FISHES)

- However, the brain of *Labeo* bony fishes is more highly developed than that of *Scoliodon* (cartilaginous fishes)
- Olfactory lobes, cerebrum (undivided) and diencephalon are somewhat smaller while the optic lobes and cerebellum larger than in dogfish
- Bony fishes share the keen senses of smell and taste with cartilaginous fishes
- The olfactory sacs do not communicate with mouth cavity and take no part in respiration



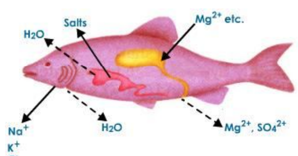
CLASS OSTEICHTHYES
(BONY FISHES)

Endocrine System
- Anterior & posterior pituitary glands are evident in teleosts but only anterior in sharks
- Teleosts possess ultimobranchial bodies in the gill region below the esophagus (it is related to parathyroid gland)
- It produces calcitonin – important for Ca metabolism
- It picks Ca & phosphates from the circulating blood; so these ions can be utilized mainly for bone formation, muscle contraction & nerve transmission



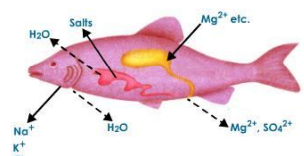
CLASS OSTEICHTHYES
(BONY FISHES)

Excretory System
- The kidney is mesonephric type as that of chondrichthyes
- Ammonia and urea are the major wastes
- These wastes are eliminated from the body mainly through gills not by mesonephric kidney
- Other minor wastes are like creatine & uric acid released through the kidney



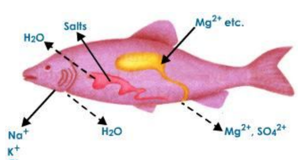
CLASS OSTEICHTHYES
(BONY FISHES)

- Kidneys are largely involved in osmoregulation
- In fresh water, the environment is hypotonic to the body tissue of teleosts
- Excess water must be removed; for these they have well developed glomeruli and to conserve salt they have well developed tubules
- In marine habitat, the environment is hypertonic to the body tissue of teleosts



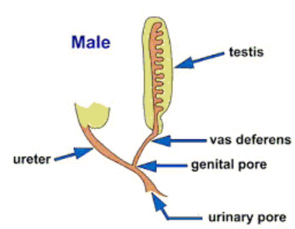
CLASS OSTEICHTHYES
(BONY FISHES)

- Water draws out from the body; thus, glomeruli is highly reduced/lost to retain water
- For removing excess salt, they have chloride secreting cells in the gills which are specialized to excrete excess salt out of their body



CLASS OSTEICHTHYES
(BONY FISHES)

Reproductive System
- In chondrichthyes, sexes are totally separate but there are hermaphroditic teleosts; both simultaneous & sequential hermaphroditic
- Most are oviparous; some are viviparous & ovoviviparous
- Identifying sexes by external morphology is very difficult in teleosts



CLASS OSTEICHTHYES
(BONY FISHES)

Some outstanding behavior of teleosts
1. Production of poison (venom)
a. Localized – produced from poison gland & the poison is transmitted through duct
- Use for defense or offense
- Depending on the dose it might be deadly to humans

b. Non-localized
- Fishes can be intoxicated by consuming toxic marine plants
- Concentration increases from producers to consumers – bioaccumulation (bimagnification)
- Human beings can be attacked as a result of consuming toxic flesh

CLASS OSTEICHTHYES
(BONY FISHES)

Production of light – bioluminescence
- There are about40 families of luminous teleosts; mostly live in deep seas (eternal darkness)
- Photophores are epidermal glands modified to function as light-emiting organs
- Light can be produced in two ways:
  i. Produced chemically by the interaction of an enzyme (luciferase) with a phenol (luciferine)
  Luciferine →(Luciferase, ATP, O_2) light
  ii. Through bioluminescent bacteria that reside in specialized gland like organs
- Used for various purposes:
  a. For detecting prey – since there is no light in deep sea
  b. For defense
  c. For communication

CLASS OSTEICHTHYES
(BONY FISHES)

Production of electricity
- Not unique to teleosts, but production of electricity reach at its peak in teleosts

Production of colour
- Teleosts are capable of changing their colours
- Chromatophores – dermal cells producing a variety of colours b/c of the presence of d/t pigments
- Melanophores (melanin- black); erythrophores (red); xanthophores (yellow); leucopores (white)
- Compound chromatophores – more than one pigment
- B/c of movement of pigments in the skin, there is change of colour
- Very important in fishes, amphibians and reptiles
- Function – to conceal (hide) themselves by resembling the environment and for sexual recognition

CLASS OSTEICHTHYES
(BONY FISHES)

Migration
- Any mass movement of animals from one habitat to another with characteristic regularity in time or according to life history; it has to be round trip
- Why animals do migrate? Most likely b/c of 3 reasons
  i. For breeding – to search appropriate place
  ii. For feeding – when there is scarcity of food
  iii. For wintering – when the weather condition is unfavourable

CLASS OSTEICHTHYES
(BONY FISHES)

Several ways of migration
i. Diadromous - migration b/n 2 major types of water environments
a. Anadromous : From sea to fresh water for breeding e.g. Chinook salmon
b. Catadromous : From fresh water to sea for breeding e.g. Eels
c. Amphidromous: From fresh water to sea or vice versa but not for breeding e.g. Mullests
ii. Potamodromous: Fishes migrate within fresh water environment but in d/t habitats. It could be from upstream to downstream; from shallow to deep e.g. Barbus in Lake Tana to Rub river
iii. Oceanodromous: Fishes migrate within marine environment but in d/t habitats e.g. Tuna fishes

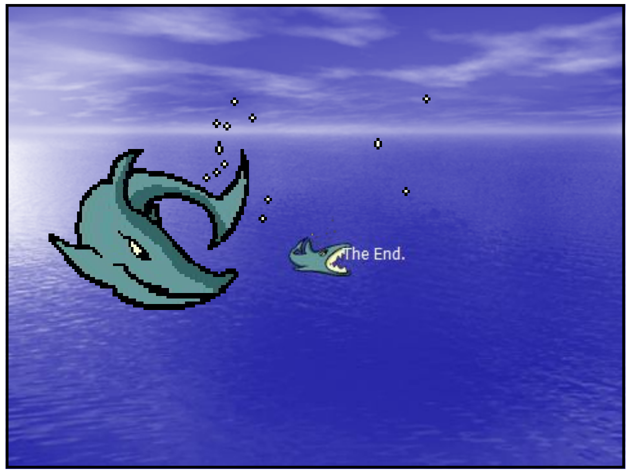
CLASS OSTEICHTHYES
(BONY FISHES)

Advantages of migration
- For getting additional food sources, good climate & for breeding

Disadvantages of migration
- Expenditure of energy: During the journey and spawning
- Exposure to predators: While moving longer distant places Problem of adjusting osmoregulation
- Problem of adjusting themselves to the new environment, especially in the case of diadromous migration

Reading assignment on the differences b/n sharks (cartilaginous fishes) and teleosts (bony fishes)

Assignment:
Enlist the name of the fishes that produce electricity and how they produce electricity



VERTEBRATE ZOOLOGY

LAND VERTEBRATES

ORIGIN OF TETRAPODS AND THEIR FISH ANCESTORS

By

Dr. K. S. Goudar

ORIGIN OF TETRAPODS

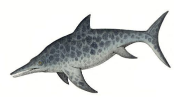
The word "tetrapod" means "four feet" and includes all species alive today that have four feet — but this group also includes many animals that don't have four feet. That's because the group includes all the organisms (living and extinct) that descended from the last common ancestor of amphibians, reptiles, and mammals.

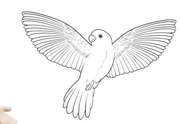
Video

3

ORIGIN OF TETRAPODS

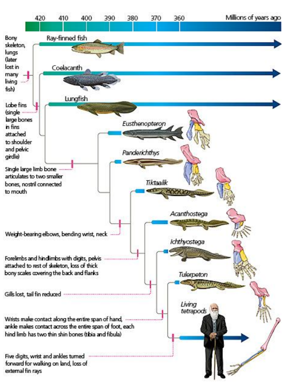
So, for example, the ichthyosaur, an extinct swimming reptile, is a tetrapod even though it did not use its limbs to walk on land. So is the snake, even though it has no limbs. And birds and humans are tetrapods even though they only walk on two legs. All these animals are tetrapods because they descend from the tetrapod ancestor described above, even if they have secondarily lost their "four feet."





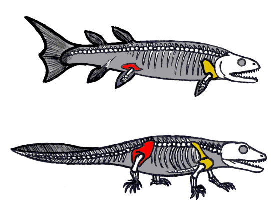
ORIGIN OF TETRAPODS

Tetrapods evolved from a finned organism that lived in the water. However, this ancestor was not like most of the fish we are familiar with today. Most animals we call fishes today are ray-finned fishes, the group nearest the root of this evogram.



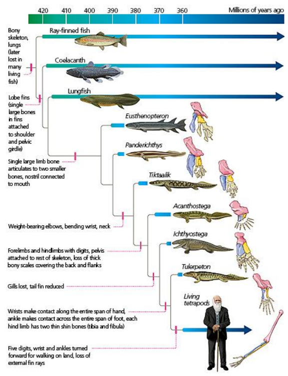
ORIGIN OF TETRAPODS

Ray-finned fishes comprise some 25,000 living species, far more than all the other vertebrates combined. They have fin rays — that is, a system of often branching bony rays (called lepidotrichia) that originate from the base of the fin.



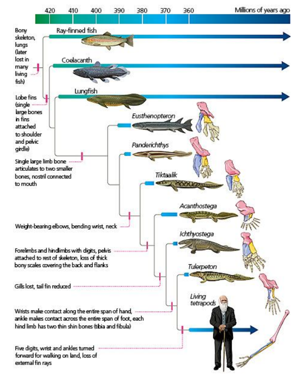
ORIGIN OF TETRAPODS

In contrast, the other animals in the evogram — coelacanths, lungfishes, all the other extinct animals, plus tetrapods have what we call "fleshy fins" or "lobe fins."



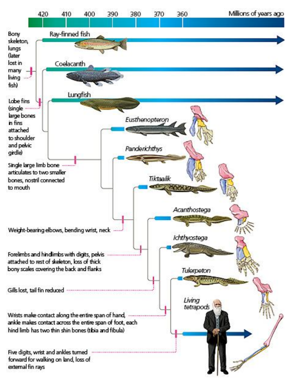
ORIGIN OF TETRAPODS

That is, their limbs are covered by muscle and skin. Some, such as coelacanths, retain lepidotrichia at the ends of these fleshy limbs, but in most fleshy-finned animals these have been lost.



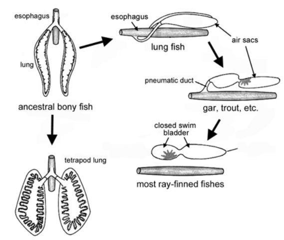
ORIGIN OF TETRAPODS

The common ancestor of all those different organisms (ray-fins, coelacanths, lungfishes, tetrapods, etc.) was neither a lobe-fin nor a ray-fin. This ancient vertebrate lineage had fins (with lepidotrichia), scales, gills, and lived in the water.



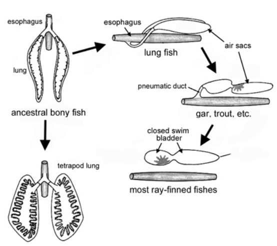
ORIGIN OF TETRAPODS

Yet they also had air bladders (air-filled sacs) connected to the back of their throats that could be used for breathing air (i.e., as lungs) or for buoyancy control. The air bladders of many ray-fins no longer connect to their throats, and so they are not able to breathe air.



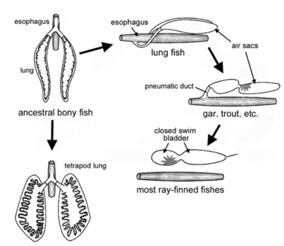
ORIGIN OF TETRAPODS

In these ray-fins, the air bladder is used mainly for buoyancy control and is known as a swim bladder. By contrast, tetrapods have taken an alternative route: they have lost the buoyancy control function of their air bladders, and instead this organ been elaborated to form the lungs that we all use to get around on land.



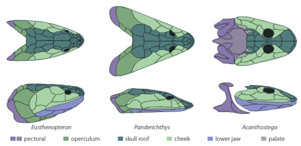
ORIGIN OF TETRAPODS

Lot of fossil forms that lived between about 390 and 360 million years ago during the Devonian Period. During this interval, this lineage of fleshy-finned organisms moved from the water to the land. Many parts of the skeleton changed as new innovations that permitted life on land evolved.



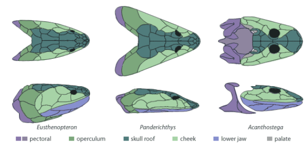
ORIGIN OF TETRAPODS

The ancestors ray-fins, coelacanths, lungfishes, tetrapods, etc lived fully in the water and had skulls that were tall and narrow, with eyes facing sideways and forwards.



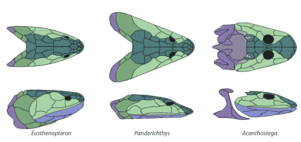
ORIGIN OF TETRAPODS

This allowed them to look around in their watery environments for predators and prey. However, as ancestors of the first tetrapods began to live in shallower waters, their skulls evolved to be flatter, with eyes on the tops of their heads.



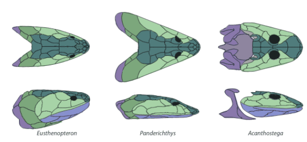
ORIGIN OF TETRAPODS

This probably allowed them to look up to spot food. Then, as tetrapods finally moved fully onto land and away from the water, many lineages once again evolved skulls that were tall and narrow, with eyes facing sideways and forwards, allowing them to look around their terrestrial environments for predators and prey.



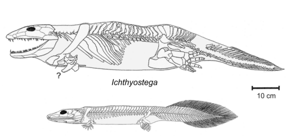
ORIGIN OF TETRAPODS

As lineages moved into shallower water and onto land, the vertebral column gradually evolved as well. You may have noticed that fishes have no necks. Their heads are simply connected to their shoulders, and their individual vertebrae look quite similar to one another, all the way down the body.



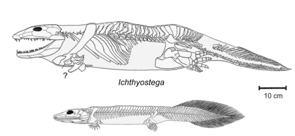
ORIGIN OF TETRAPODS

Mobile necks allow land animals to look down to see the things on the ground that they might want to eat. In shallow water dwellers and land dwellers, the first neck vertebra evolved different shapes, which allowed the animals to move their heads up and down.



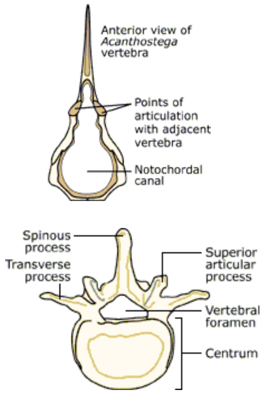
ORIGIN OF TETRAPODS

Eventually, the second neck vertebra evolved as well, allowing them to move their heads left and right. Later tetrapods evolved necks with seven or more vertebrae, some long and some short, permitting even more mobility.



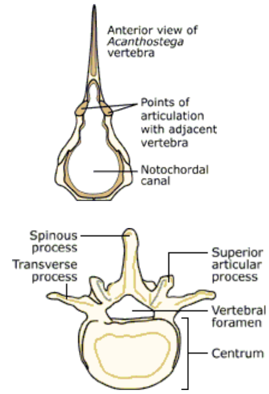
ORIGIN OF TETRAPODS

The vertebrae you are probably most familiar with (like our own!) consist of a spool-like centrum, which connects in front and back with other centra. On top of the centra are vertebral spines and arches to which muscle segments attach, and lateral to the centra are the ribs; these anchor muscles that flex as the animals move.



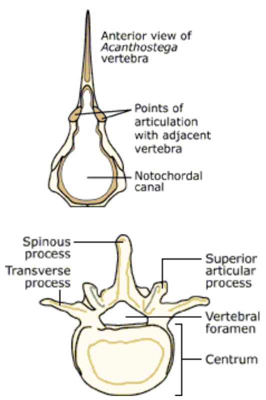
ORIGIN OF TETRAPODS

Fishes swim with simple lateral motions, so their arches are relatively straight and needle-like, and so are their ribs. When you eat fish and pick out the bones, these are mostly what you're finding.



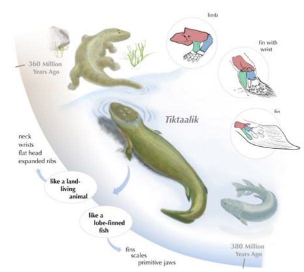
ORIGIN OF TETRAPODS

Because fishes live in the water, gravity is not a big problem for them. But on land, a quadruped with a backbone between forelimbs and hindlimbs developed.



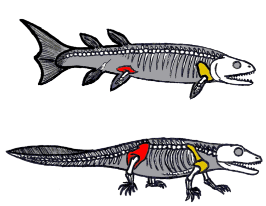
ORIGIN OF TETRAPODS

As the fleshy-finned organisms began to venture onto land, they evolved a series of interlocking articulations on each vertebra, which helped them overcome the difficulty of interconnecting and hold the backbone straight with minimal muscular effort.



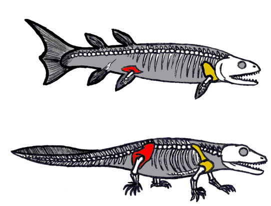
ORIGIN OF TETRAPODS

The connection between the pelvis and hindlimbs in early tetrapods is a prime example of expatiation. We call this fused connection the sacrum. It is extremely useful for terrestrial organisms because it allows them to use their hindlimbs efficiently for locomotion on land.



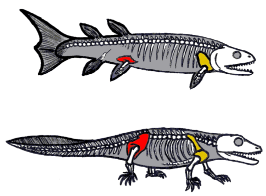
ORIGIN OF TETRAPODS

Since the aquatic ancestors of fishes and tetrapods had no such connection, one might guess that this feature first evolved serving the function of enabling terrestrial locomotion. However, the earliest form of this connection (as seen in Acanthostega) evolved while these tetrapod precursors were still living in the water.



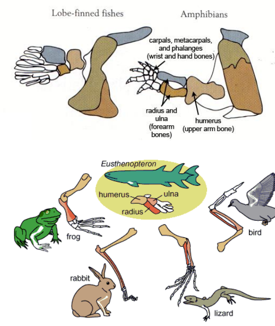
ORIGIN OF TETRAPODS

Based on current evidence, Acanthostega appears to have been fully aquatic, so this connection likely evolved to function in something other than terrestrial locomotion. Only later, as tetrapod ancestors moved onto land, was this trait co-opted for terrestrial support — and as it was, additional vertebrae were fused in the same way, providing further support.



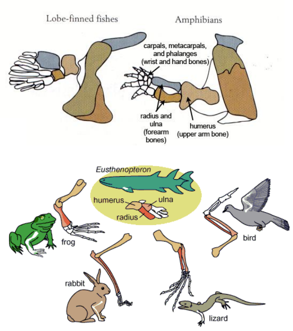
ORIGIN OF TETRAPODS

As the limbs and their connections to the rest of the skeleton evolved, limb bones took on distinct roles and many bones were lost. The humerus and the femur were already connected to two outer bones (the radius and ulna in the forelimb, the tibia and fibula in the hindlimb).



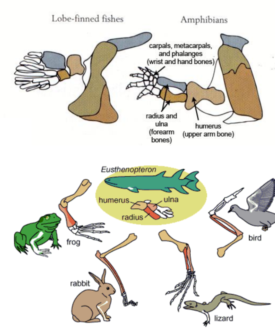
ORIGIN OF TETRAPODS

This is something that evolved about 30 million years before vertebrates came onto land. However, muscular connections between these bones began to change on the road to land and allowed the limbs to be used for terrestrial locomotion.



ORIGIN OF TETRAPODS

The ankle was originally composed of many small bones arranged in two rows, but gradually many of these small bones were lost. The first animals to get close to walking on land had eight digits on each limb. Over time, some of these digits were lost, leading to animals with seven digits, then six, and then five, which is the common condition now seen in living tetrapods.



ORIGIN OF TETRAPODS

As these animals evolved to live on land, other changes in the rest of their bodies evolved. Many would eventually lose their gills, which only work well for getting oxygen when wet, and their tail fins got smaller. Similarly they lost the lateral line system, a network of vibration-sensitive canals along the skull and jaw, which doesn't work out of water.

ORIGIN OF TETRAPODS

General adaptive changes (External):

- Skin is keratinized
- Scales and shells in reptiles
- Feathers in birds
- Hairs and layer of fat in the skin of mammals

General adaptive changes (Internal):

- Development of large intestine for re-absorption of water from waste food material
- Breathing by nostrils
- Modified eye and ear and nostrils
- Eggs became shelled, embryos covered with fetal membranes

Thank you

31

VERTEBRATE ZOOLOGY

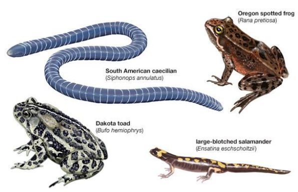
LAND VERTEBRATES

CLASS AMPHIBIA

By
Dr. K. S. Goudar

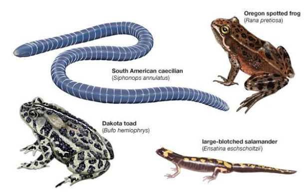
GENERAL CHARACTERS

- Aquatic or semiaquatic (freshwater), air and water breathing, carnivorous, cold-blooded, oviparous, tetrapod vertebrates.
- Head distinct, trunk elongated. Neck and tail may be present or absent.
- Limbs usually 2 pairs (tetrapod), some limbless. Toes 5 (pentadactyle) or less. Paired fins absent. Median fins, if present, without fin rays.



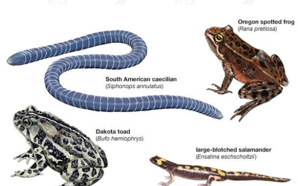
GENERAL CHARACTERS

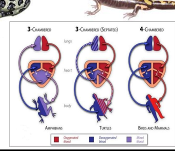
- Skin soft, moist and glandular. Pigment cells (chromatophores) present.
- Exoskeleton absent. Digits clawless. Some with concealed dermal scales.
- Endoskeleton mostly bony. Notochord does not persist. Skull with 2 occipital condyles.
- Mouth large. Upper or both jaws with small homodont teeth. Tongue often protrusible.
- Alimentary canal terminates into cloaca.



GENERAL CHARACTERS

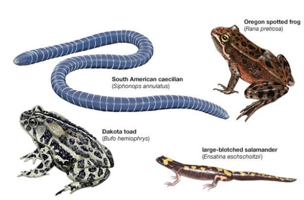
- Respiration by lungs, skin and mouth lining. Larvae with external gills which may persist in some aquatic adults.
- Heart 3-chambered (2 auricles+1 ventricle). Sinus venosus present. Aortic arches 1-3 pairs. Renal and hepatic portal systems well developed. Erythrocytes large, oval and nucleated. Body temperature variable (poikilothermous).





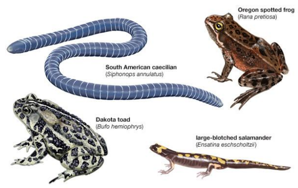
GENERAL CHARACTERS

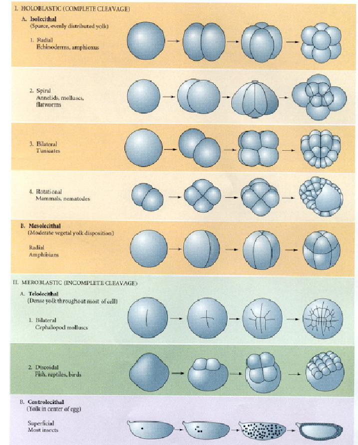
- Kidneys mesonephric. Urinary bladder large. Urinary ducts open into cloaca. Excretion ureotelic.
- Brain poorly developed. Cranial nerves 10 pairs,
- Nostrils connected to buccal cavity. Middle ear with a single rod-like ossicle, columella. Larval forms and some aquatic adults with lateral line system.



GENERAL CHARACTERS

- Sexes separate. Male without copulatory organ. Gonoducts open into cloaca. Fertilization mostly external. Females mostly oviparous.
- Development indirect. Cleavage holoblastic but unequal. No extra-embryonic membranes. Larva a tadpole which metamorphoses into adult.





CLASSIFICATION

The living amphibians are represented by about 2,500 species, a very much smaller number than that of other principal classes of vertebrates. They are classified into two Sub classes. They are

- Stegocephalia (Extinct)
- Lissamphibia (living)

CLASSIFICATION

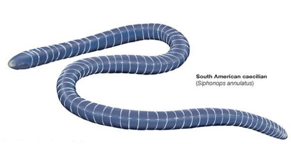
There are three orders in Lissamphibia subclass

- Gymnophiona (A pod or Without foot*)*
- Urodela (Visible tail)
- Anura (Without tail)

CLASSIFICATION

Order 1. Gymnophiona (A pod or Without foot)

- Limbless, blind, elongated worm like, burrowing tropical forms known as caecilians (blind one).
- Tail short or absent, cloaca terminal,
- In some dermal scales embedded in skin which is transversely wrinkled.
- Skull compact, roofed with bone.
- Limb gridles absent.
- Males have protrusible copulatory organs.
- Examples : *Ichthyophis*



CLASSIFICATION

Order 2. Urodela (Visible tail)

- Lizard-like amphibians with a distinct tail.
- Limbs 2 pairs, usually weak, almost equal.
- Skin devoid of scales and tympanum.
- Gills permanent or lost in adult.
- Males without copulatory organs.
- Larvae aquatic, adult-like, with teeth. Ex. Triton

CLASSIFICATION

Order 3. Anura (Without tail)

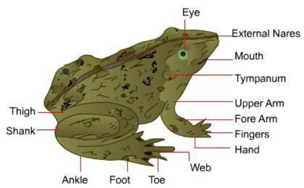
- Specialized Amphibia without tail in adults.
- Hind limbs usually adapted for leaping and swimming.
- Adults without gills or gill openings.
- Eyelids well-formed. Tympanum present.
- Skin loosely-fitting, scaleless; Mandible toothless.
- Pectoral girdle bony. Ribs absent or reduced.

CLASSIFICATION

- Vertebral column very small of 5-9 presacral vertebrae and a slender urostyle.
- Fertilization always external.
- Fully metamorphosed without neotenic forms.
- Ex. frogs and toads

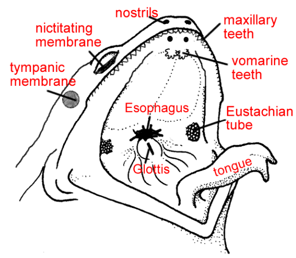
EXTERNAL FEATURES– FROG

Shape: body streamlined for swimming and oval. Flattened dorso-ventrally
Colour: Dorsal surface green with black or brown patches. Ventral surface pale white. Colour changes according to the background.
Exoskeleton: Totally absent so that skin surface is smooth.
Divisions of Body: consists of two regions only head and trunk
Mouth: Large, terminal, semicircular, bounded by hard immovable lips



EXTERNAL FEATURES– FROG

Teeth: Small, conical, backwardly pointed, acrodont, homodont and present only on upper jaw.
Nostrils: Dorsally on snout, small, circular and serve for respiration
Ear openings: No ear openings. Behind each eye present a circular patch of tight skin, the Tympanum, covering the middle ear cavity.
Eyes: Eyes large, dorso-lateral and building. Pupil horizontal. Lower eyelid movable. Nictitating membrane present.



EXTERNAL FEATURES– FROG

Gill-slits: Gill slits found in tadpole larva. Absent in adult.
Vocal sacs: A pair of oval, wrinkled, bluish vocal sacs found ventrally on throat of male frog only
Neck: Absent
Copulatory Organ: Absent
Scrotal sac: Absent
Clocal Apertures: Small, terminal and circular. Abdominal pores absent.
Teats: Absent

EXTERNAL FEATURES– FROG

Limbs: Paired fore and hind limbs present. Digits clawless.. Hand with 4 fingers. Food with 5 toes having webs or transparent skin for swimming.
Lateral lines: Absent in adult. Instead a mid-dorsal line present.
Tail: Present in tadpole larva but absent in adult frog

INTEGUMENT – FROG

Skin surface and attachment: Thin smooth slimy and moist. Loosely attached to body wall due to subcutaneous lymph spaces below dermis.

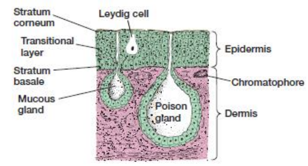
Colour: Dark green on the back and limbs with black and brown patches and streaks but on the ventral side pale yellow.

Ability to change in colour: skin colour changes to harmonise with the surroundings – a protective measure.

INTEGUMENT – FROG

Epidermis: Many layered epithelial cells which are stratified. Stratum corneum of thin, flat and dead keratinized cells which sheds in patches.

Dermis: Consists of outer loose stratum spongiosum having loose connective tissue, blood vessels and lymph space, and an inner stratum compactum having dense connective tissue layer with horizontal and vertical strands. Pigment cells also present in dermis.



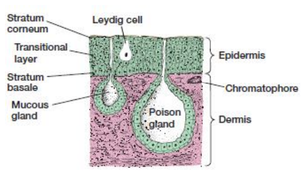
INTEGUMENT – FROG

Pigmentation: Pigment cells chromatophores are located in the upper portion of dermis.

Glands: Multi-cellular mucus gland cells in stratum spongiosum which open at the surface of epidermis.

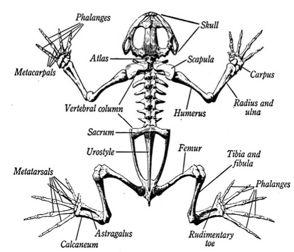
Exoskeleton: Absent.

Function: Protective, sensory , gives texture to body. Respiration structure because permeable to water



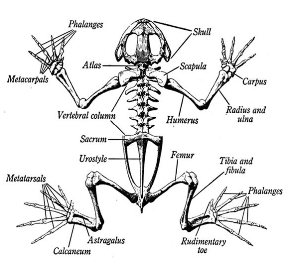
SKELETAL SYSTEM – FROG

- Well developed endoskeleton of bone and cartilage
- Are specilized for jumping and swimming
- Flexible characteristics of vertebral column was lost because anurans move with limbs rather than swimming.
- Vertebrae ranges from 9 to 285.
- Skull is lighter in weight, less ossified flattened in profile.
- Front skull is well developed than back of the skull



SKELETAL SYSTEM – FROG

- Limbs are having three joints (Hip, Knee and Ankle; Shoulder, Elbow and wrist).
- Radius and ulna in the forelimbs are articulated helps them to jump efficiently.
- Tibia and Fibula of the hind limbs are articulated as well.
- Hind limbs are larger than forelimbs.



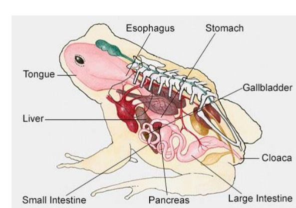
DIGESTIVE SYSTEM – FROG

Major parts of alimentary Canal:

1. Buccal cavity
2. Pharynx
3. Oesophagus
4. Stomach
5. Intestine
6. Cloaca

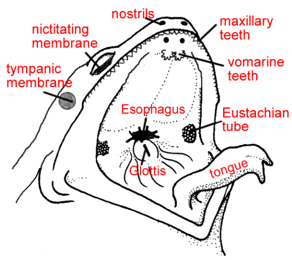
Mouth opening: Terminal along anterior end of head. Large, semicircular, slit-like bounded by jaws.

Jaws and lips: Lower jaw movable. Lips hard, immovable, scaleless.



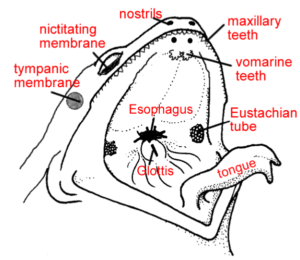
DIGESTIVE SYSTEM – FROG

Function of Teeth: Teeth small, conical, attached to bones and present on upper jaw only in a single row
Buccal cavity: Large, wide and shallow.
Vestibule: Absent
Palate: Absent. Skull forms roof of buccal cavity.



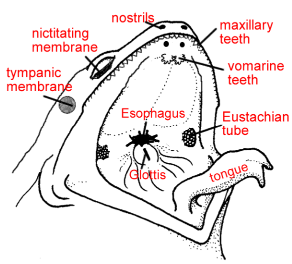
DIGESTIVE SYSTEM – FROG

Tongue: Large, muscular, sticky. Anterior end attached. Posterior end free bifid, highly protrusible and used for capturing insect prey. Covered with few taste buds.
Pharynx: Buccal cavity passes without demarcation into a short pharynx.
Gill slits: Spiracles and gill slits absent.
Eustachian Openings: A wide eustachian opening lies on roof, laterally near jaw angle, on either side.



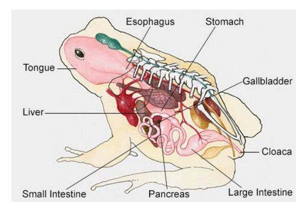
DIGESTIVE SYSTEM – FROG

Glottis: Floor carries a Mucous lining of slit like opening or glottis leading into laryngotracheal chamber.
Epiglottis: Absent
Esophagus: Short, wide, muscular with longitudinal mucous folds highly distensible and not clearly demarcated from pharynx and stomach.



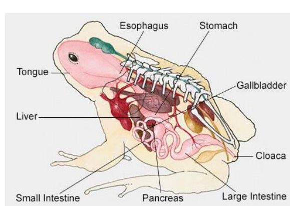
DIGESTIVE SYSTEM – FROG

Stomach: Stomach large, broad, simple, curved, muscular sac, on left side of body cavity. Anterior cardiac and posterior pyloric parts not marked off externally. Blind sac and cardiac valve absent.
Bursa entiana and gizzard: Absent
Intestine: Long, coiled and narrow tube differentiated into small and large intestines.
Small intestine: Duodenum and ileum well marked



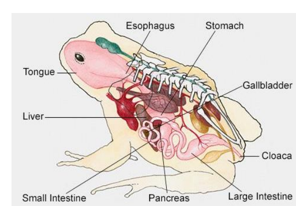
DIGESTIVE SYSTEM – FROG

Duodenum: Straight tube forming U with stomach. Receives bile and pancreatic ducts juice through a common hepato-pancreatic duct.
Ileum: Small and coiled Valves & villi. Mucous lining forms several longitudinal folds, but spiral valves and villi are absent.
Caecum: Absent
Vermiform Appendix: Absent
Large Intestine: it forms a short but broad rectum opening into cloaca



DIGESTIVE SYSTEM – FROG

Cloaca, abdominal Pores: Rectum opens through anus into a single sac like cloaca, also containing Urinogenital apertures. ***Anal sphincter present*** but ***abdominal pores and bursa Fabrici absent.***
Cloacal Aperture: Cloaca opens at the hind end of trunk between hind limbs through a circular cloacal aperture



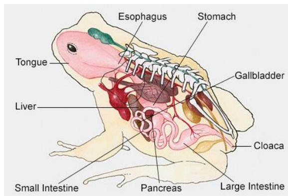
DIGESTIVE SYSTEM – FROG

Mucous glands: Present in internal epithelial lining of bucco-pharyngeal cavity and esophagus. Secrete mucus to lubricate passage of food.

Salivary glands: Absent

Gastric glands: Present in stomach lining secreting pepsinogen and HCl.

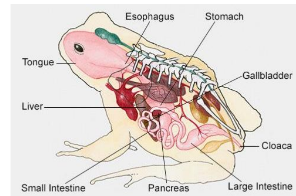
Pancreas: Much branched, irregular, cream coloured gland lying between stomach and duodenum.



DIGESTIVE SYSTEM – FROG

Liver: Large, reddish brown and 3- lobed : right, left and median. Gall bladder: Large, spherical, greenish, situated ventrally between two main liver lobes.

Bile ducts: Bile duct passes through pancreas, receiving pancreatic ducts. Thus a combined hepatopancreatic duct opens into duodenum.

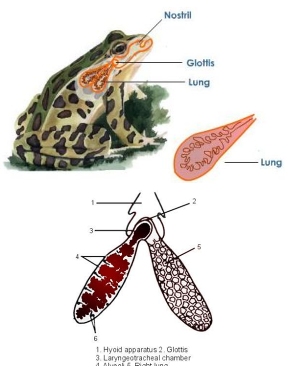


RESPIRATORY SYSTEM – FROG

Type of Respiration: *Amphibious,* i.e., aquatic as well as aerial, as it lives both on land and in water.

Parts of respiratory Tract: **i**ncludes external nares, nasal chambers, internal nares, bucco-pharyngeal cavity, glottis and laryngotracheal chamber. Gill slits and gill pouches absent.

Passage of Air: Air enters through external nares and leaves also through them. Mouth not used for entry of air.



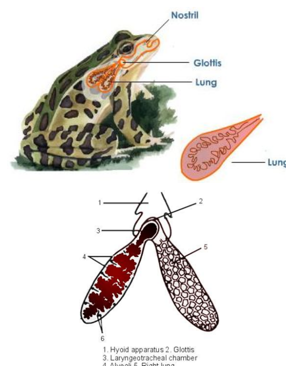
(A) Structure of lung

RESPIRATORY SYSTEM – FROG

External nares: Dorsal on tip of snout. Small, circular apertures without valves. Used in respiration.

Glottis & Epiglottis: Floor of pharynx carries a median slit-like aperture or glottis leading into laryngo – tracheal chamber. Epiglottis absent.

Larynx and Trachea: Fused forming a laryngo-tracheal chamber containing vocal cords. Thyroid cartilage absent.



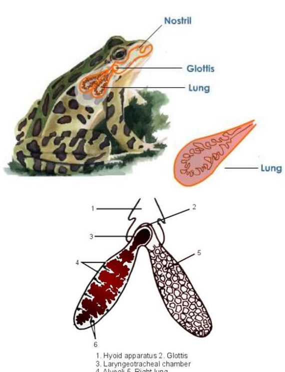
(A) Structure of lung

RESPIRATORY SYSTEM – FROG

Respiratory Organs: Gills present in tadpole larva for aquatic respiration and lungs in adult for aerial respiration.

Gills and gill Clefts: Tadpole larva use gills for aquatic respiration. Gills Later disappear during metamorphosis.

Lungs: 2 lungs, ovoid, thin walled, elastic hollow sacs of pinkish colour, suspended freely inside Peritoneal cavity.



(A) Structure of lung

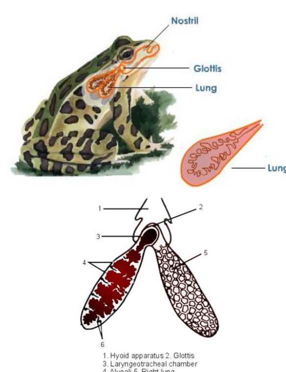
RESPIRATORY SYSTEM – FROG

Alveoli: Alveoli providing surface for gaseous exchange few in number. Therefore central cavity of lungs large.

Air sacs: Air sacs absent.

Buccopharyngeal Respiration: Epithelial lining highly vascular so that bucco- pharyngeal respiration very effective.

Cutaneous Respiration: Moist and richly vascular skin serves efficiently for exchange of gases.



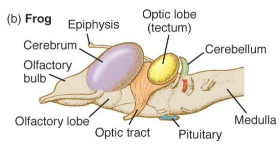
(A) Structure of lung

NERVOUS SYSTEM – FROG

Three fundamental parts of the brain

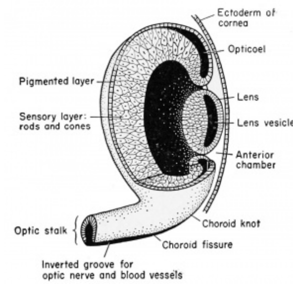
- Forebrain, concerned with the sense of smell;
- Midbrain, concerned with vision;
- Hindbrain, concerned with hearing and balance

Lachrymal glands and eyelids keep eyes moist, wiped free of dust, and shielded from injury



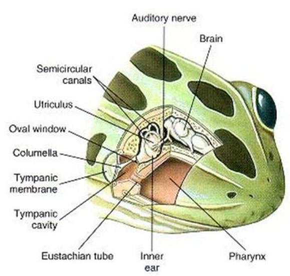
NERVOUS SYSTEM – FROG

- Unlike eyes of most fishes, amphibian eyes at rest are adjusted for distant objects, and the lens is moved forward to focus on nearby objects
- Retina contains both rods and cones, the latter providing frogs with color vision.
- The upper lid of the eye is fixed, but the lower one is folded into a transparent nictitating membrane capable of moving across the eye surface – true for most terrestrial vertebrates



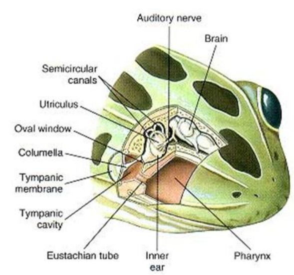
NERVOUS SYSTEM – FROG

- Olfaction is equipped with mucous glands to solve desiccation problem
- The pressure sensitive lateral-line system of fishes remains only in aquatic larvae of amphibians and in a few strictly aquatic adult amphibian species
- In frogs ear a middle ear closed externally by a large tympanic membrane (eardrum and containing a stapes) that transmits vibrations to the inner ear



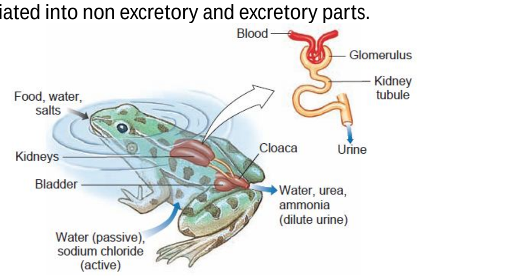
NERVOUS SYSTEM – FROG

- The inner ear has 3 semicircular canals and can produce true sounds
- Taste buds are found on the tongue & palate and able to discriminate salt and sour
- Other sensory receptors include tactile and chemical receptors in skin
- Endocrine system is concern more or less similar with osteichthyes, but there is some advancement
- Parathyroid gland first appeared in this group



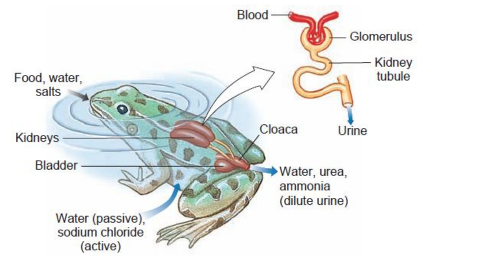
EXCRETORY SYSTEM – FROG

Excretory organs: Consists of a pair of kidneys, a pair of ureters, and urinary bladder and cloaca.
Kidneys: Elongated, oval, flat, attached dorsally one on either side of the vertebral column in posterior abdominal cavity. Not differentiated into non excretory and excretory parts.



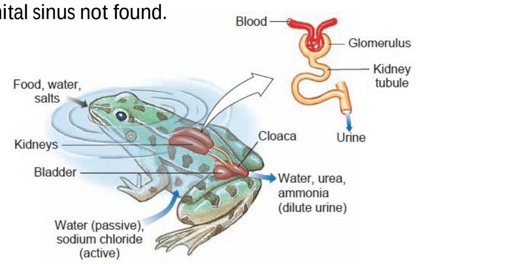
EXCRETORY SYSTEM – FROG

Whole kidney is excretory. It is mesonephric kidney.
Histology: Composed of a compact mass of uriniferous tubules, not differentiated into cortex and medulla and ventrally covered by peritoneum.



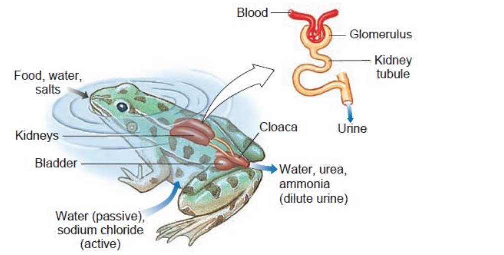
EXCRETORY SYSTEM – FROG

Nephrostomes: Present
Uriniferous tubule or nephrons : Urea absorbing area and loop of Henle not differentiated. Glomerulus helps in urea filtration
Ureters: : Ureters or mesonephric ducts originate and run along outer surface of kidneys and open separately directly into cloaca. Urinogenital sinus not found.



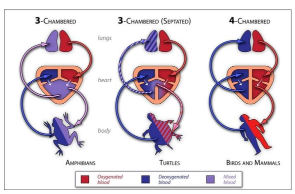
EXCRETORY SYSTEM – FROG

Urinary bladder: Large, bilobed, thin walled elastic urinary bladder opens ventrally into cloaca.
Nature of excretion: Ammonotelic in tadpole stage but ureotelic in adult because nitrogenous wastes are excreted mainly are urea dissolved in water as urine.



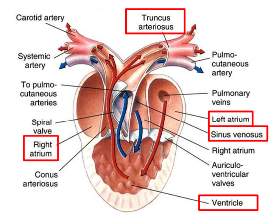
CIRCULATORY SYSTEM – FROG

Position of heart in body: Heart lies midventrally beneath oesophagus in thoracic cavity. Septum transversum is absent.
Pericardium: Heart lies enclosed by a thin, transparent 2-layered sac, the ***pericardium.***
Size, shape and colour: Small, somewhat conical or triangular and reddish in colour.



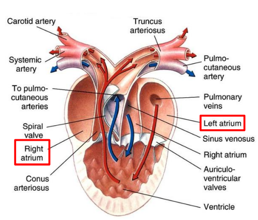
CIRCULATORY SYSTEM – FROG

Chambers: *3-chambered,* made of 2 auricles and 1 ventricle. Auricles not demarcated externally. Besides, sinus venosus and truncus arteriosus also present.
Sinus venosus: Triangular, dark coloured, attached dorsally over auricles and ventricles. Receives venus blood by 3 venae cavae : two anterior ***precavals*** and one posterior ***postcaval,*** joining at its angles



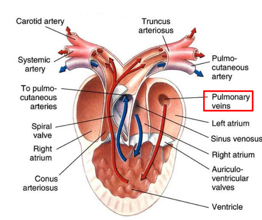
CIRCULATORY SYSTEM – FROG

Sinus-atrial aperture: Sinus opens into dorsal wall of auricle by a large, oval, sinu-atrial aperture guarded by a pair of flaplike ***valves.***
Atria or auricles: Auricles somewhat rectangular. Do not form auricular appendages. Internally divided completely into right and left auricles by an ***interauricular septum.***



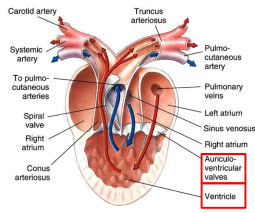
CIRCULATORY SYSTEM – FROG

Atrial wall: Thin walled, without muscular processes.
Auricular appendix: Absent
Pulmonary veins: A common pulmonary vein opens into left auricle.



CIRCULATORY SYSTEM – FROG

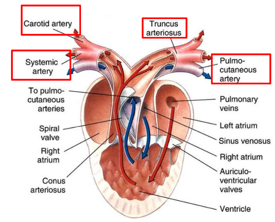
Auriculoventricular aperture & valves : Both auricles open into ventricle posteriorly through a common large auriculo-ventricular aperture guarded by 2 pairs of flaplike valves.
Ventricles: Small, conical, thick walled undivided chamber lying posterior to auricles. No ***interventricular septum.***



CIRCULATORY SYSTEM – FROG

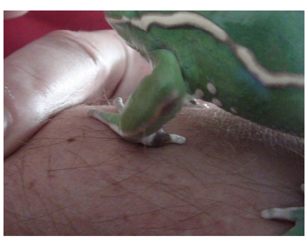
Aortic arches: Truncus bifurcates anteriorly into right and left trunks each dividing into 3 aortic arches : ***common carotid, systemic*** and ***pulmocutaneous.***

Working: Heart receives venous as well as oxygenated bloods. It supplies mixed blood to different regions of body. Called ***transitional heart*** with a ***single circulation.***



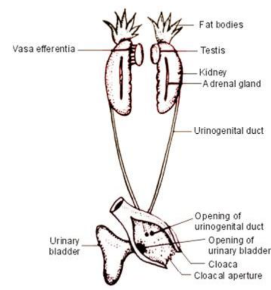
REPRODUCTIVE SYSTEM– FROG

Sexual dimorphism: Indirect but during breeding season male frog develops nuptial pad at the base of first finger to clasp the female frog in amplexus



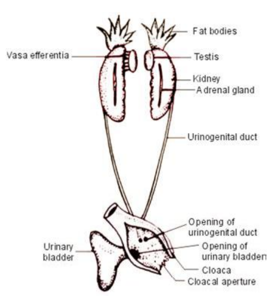
REPRODUCTIVE SYSTEM– FROG

Male reproductive system: consists of pair of testes, vasa efferentia, paired urinogenital ducts and cloaca.
Testes: small, rod like, oval bodies, yellowish in colour attached to antero-ventral surface of kidneys.
Scrotal sacs: Absent
Vasa efferentia: emerge from inner end of testis and enter kidney to join Bidder's canal which opens into urinogenital duct.
Epididymis: Not found



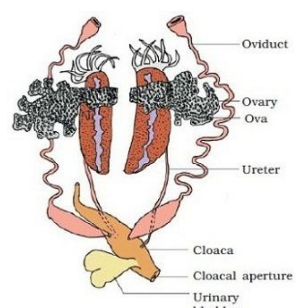
REPRODUCTIVE SYSTEM– FROG

Vasa deferentia: vas deferens of each side unite with the ureter of its side to form urinogenital duct which opens separately in the roof of cloaca.
Seminal vesicle: Terminal part of urinogenital duct enlarges to form seminal vesicle.
Sperm sacs: Not found.
Copulatory organs: No copulatory organs



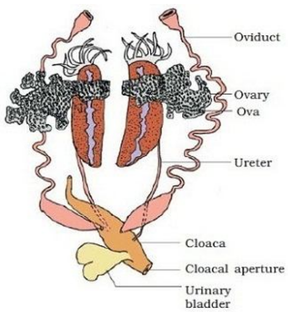
REPRODUCTIVE SYSTEM– FROG

Female reproductive system: consist of a pair of ovaries, oviducts and cloaca.
Ovaries: Paired, large, irregular, lobulated structures situated near kidneys attached to dorsal abdominal.
Epigonal organs: Not found



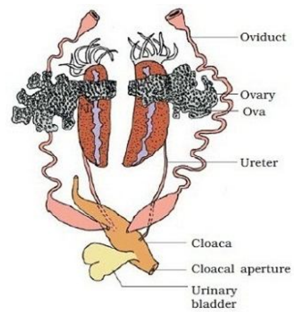
REPRODUCTIVE SYSTEM– FROG

Oviducts: oviducts are very long and much coiled glandular opening behind into cloaca. Their anterior ends possess separate wide oviducal funnels having opening called Ostia at base of the lung.
Shell glands: Not found
Uterus : Uterus is absent but each oviduct is dilated to form ovisac before opening into cloaca.



REPRODUCTIVE SYSTEM– FROG

Vagina and vestibule: vagina and vestibule absent. Ovisacs directly open into cloaca.
Vulva: Absent. Cloaca opens out through a small circular aperture.
Accessory reproductive glands: Not found
Fertilization: external oviparous



Thank you

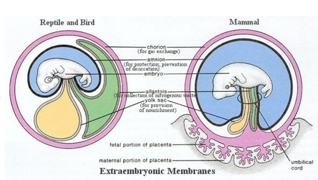
VERTEBRATE ZOOLOGY

AMNIOTES
ORIGIN OF AMNIOTIC EGG AND ITS STRUCTURE
BRIEF EVOLUTIONARY ORIGIN OF REPTILES

By
Dr. K. S. Goudar

ORIGIN OF AMNIOTIC EGG AND ITS STRUCTURE

The origin of the amniotic egg is a fascinating evolutionary problem, but it is still poorly understood because the fossil record does not provide much evidence on this problem. But this type of egg has developed to meet the challenges of dryness as these animals started living on land.



ORIGIN OF AMNIOTIC EGG AND ITS STRUCTURE

Assignment
Draw neat diagram and label the amniotic egg
Explain the role of each embryonic membrane

BRIEF EVOLUTIONARY ORIGIN OF REPTILES

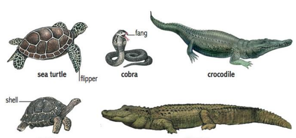
It is generally agreed that primitive reptiles originated from some primitive labyrinthodont (Amphibia) and some labyrinthodont amphibians gradually took on reptilian characters. These earliest reptiles are called the *stem reptiles.* They belong to the order *Cotylosauria* of the subclass *Anapsida.* The transition was so gradual that often it is difficult to decide whether some fossil skeletons are those of advanced amphibians or primitive reptiles.

BRIEF EVOLUTIONARY ORIGIN OF REPTILES

One of the members of the Cotylosauria was *Seymouria,* found in the Lower Permian of Texas (U.S.A.), perhaps 250 million years old. Structure of *Seymouria* was intermediate between the amphibians of that time and the early reptiles.

GENERAL CHARACTERS

- Predominantly terrestrial, creeping or burrowing, mostly carnivorous, air-breathing, cold-blooded, oviparous and tetrapodal vertebrates.
- Body bilaterally symmetrical and divisible into 4 regions—head, neck, trunk and tail.
- Limbs 2 pairs, pentadactyle (5 digits). Digits provided with horny claws. However, limbs absent in a few lizards and all snakes.

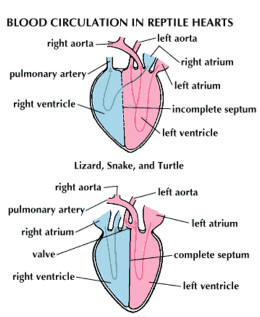


GENERAL CHARACTERS

- Exoskeleton of horny epidermal scales, shields, plates and scutes.
- Skin dry, cornified and devoid of glands.
- Mouth terminal and bear simple conical teeth. In turtles teeth replaced by horny beaks.
- Alimentary canal terminates into a cloacal aperture.
- Endoskeleton bony. Skull with one occipital condyle (monocondylar).

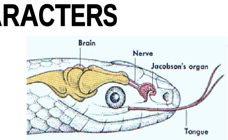
GENERAL CHARACTERS

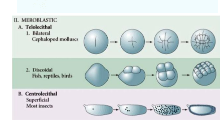
- Heart usually 3-chambered, 4-chambered in crocodiles. Sinus venosus reduced. 2 systemic arches present. Red blood corpuscles oval and nucleated. Cold-blooded.
- Respiration by lungs throughout life.
- Kidneys metanephric. Excretion uricotelic.
- Brain with better development of cerebrum than in Amphibia. Cranial nerves 12 pairs.

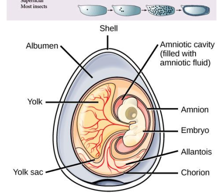


GENERAL CHARACTERS

- Lateral line system absent. Jacobson's organs present in the roof of mouth, helps in moisture-borne odour particles detection.
- Sexes separate. Male usually with muscular copulatory organ.
- Fertilization internal. Mostly oviparous. Large yolky meroblastic eggs, always laid on land. Embryonic membranes (amnion, chorion, yolk sac and allantois) appear during development. No metamorphosis. Young resemble adults.
- Parental care usually absent.



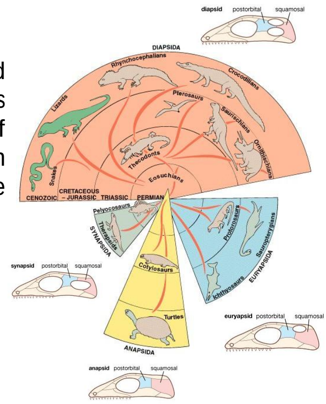




CLASSIFICATION

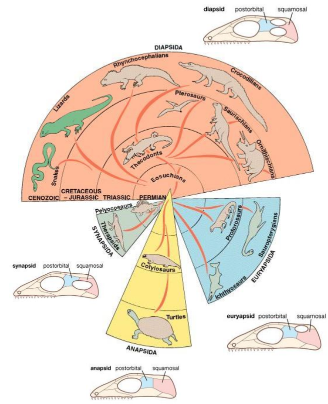
The class Reptilia is divided into *subclasses on the* basis of presence or absence of certain openings through the temporal region of the skull.

- Anapsida - Primitive reptiles with a solid skull roof. No temporal openings.(Ex. Turtles)



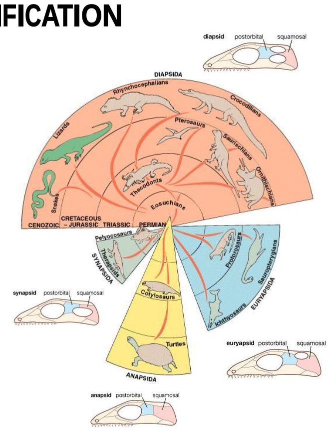
CLASSIFICATION

- Diapsida - Skull with two temporal openings on either side, separated by the bar of postorbital and squamosal bones.(Ex. Tautora, Snakes, lizards and crocodiles)



CLASSIFICATION

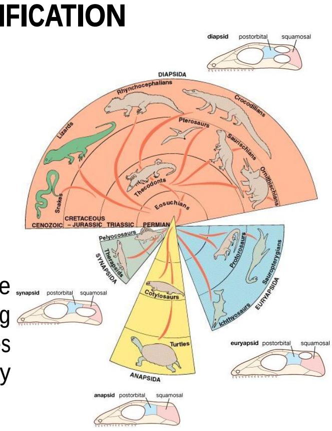
- Synapsida - Skull with a single lateral temporal opening on either side bounded above by the postorbital and squamosal bones. (Mammals like animals)



CLASSIFICATION

- Euryapsida Skull with a single dorso-lateral temporal opening on either side, bounded below by postorbital and squamosal bones (Extinct animals)

But we will see some general characters of living animals they are categories into different orders. They are

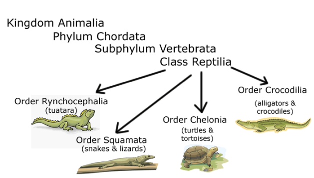


CLASSIFICATION

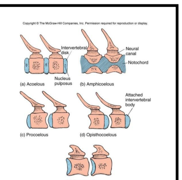
Order Rynchocephalia

(Snout head):

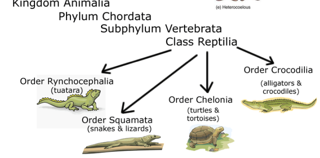
- Body small, elongated and lizard like
- Limbs pentadactyle, clawed and burrowing
- Skin covered by granular scales and mid-dorsal row of spines.
- Skull diapsid. Nasal openings Parietal foramen with vestigeal pineal eye present. Quadrate is fixed.



CLASSIFICATION

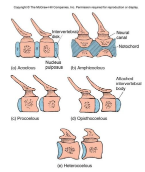


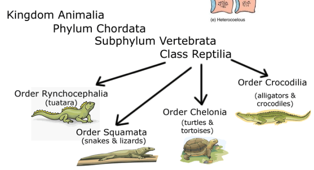
- Vertebrae amphicoelous or biconcave. Numerous abdominal ribs present.
- Teeth acrodont.
- Heart incompletely 4-chambered.
- No copulatory organ in male.



CLASSIFICATION

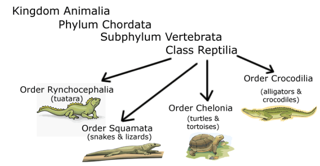
- **Oder Squamata** (Scaly animal):
- Advanced, small to medium, elongated.
- Limbs clawed, absent in snakes and lizards.
- Exoskeleton of horny epidermal scales, shields and spines.
- Skull diapsid. Quadrate movable.
- Vertebrae procoelous. Ribs single—headed.





CLASSIFICATION

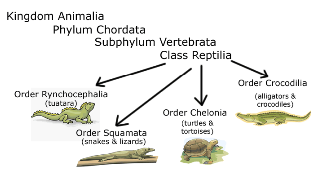
- Teeth acrodont or pleurodont.
- Heart incompletely 4-chambered.
- Cloacal aperture is transverse.
- Male with eversible double copulatory organs
- (hemipenes).



CLASSIFICATION

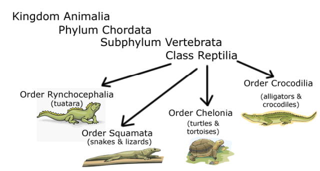
Order Chelonia (Turtle):

- Body short, broad and oval.
- Limbs clawed and/or webbed, paddle-like.
- Body encased in a firm shell of dorsal carapace and ventral plastron, made of dermal bony plates. Thoracic vertebrae and ribs usually fused to carapace.



CLASSIFICATION

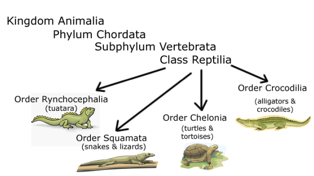
- Skull anapsid, with a single nasal opening.
- No sternum is found.
- Teeth absent. Jaws with horny sheaths.
- Cloacal aperture a longitudinal slit.
- Heart incompletely 4-chambered with a partly divided ventricle.
- Copulatory organ single and simple.



CLASSIFICATION

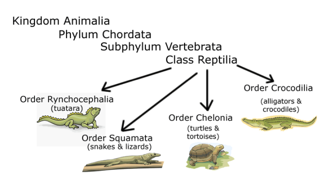
Order Crocodilia (Crocodile):

- Large-sized, carnivorous and aquatic reptiles.
- Tail long, strong and laterally compressed.
- Limbs 'short but powerful, clawed and webbed.
- Skin thick with scales.
- Skull diapsid. A seudopalate present.



CLASSIFICATION

- Ribs bicephalous. Abdominal ribs present.
- Teeth numerous, thecodont, lodged in sockets.
- Heart completely 4-chambered.
- Cloacal aperture is a longitudinal slit.
- Male with a median, erectile, grooved penis.



DIFFERENCES BETWEEN LIZARD AND SNAKE

Lizard

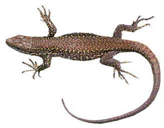
Body elongated, lizard-like.

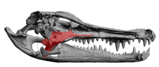
Limbs and girdles usually well-developed.

Eyelids movable. Nictitating membranes present.

Ear openings and tympanum present.

Maxillae, palatines and pterygoids fixed.





Snake

Body slender, narrow, snake like.

Absent, vestigial hind limbs and pelvic girdle in python.

Eyelids fixed. Nictitating membranes absent.

Auditory openings and tympanum lost.

These skull bones freely movable helping in biting mechanism

DIFFERENCES BETWEEN LIZARD AND SNAKE

Lizard

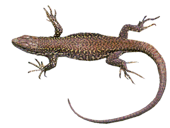
Two rami of mandible firmly united anteriorly. Mouth non-expansible.

Sternum, epistemum and urinary bladder usually present.

Premaxillae bear conical teeth.

Tongue rarely notched or extensile.

Caudal autonomy with regeneration in some.



Snake

Mandibular rami joined by an elastic ligament and can be widely separated during swallowing of large prey.

Sternum, epistemum and urinary bladder usually absent.

Premaxillae are toothless.

Tongue slender, bifid and extensile.

Caudal autonomy does not occur.

DIFFERENCES BETWEEN LIZARD AND SNAKE

Lizard

Both lungs equally developed.

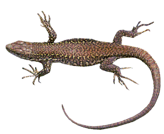
About 3,800 living species.

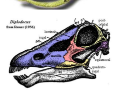
Single occipital condyle.

Jagal bone present.

Cerebral hemispheres are short.

Cranial nerves 12 pairs.





Snake

Left lung greatly reduced.

About 3,000 living species.

Occipital condyle distinctly triple.

Jagal bone absent.

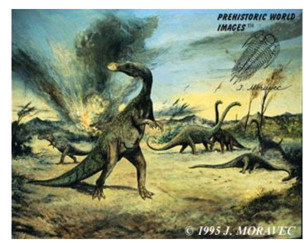
Extremely elongated and project between the eyes.

Cranial nerves 10 pairs only.

EXTINCTION OF DINOSAURS

Extinction of animals is nothing but no longer existing in this world. During cretaceous period there was mass extinction of reptiles. There are several prevailing theories.

Geological & cosmological hazards:
There were many earth quakes, volcanic eruptions and showers of meteors from supernova.

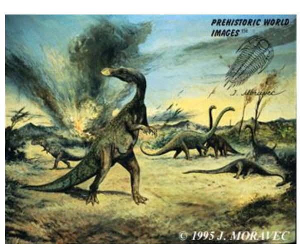


EXTINCTION OF DINOSAURS

Meteor – a piece of rock from outer surface that makes a bright line across the night sky as it burns up while falling through the earth's atmosphere

Supernova – a star that suddenly becomes much brighter b/c it is exploding

But, the question is why other vertebrates survived?



EXTINCTION OF DINOSAURS

Mammals: Mammals used to feed on the egg of dinosaurs (& other giant reptiles)

Epidemic diseases:
Might have occurred and affect those giant reptiles

Fluctuations in climate – The most accepted and supported by paleoclimatologists that birds and mammals could resist this fluctuation (b/c they are homeotherms). However, those large reptiles had no means of regulating their body temperature (since they were poikilotherms). They needed shade to escape extremely hotness or coldness

EXTINCTION OF DINOSAURS

But, how did smaller amphibians and reptiles resist?
Since they were small, they had large surface area to volume ratio; they can hide themselves in small bushes, under stones, etc (have place to escape)

EXTINCTION OF DINOSAURS

Assignment
Enlist the differences between Crocodile and Alligator

Thank you

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VERTEBRATE ZOOLOGY

AMNIOTES

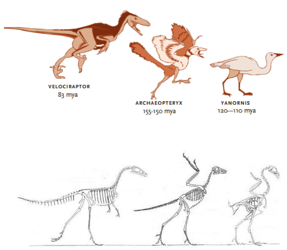
CLASS AVES

THE ORIGIN OF FEATHER AND FLIGHT

By
Dr. K. S. Goudar

THE ORIGIN OF FEATHER AND FLIGHT

Birds are sometimes referred to as reptiles with feathers, but we know nothing about the evolution of feathers from the reptilian scales, although intermediate structures between scale and feather are present on the legs of ostrich and fowl.



THE ORIGIN OF FEATHER AND FLIGHT

THE ORIGIN OF FEATHER AND FLIGHT

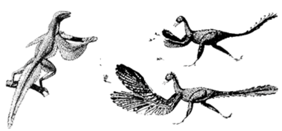
We of course, do not know just how flight evolved in the ancestors of *Archaeopteryx. It* is possible that the ancestors were becoming more active and possibly warm blooded and feathers developed from scales primarily to conserve their body heat. Later, the feathers enlarged on the limbs and the tail probably to confer stability in fast running on ground or in rudimentary gliding from low branches.

THE ORIGIN OF FEATHER AND FLIGHT

Different views have been expressed to explain the origin of flight in birds, starting from either a terrestrial bipedal and cursorial (Adopted for running) ancestor or an arboreal ancestor.

THE ORIGIN OF FEATHER AND FLIGHT

Theory of cursorial origin of flight:
According to this theory, the ancestors of birds were long-tailed, *cursorial, bipedal animals. They were* fast runners who leaped on their strong hind limbs and flapped their forelimbs in air to help them along, as do many modern birds that run fast.



THE ORIGIN OF FEATHER AND FLIGHT

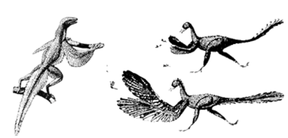
Gradually, the forelimbs enlarged due to fraying out or elongation of scales forming quill-feathers through the processes of mutation and selection. In the end, the forelimbs became organs of flight or wings rather than accessories to rapid running.

THE ORIGIN OF FEATHER AND FLIGHT

Theory of arboreal origin of flight:
The other theory postulates that the ancestral birds were *arboreal creatures* They climbed trees from which they glided to the ground or to other trees, like the modern living squirrels.

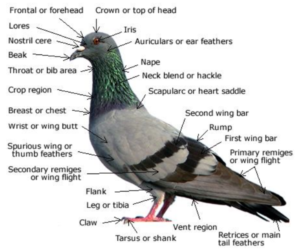
THE ORIGIN OF FEATHER AND FLIGHT

Compromise theory of origin of flight:
Believers in the dual origin of birds, maintain that some birds evolved from arboreal and others from cursorial ancestors.
Theory of division of origin:
This states that pro-aves were aquatic reptiles. Flight might have started in connection with soaring over the water during diving for fishes.



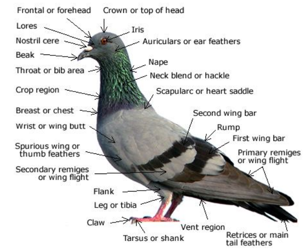
GENERAL CHARACTERISTICS

- Feather- clad, air-breathing, warm-blooded, oviparous, bipedal flying vertebrates.
- *Body is more or less spindle-shaped and* divisible into four distinct regions : head, neck, trunk and tail. Neck is long and flexible. Tail is short and stumpy.



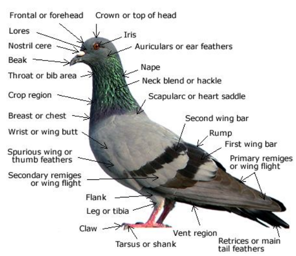
GENERAL CHARACTERISTICS

- Limbs are two pairs. Forelimbs are modified as wings for flying. Hind limbs or legs are large, and variously adapted for walking, running, scratching, perching, food capturing, swimming or wading, etc. Each foot usually bears four clawed toes, of which the first or *hallux* is directed backwards.



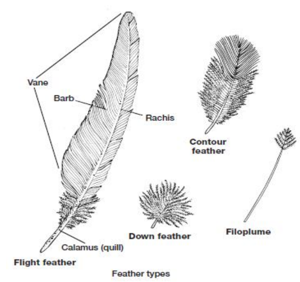
GENERAL CHARACTERISTICS

- Exoskeleton is epidermal and horny, represented by
  1. Feathers forming a non-conducting body covering for warmth,
  2. Scales on the legs, similar to those of reptiles,
  3. Claws on the toes, and
  4. Sheaths on the beaks



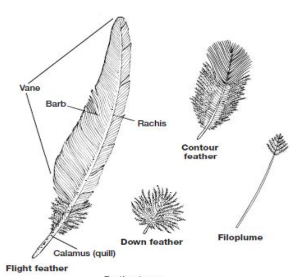
GENERAL CHARACTERISTICS

Feathers are found only in birds and are modified reptilian scales. They are formed from the epidermis in which the stratum corneum is highly specialized.



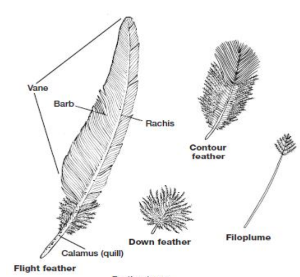
GENERAL CHARACTERISTICS

Feathers are light, strong, elastic and waterproof and show many colours due to pigments and structural arrangement.



GENERAL CHARACTERISTICS

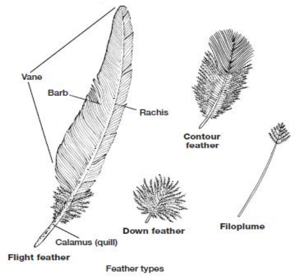
They form a protective covering, regulate body temperature and support the body in flight. There are three kinds of feathers in birds. They are



1. Contour feathers,
2. Down feathers
3. Filoplumes.

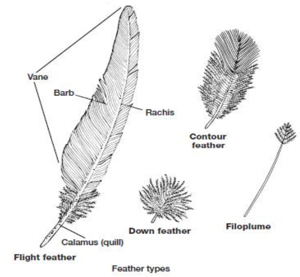
GENERAL CHARACTERISTICS

Contour feathers: The contour feathers occur all over the body. They are of two types. **Flight feathers or quills** are large in size.



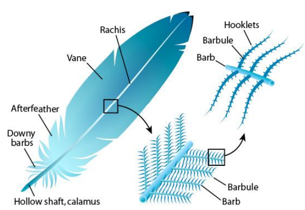
GENERAL CHARACTERISTICS

Those on the wings are remiges (flight feathers) and those on the tail are rectrices (Larger feathers in a bird's tail, used for steering in flight). **Coverts** are smaller in size and cover the body.



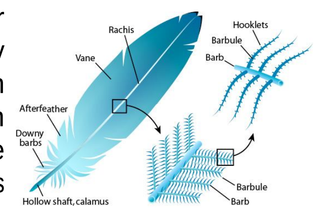
GENERAL CHARACTERISTICS

A contour feather of flight has a stalk or quill. Its basal part called calamus is embedded in the skin. The calamus is hollow and has pith formed from the dry remains of the feather pulp.



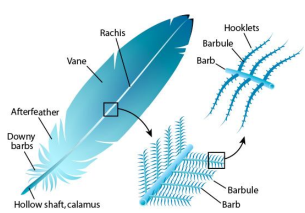
GENERAL CHARACTERISTICS

The rachis bears an expanded vane or vexillum made of many parallel barbs on both sides of the rachis. Each barb is a thin flat plate bearing distal barbules on one side which have many curved hamuli of hooks.



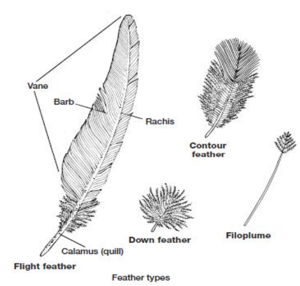
GENERAL CHARACTERISTICS

On the other side each barb has proximal barbules which have grooved edges. Hamuli of distal barbules hook over the grooved edges of proximal barbules binding the barbs together so that the entire vane acts as one flat piece offering resistance to air.



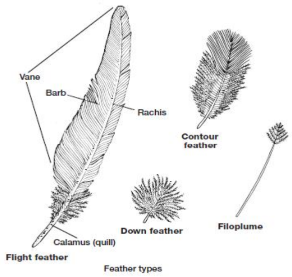
GENERAL CHARACTERISTICS

Coverts are smaller than flight feathers and their hamuli are poorly developed they cover the body wings legs and tail.



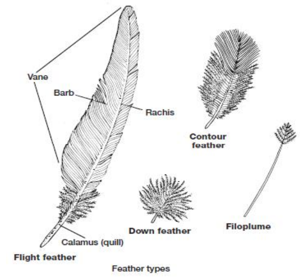
GENERAL CHARACTERISTICS

Down feather or plumule: It has a very small quill having barbs with barbules arising from its tip. They have no hamuli. In an adult the down feathers form powder which powdery fragments are dropped for cleaning the plumage.



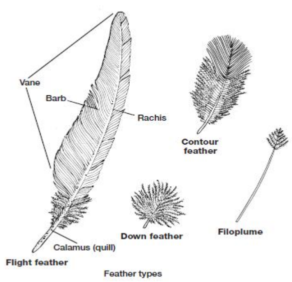
GENERAL CHARACTERISTICS

They are concealed in contour feathers forming a dense layer in which no air movement occurs. So that they do not permit loss of body heat and prevent freezing in clod (a compact mass) upper strata.



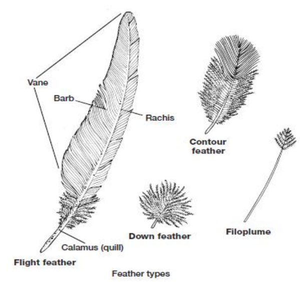
GENERAL CHARACTERISTICS

In a young one the down feathers cover the body and are called nestling down. They appear on the tips of developing feathers and are soon worn off after temporary service on the young ones.



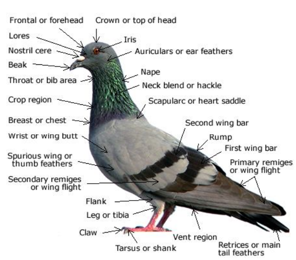
GENERAL CHARACTERISTICS

Filoplumes: Filoplumes are delicate hair like feathers with a long slender stalk having a few terminal barbs with no hamuli they lay among contour feathers.



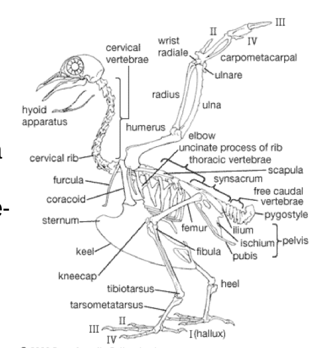
GENERAL CHARACTERISTICS

- Skin is dry and devoid of glands except the oil or preen gland at the root of tail.
- Pectoral muscles of flight are well developed.
- Endoskeleton fully ossified, light but strong. Long bones pneumatic or hollow and have no marrow. Usually, there is a fusion of bones.



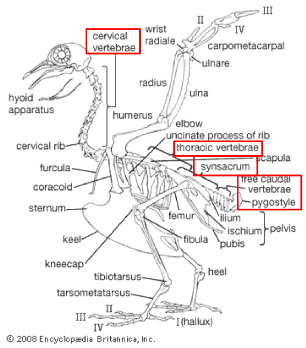
GENERAL CHARACTERISTICS

- Skull smooth and monocondylic, bearing a single occipital condyle. Cranium large and dome-like. Sutures indistinct.
- Lower jaw or mandible consist of 5 or 6 bones.



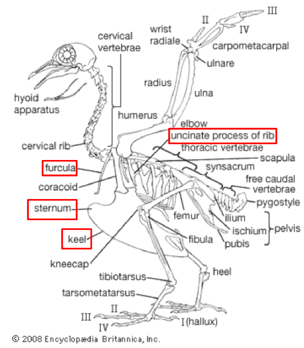
GENERAL CHARACTERISTICS

- Vertebral column short. Central of vertebrae heterocoelous (saddle - shaped).
- Cervical vertebrae numerous, bear small cervical ribs. Some thoracic vertebrae fused together.
- A synsacrum results by fusion of posterior thoracic, lumbar, sacral and anterior caudal vertebrae.
- Tail vertebrae few, compressed laterally and the last 3 or 4 fused into a ploughshare bone, pygostyle.



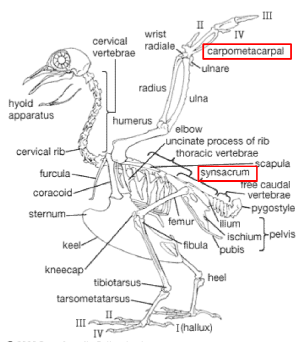
GENERAL CHARACTERISTICS

- Sternum large, usually with a vertical, mid-ventral keel for attachment of large flight muscles.
- Ribs double-headed (bicephalous) and bear posteriorly directed uncinate processes.
- Both clavicles and single interclavicle fused to form a V-shaped bone, called *furcula or wishbone.*



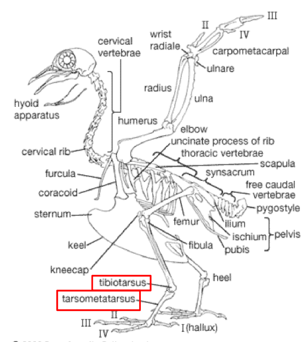
GENERAL CHARACTERISTICS

- Pelvic girdle large, strong and fused with synsacrum throughout its length.
- Proximal carpals free. Distal carpals fuse with three metacarpals to form carpometacarpus



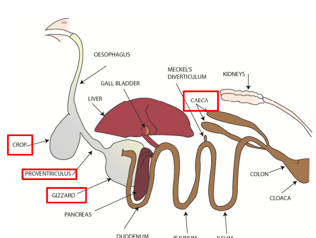
GENERAL CHARACTERISTICS

- Proximal tarsals and tibia fused to form tibiotarsus. Distal tarsals fused with II, III and IV metatarsals to form tarso-metatarsus. metatarsal remains free.



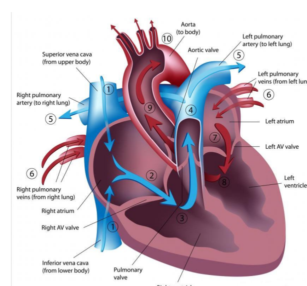
GENERAL CHARACTERISTICS

- Oesophagus is frequently dilated into a crop for quick feeding and storage.
- Stomach divided into a glandular proventriculus and muscular gizzard. Junction of small intestine and rectum marked by a pair of rectal caeca. A three-chambered cloaca present.



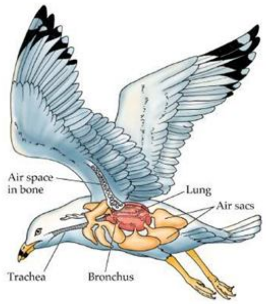
GENERAL CHARACTERISTICS

- Heart completely 4-chambered. There is neither sinus venosus nor truncus arteriosus. Only right aortic (systemic) arch persists in adult. Red blood corpuscles nucleated.



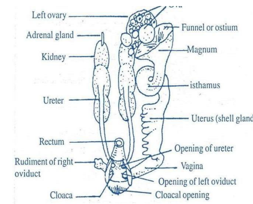
GENERAL CHARACTERISTICS

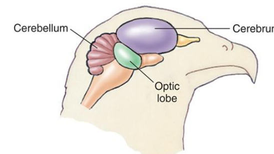
- Birds are the first vertebrates to have warm blood. Body temperature is regulated (homoiothermous).
- Respiration by compact, spongy, nondistensible lungs continuous with thin-walled air-sacs.
- Larynx without vocal cords, A sound box or syrinx, producing voice, lies at or near the junction of trachea and bronchi.



GENERAL CHARACTERISTICS

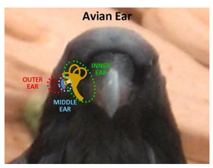
- Kidneys metanephric and 3-lobed. Ureters open into cloaca. Urinary bladder absent. Birds are urecotelic. Excretory substance of urates eliminated with faeces.
- Brain large but smooth. Cerebrum, cerebellum and optic lobes greatly developed. Cranial nerves 12 pairs.

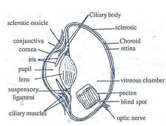


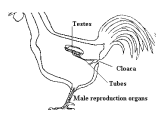


GENERAL CHARACTERISTICS

- Olfactory organs poor. Middle ear contains a single ossicle. Eyes large and possess nictitating membranes, sclerotic plates and a vascular pecten.
- Sexes separate. Sexual dimorphism often well marked. Male has a pair of abdominal testes and a pair of sperm ducts. A copulatory organ absent except in ratites, ducks, geese, etc. Female has a single functional left ovary and oviduct.

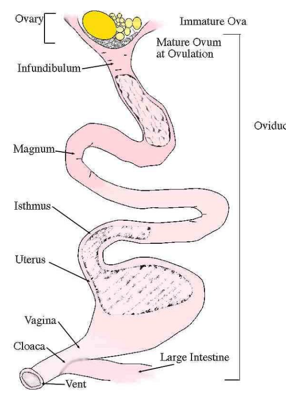






GENERAL CHARACTERISTICS

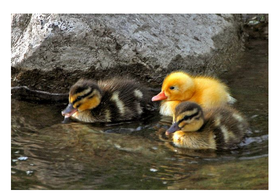
- Fertilization internal, preceded by copulation and courtship. Females oviparous. Eggs large with much yolk and hard calcareous shell.
- Eggs develop by external incubation. Cleavage discoidal, meroblastic. Development direct. Extra-embryonic membranes (amnion, chorion, allantois and yolk-sac) present.



Video

GENERAL CHARACTERISTICS

- Newly-hatched young fully formed (precocial) or immature (altricial).
- Parental care is well marked.



ASSIGNMENT

Draw any one Ethiopian bird and write their classification and salient characteristics features

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Thank you

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VERTEBRATE ZOOLOGY

AMNIOTES

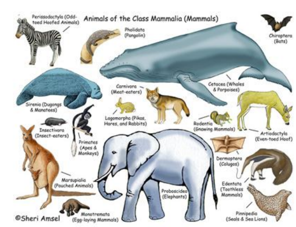
CLASS MAMMALIA

EVOLUTIONARY HISTORY OF THEIR ORIGIN

By
Dr. K. S. Goudar

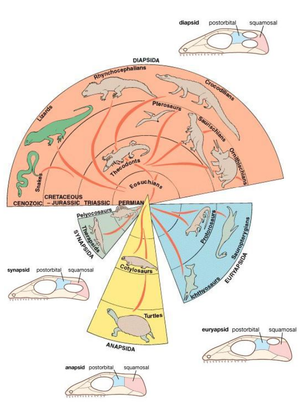
EVOLUTIONARY HISTORY OF THEIR ORIGIN

- Mammals have been thoroughly described and adequately classified. They include approximately 5,000 living species (15,000 subspecies) and numerous fossil forms.
- From the fossil record, we can trace the derivation over 150 million years of endothermic, furry mammals from their small, ectothermic, hairless ancestors



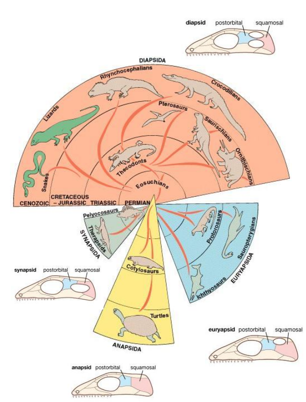
EVOLUTIONARY HISTORY OF THEIR ORIGIN

- Skull structures and especially teeth are the most abundant fossils, and it is largely from these structures that we identify the evolutionary descent of mammals.
- The structure of the skull roof permits us to identify three major groups of amniotes that diverged in the Paleozoic era, the **synapsids, anapsids, and diapsids**



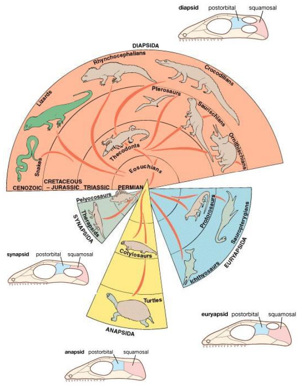
EVOLUTIONARY HISTORY OF THEIR ORIGIN

- The synapsid group, which includes the mammals and their ancestors, has temporal openings in the skull associated with attachment of jaw muscles
- Synapsids were the first amniote group to radiate widely into terrestrial habitats



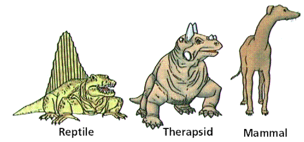
EVOLUTIONARY HISTORY OF THEIR ORIGIN

- The earliest synapsids radiated extensively into diverse herbivorous and carnivorous forms often collectively called **pelycosaurs**
- Pelycosaurs share a general outward resemblance to lizards, but this resemblance is misleading
- Pelycosaurs are not closely related to lizards



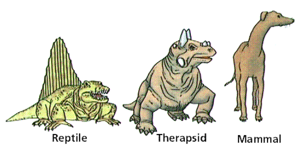
EVOLUTIONARY HISTORY OF THEIR ORIGIN

- From one group of early carnivorous synapsids arose the **therapsids,** the only synapsid group to survive beyond the Paleozoic
- With therapsids we see for the first time an efficient erect gait (walk) with upright limbs positioned beneath the body, rather than sprawled out to the sides of the body, as in lizards and primitive pelycosaurs



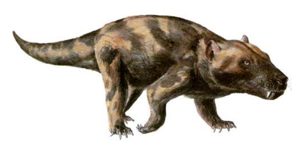
EVOLUTIONARY HISTORY OF THEIR ORIGIN

- Since stability was reduced by raising the animal from the ground, the muscular coordination center of the brain, the cerebellum, assumed an expanded role
- Modifications in the morphology of the therapsid skull and mandibular adductor muscles increased feeding efficiency
- Therapsids radiated into numerous herbivorous and carnivorous forms



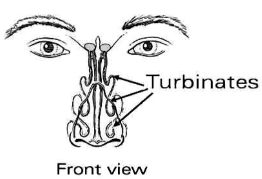
UNIQUE FEATURES OF MAMMALS

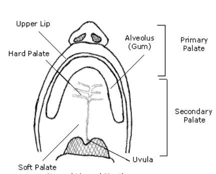
- One therapsid group to survive into the Mesozoic era was the **cynodonts.**
- Cynodonts evolved several features that supported a high metabolic rate:
  - Increased and specialized jaw musculature, permitting a stronger bite;
  - Several skeletal changes, supporting greater agility (Quickness)
  - Heterodont teeth, permitting better food processing and use of more diverse foods



UNIQUE FEATURES OF MAMMALS

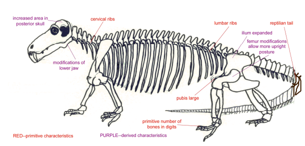
- Turbinate bones, in the nasal cavity, aiding retention of body heat
- A secondary bony palate, enabling an animal to breathe while holding prey in its mouth or chewing food
- The secondary palate would be important to subsequent mammalian evolution by permitting the young to breathe while suckling

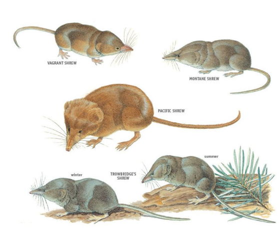




UNIQUE FEATURES OF MAMMALS

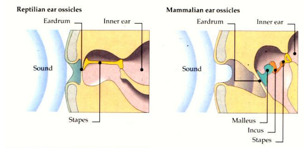
- Loss of lumbar ribs in cynodonts is correlated with the evolution of a diaphragm and also may have provided greater dorsoventral flexibility of the spinal column
- The earliest mammals of the late Triassic period were small mouse- or shrew-sized animals with enlarged crania, redesigned jaws, and a new type of dentition, called diphyodont

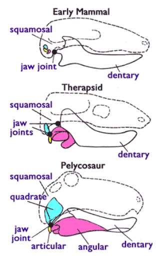




UNIQUE FEATURES OF MAMMALS

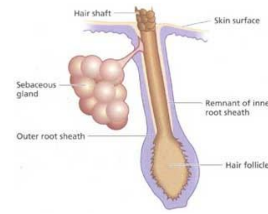
- One of the more amazing transformations involved the three middle ear bones, the malleus, incus, and stapes, which function to transmit sound vibrations in mammals
- A new jaw joint was formed between the dentary and squamosal (temporal) bones.
- This dentary-squamosal joint is the defining characteristic for fossil mammals.





UNIQUE FEATURES OF MAMMALS

- Hair was essential for insulation, and the presence of hair implies that sebaceous and sweat glands must also have evolved at this time to condition hair and to facilitate thermoregulation.

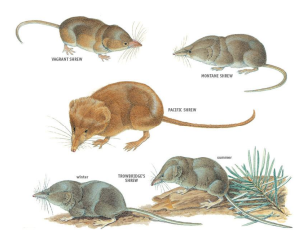


UNIQUE FEATURES OF MAMMALS

- The fossil record is silent on the appearance of mammary glands, but they must have evolved before the end of the Triassic
- The young of early mammals probably hatched from eggs in a very immature condition, totally dependent on maternal milk, warmth, and protection
- This mode of reproduction occurs today only in monotremes (Ex. Platypus)

UNIQUE FEATURES OF MAMMALS

- Mammals survived, first as shrew like, probably nocturnal, creatures.
- Mammalian radiation was almost certainly promoted by the facts that mammals were agile (lively), endothermic, intelligent, adaptable, and gave birth to living young, which they protected and nourished from their own milk supply.



CLASSIFICATION OF MAMMALS

- The main characters forming the basis of their classification into orders include :
  - Mode of caring for their young
  - Nature of dentition
  - Foot posture,
  - Nails, claws and hoofs
  - Complexity of nervous system

CLASSIFICATION OF MAMMALS

i. Subclass Prototheria (Gr. first, wild animal)

- Primitive, reptile-like, oviparous or egg-laying mammals.
- Represented by a single order (3 species): Order Monotremata. Monotremes are mammals that lay eggs (Prototheria) instead of giving birth to live young like marsupials (Metatheria) and placental mammals (Eutheria). Example: duck-billed platypus and spiny anteater

CLASSIFICATION OF MAMMALS

ii. Subclass Theria

- Divided into 2 infraclasses

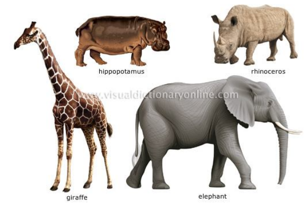
a. Infraclass Metatheria

- Order Marsupialia – Pouched (marsupial) mammals
- Born in a very immature state, and complete their development attached to teats or nipples in the abdominal pouch or marsupium.
- Usually 3 premolars and 4 molars in each jaw on either side
- E.g. Opossum, Wombat, Bandicoots, etc

CLASSIFICATION OF MAMMALS

b. Infraclass Eutheria

- Placental mammals without marsupium
- Young born in a relatively advanced stage
- Dentition never exceeds 3.1.4.3/ 3.1.4.3 = 44.
- Eutherians constitute the vast majority of living mammals arranged in 16 orders



CLASSIFICATION OF MAMMALS

VERTEBRATE ZOOLOGY

VERTEBRATE OF DIVERSITY OF ETHIOPIA

By
Dr. K. S. Goudar

VERTEBRATE OF DIVERSITY

Ethiopia is one of the most physically and biologically diverse countries in the world with unique environmental conditions and varied topography from vast plains to high mountains having an altitudinal range of 110 m below sea level (Kobar sink) in the Afar depression to the highest peak of 4620 m above sea level (asl)(Ras Dashen) in the Siemen Mountains. The country has more than 300,000 km^2 of land area above 2000 m,(asl) and over 25,000 km2 area above 3000 m asl, which forms more than 80 % of all the Afro-Alpine habitat.

VERTEBRATE OF DIVERSITY

The diversity and endemism of Ethiopian fauna are high. It consists of 862 species of birds, 288 species of mammals, 201 species of reptiles, 64 species of amphibians and 150 species of fish. Among these, 31 species of mammals, 17 species of birds, 30 species of amphibians, 9 species of reptiles and 40 species of fish are endemic to Ethiopia (Jacobs and Schloeder, 2001)

VERTEBRATE OF DIVERSITY

Bale Mountains Vervet: This species was previously classified as Data Deficient but is now Vulnerable according to the IUCN (IUCN, 2008). There is no definitive information about population size but the trend is said to be decreasing.

VERTEBRATE OF DIVERSITY

Gelada baboon: The gelada baboon bleeding-heart baboon, is a species of Old World monkey found only in the Ethiopian Highlands, with large populations in the Semien Mountains.

VERTEBRATE OF DIVERSITY

Ethiopian Highland Hare: The Ethiopian highland hare is a species of mammal. It is endemic to the Ethiopian Highlands, where it is almost entirely restricted to altitudes above those of other African hares.

VERTEBRATE OF DIVERSITY

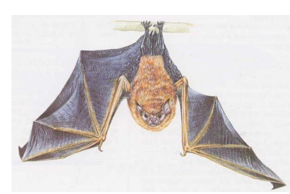
Bale Shrew: The Bale Shrew is a species of mammal. It is endemic to Ethiopia. Its natural habitats are subtropical or tropical moist montane forests and subtropical or tropical high-altitude grassland. It is threatened by habitat loss.

VERTEBRATE OF DIVERSITY

Bale Long-eared Bat (Flaying mammal): This recently described species is endemic to the Ethiopian highlands were it is currently known only with certainty from the upper belts of the Harenna Forest in the Bale Mountains National Park and from Abune Yosef

VERTEBRATE OF DIVERSITY

Ethiopian Woolly Bat (Flaying mammal): It is found only in Ethiopia.



VERTEBRATE OF DIVERSITY

Ethiopian Wolf: The Ethiopian wolf is a canid native to the Ethiopian Highlands. It is distinguished by its long and narrow skull, and its red and white fur

VERTEBRATE OF DIVERSITY

Mountain Nyala: Mountain nyala are endemic to the Ethiopian highlands southeast of the Rift Valley.

VERTEBRATE OF DIVERSITY

Walia Ibex: is an endangered species of ibex. Only about 500 individuals survived in the mountains of Ethiopia, concentrated in the Semien Mountains.

VERTEBRATE OF DIVERSITY

Big-headed Mole Rat: Also known as the giant root-rat, Ethiopian African mole-rat, or giant mole-rat. It is endemic to Ethiopia's Bale Mountains. Its natural habitat is subtropical or tropical high-altitude grassland

VERTEBRATE OF DIVERSITY

Assignment
Enlist the Ethiopian endemic animals(Mammals, Birds, Reptiles, Amphibians and Fishes)

Thank you

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