Comparative Vertebrate Anatomy
Vertebrata **Dr/Ilham alsaleem**

Phylum: Chordata

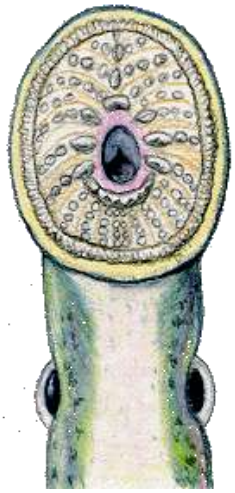
Subphylum: Vertebrata

1-Superclass: Pisces
- Class Agnatha
- Class Placodermii
- Class Chondricthyes
- Class Acanthodii
- Class Osteichthyes

2-Superclass: Tetrapoda
- Class Amphibia
- Class Reptilia
- Class Aves
- Class Mammalia

Class Agnathaعديمة الفكوك

Orders:
1 - **Osteostraci**
2 - Anaspida
3 - Thelodonti
4 - Galeaspida
5 - Pituriaspida
6 - **Petromyzontia (lampreys)**
7 - Myxinoidea (hagfishes)



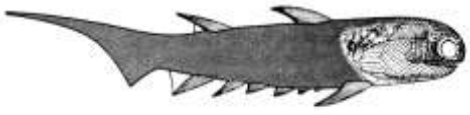
Order : (Osteostraci, Anaspida,
1 - extinct Paleozoic (Cambrian to Devonian) jawless fish with an external skeleton of bone ('bony armor')
2 - oldest known vertebrates
3 - many had flattened appearance (some may have been bottom-dwellers)
Order :petromyzontia :**Lampreys - parasitic with horny, rasping**خشنة **teeth**

Order Myxinoidea :**Hagfishes** - primarily scavengers

Gnathostomes ذوات الفكوك

All the rest classes of pisces are gnathostomes

Class: Acanthodians: قرشيات شوكية
1 - earliest known **gnathostomes**



2 - *probably* related to modern bony fishes

3 - small (less than 20 cm long) with large eyes

4 - **Acanthodians** most likely died out because of the rapidly increasing number of ray-finned fishes and sharks during the **Permian** العصر القديم

Class :Placodermii:

1 - probably off the main line of vertebrate evolution

2- many had bony dermal shields

3 - some were probably predators (with large, sharp 'tooth plates')

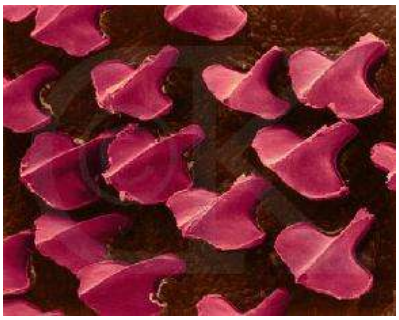
Placoderms :were armoredمدرعة jawed fishes . Placoderms (= plated skin) were named for their heavy armor of dermal bone, which formed large shieldsدروع on the head and thorax. The rest of their bodies was covered with small bony scales or was without dental armor. The head and trunk shields of most placoderms were articulated by bony joints. This joint apparently allowed the forward part of the skull to tilt امالةup, increasing the gape فتحة الفم. Placoderms lacked teeth, but biting or grinding structures are often be found in the dermal bones lining their mouths. Placoderms evolved تطورتinto a variety of body forms in a relatively short time. Many were torpedo-shaped,. Most placoderms were less than 30 cm (2 feet) in length, but some members of the dinichthyids (= terrible fish) reached or exceeded 6 m (20 ft), making them the first giants of the vertebrate lineage.

Class Chondrichthyes - cartilaginous fishes

1 – ancestors اسلافها had bony skeletons so cartilaginous skeleton is specialized

2 - pelvic fins of males are modified as claspers مشبك

3 - placoid scales حراشف ابرية



4 - Numerous today but more abundant وفيرة in the past

Subclass :Elasmobranchii - most common cartilaginous fishes

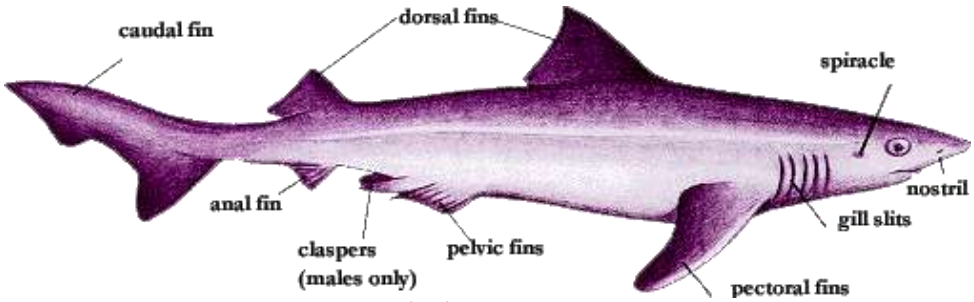
1 - 1st pharyngeal slit modified as a spiracle شقوق

2 - naked gill slits (no operculum)

3 - mouth located ventrally

Order. **selachii** - sharks

Order. **Batoidea** - rays & skates القوبعيات



Order : **Holocephali** كاملة الراس

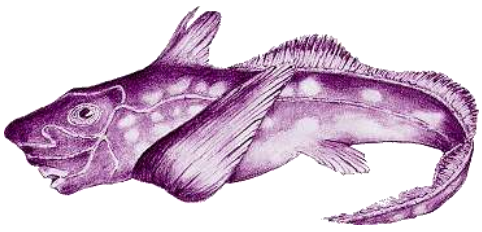
Chimaera سمكة الكايميرا

1-marineبحرية

2-gill slits have a fleshy operculumغطاء غلصمي & the spiracle is closed

3-few scales

4-common ancestor with sharks



Subphylum :vertebrata

Class :Osteichthyes - الاسماك العظمية bony fishes

1 - Skeleton is partly or chiefly bone

2 - Gill slits are covered by a bony operculum غطاء غلصمي

3 - Skin has scales with, typically, little bone

4 - Most have a swim bladder (كيس العوم) بداية رئة

5 - Ray-finned or lobe-finned زعانف شعاعية او زعانف مفصصة

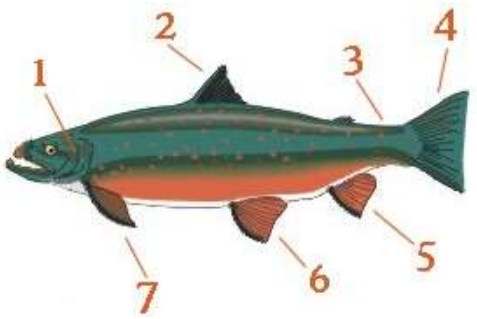
Subclass : **Actinopterygii** - ray-fins

order : **Chondrostei غضروفية التعظم**

- most primitive ray-fins
- include present-day **Sturgeons & Paddlefish** (below) الاسماك المجذافية

order: Teleostei : modern ray-finned fishesطرفية التعظم

- recent bony fishes
- 95% of all living fish
- about 40 living orders
- well-ossified skeleton
- cycloid & ctenoid scales (flexible & overlapping)
- pelvic fins often located far forward
- no spiracle لا تحتوي شق تنفسي



1 = operculum, 2 = dorsal fin, 3 = caudal peduncle (The narrow section of a fish's body directly

anterior to the insertion of the tail but before the mid-body.), 4 = caudal fin or "tail", 5 = anal fins, 6 = pelvic fins, & 7 = pectoral fins)

Subclass **Sarcopterygii - lobe-finned fishes فصية او لحمية الزعانف**

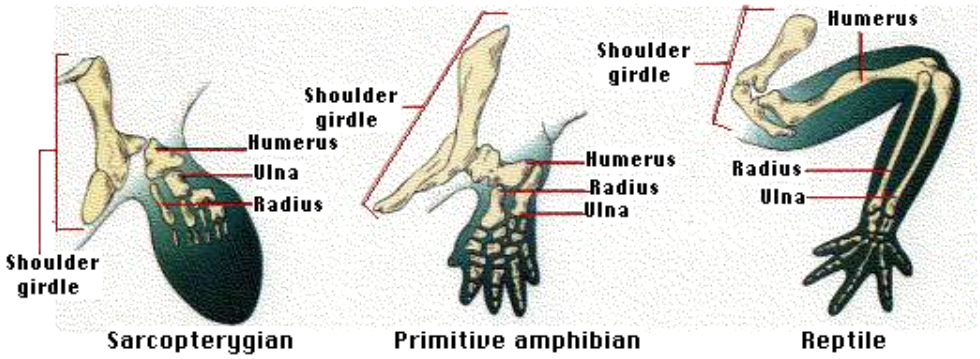
Order**: Crossopterygii مفصصة الزعانف-**

1 - resemble early amphibians مشابهة للانواع الاقل تطورا في البرمائيات

2 - skeleton of **fin lobe** corresponds closely to proximal skeletal elements of early tetrapod limbs

3 - skull similar to that of early amphibians

4 - had swim bladders that may have been used as lungs



Order: Dipnoi الاسماك الرئوية- lungfish (3 living genera; Africa, Australia, & South America)

1-African & South American species have inefficient gills & will drown تغرق if held under water

2-Australian species (***Neoceratodus*** spp.) relies on gills unless oxygen content of water is too low

Superclass: Tetrapoda

Class Amphibia

Oldest known = **subclass**: **Labyrinthodontia**

Fish-like features:

1- small bony scales in the skin

2- fin-rays in the tail (for swimming)

3- a skull similar to that of some Crossopterygians

4- a sensory canal system (like the lateral line system) that indicates a primarily aquatic existence

Labyrinthodonts ذات الاسنان الغشائية are distinguished by deeply folded structure of enamel المينا and dentine عاج layers in the teeth, that look like an intricate معقد labyrinth in the cross section, hence the name of this group. Labyrinthodonts were probably similar to fishes in their mode of living. Labyrinthodonts, like fishes and most modern amphibians, laid eggs in the water, where their larvae developed into mature animals. All labyrinthodonts had special sense organs in the skin. Moreover, some of them possessed well developed gills. The most diverse group of the labyrinthodonts was the **batrachomorphs** ('similar to a frog'). Though these animals looked more like **crocodiles,** they most probably gave rise to the order **Anura** اللاذيليات, the amphibians without tails, which include, in particular, the modern frogs.

Class:Amphibia

Subclass Lepospondyli

- ancestry uncertain due to lack of fossil evidence
- probably on a 'side branch' of vertebrate evolution

Subclass Lissamphibia - modern amphibians

Order. **Anura** عديمة الذنب- frogs & toads

Order. **Urodela** - tailed amphibians الذيليات

Order. **Gymnophiona** شبيهة الافاعي (apodans) عديمة الارجل - wormlike, burrowing amphibians البرمائيات الحفارة

Modern amphibian (Lissamphibia) characteristics:

1 - Aquatic larval stage with external gills

2 - Middle ear cavity with **ear** ossicle عظيمة(columella) عميد

3 - No bony scales (except apodans)

Class Reptilia - the first amniotes:

1 - Scaly لها حراشف

2 - Clawed لها مخالب

3 - Large, yolk-laden كثيرة المح, shell-covered eggs laid on land

Reptile Subclasses:

Subclass: **Anapsida**

Order. **Cotylosauria** - stem reptiles

Order. **Chelonia** - turtles & tortoises. Have these characteristics:

- unchanged for about 175 million years
- identified by bony dermal plates to which ribs & trunk vertebrae are fused

Subclass: **Lepidosauria**

Order. **Rhynchocephalia خطمية الراس** (Sphenodonta) - only living representative is the **Tuatara** المتحجر الحي

Order: **Squamata** - lizards, geckos, & snakes

Subclass: **Archosauria**

O. **Thecodontia - stem archosaurs**

O. **Pterosauria**

O. **Saurischia** - 2 major groups: sauropods & theropods

O. **Ornithischia**

O. **Crocodilia**

Subclass: **Euryapsida** - marine reptiles, includes the **plesiosaurs**

subclass: Synapsida

O. **Pelycosauria** - first stage in evolution to mammals

O. **Therapsida**

Class Aves - birds

1 - May have arisen from an **archosaurian reptile, perhaps a small bipedal dinosaur**

2 - Lost several dinosaur characteristics (e.g., long tail & teeth) but retained others (e.g., claws, scales, diapsid skull, single occipital condyle &, perhaps, **feathers**)

Subclass :**Archaeornithes الطيور القديمة**

Genera: **Archaeopteryx & Archaeornis**

Characteristics:

1 - solid bones

2 - weakly developed **keel عظم القص** &, probably, weakly developed **flight muscles**

Subclass **:Neornithes الطيور الحديثة**

Superorder: **Odontognathae مسننة الفكوك**

- extinct
- many features of modern birds (e.g., hollow bones & short tail)

Superorder :**Paleognatha**e قديمة الفكوك

- ratites
- small wings but powerful leg muscles

Superorder: **Neognathae** حديثة الفكوك - birds adapted for sustained flight

Modifications to reduce weight include:

- Loss of some bones
- **Pneumatic bones**
- Reduced tail
- Loss of teeth
- Loss of urinary bladder

Class Mammalia

Characteristics:

1 - Hair

2 - Mammary glands

3 - 3 middle ear bones

4 - Muscular diaphragm

5 - sweat glands

6 - Marrow within bones

7 - 2 sets of teeth

8 - Biconcave, enucleate red blood cells

9 - Well-developed cerebral cortex

Subclass **Prototheria (غير ولودة)اللبائن البدائية-** egg-laying mammals

Order. Monotremata وحيدة المسلك, platypus منقار البط + 2 spiny anteaters

1 - Lay eggs

2 - Testes within the abdominal cavity

3 - No pinna

4 - No corpus callosum

5 - Less stable body temperature

Subclass :Theria

Infraclass Metatheria اللبائن البعدية

Order:. **Marsupialia** ذات الجيب- pouched mammals ; young born alive, but at a very immature stage

Infraclass **Eutheria** (المشيمية)اللبائن الحقيقية - placental mammals

Order Proboscidea الخرطوميات(elephants)

Order Sirenia عرائس البحر(dugongs, manatees, and sea cows)

Order Lagomorpha الارنبيات (hares, pikas, and rabbits)

Order Primates (primates)human

Order Rodentia (rodents)

Order Carnivora اكلات اللحوم(carnivores)dog

Order Cetartiodactyla (Whales, Deer, Pigs & Antelopes)

Order :Chiroptera الخفاشيات(bats)

Order: Perissodactyla (horses, rhinoceroses, and tapirs)

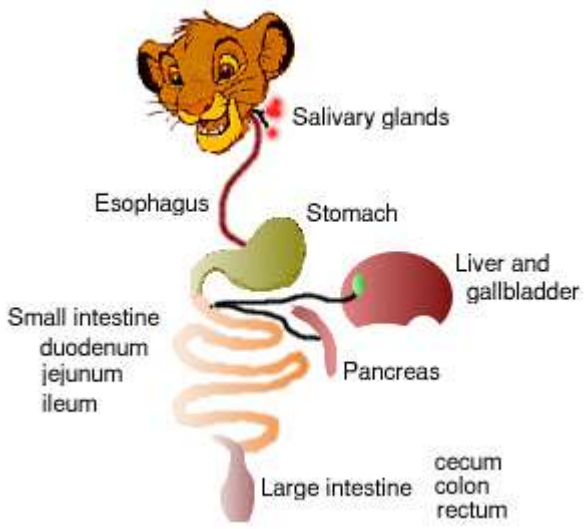
Order :Edentata الدرداء

Order: Artiodactyla الاظلاف (camel)

Order: Insectivora اكلة الاعشاب Hedgehogالقنفذ

Comparative Vertebrate Anatomy Dr: Ilham Al-Saleem

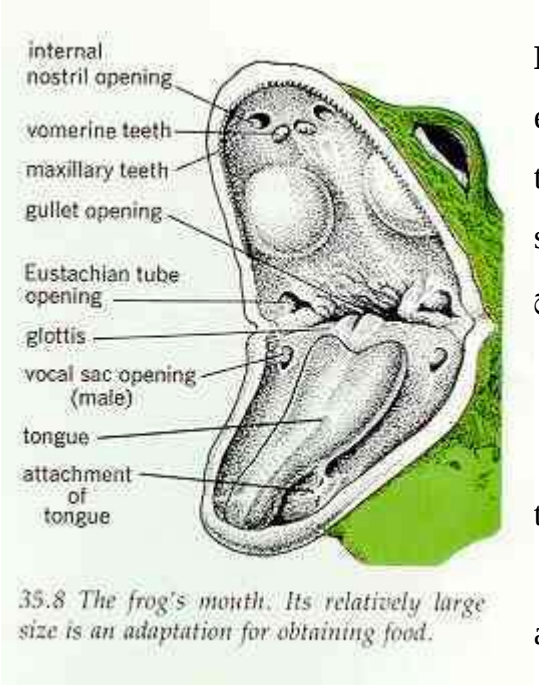
Digestive System



Digestive tract - 'tube' from mouth to vent or anus that functions in:

- ingestionالابتلاع
- Digestion الهضم
- absorption الامتصاص
- egestion الابراز

Major subdivisions اقسامها الفرعيةinclude the oral cavity, pharynx, esophagus, stomach, small & large intestines, and cloaca. **Accessory organs** include the tongue, teeth, oral glands, pancreas, liver, & gall bladder.



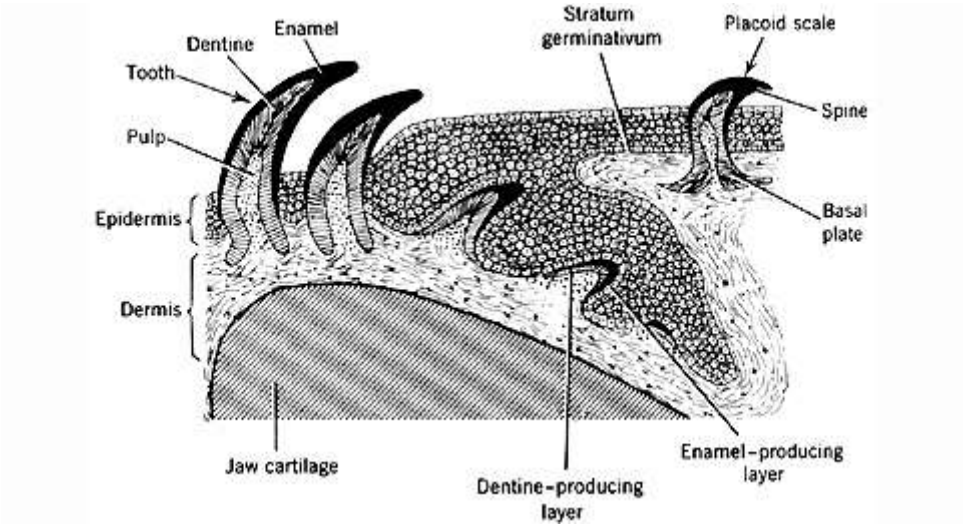
35.8 The frog's mouth. Its relatively large size is an adaptation for obtaining food.

Mouth & oral cavity. The oral cavity begins at the mouth & ends at the pharynx. Fish have a **very short oral cavity,** while tetrapods have **longer oral cavities**. The mammalian mouth is specialized to serve as a suckling الرضاعةand masticatory المضخorgan (with muscular cheeks الخد).

- Palateالحنك = roof of the oral cavity
  - primary palate - internal <u>nares</u> المنخرانlead into the oral cavity anteriorly
  - secondary palate - nasal passages are located above the secondary palate and open at the end of the oral cavity.

Teeth are derivations of dermal armorبروز ادمي.

- Placoid اللوحيscales - show gradual transition to teeth at the edge of the jaw
- Composition of teeth - primarily dentin العاجsurrounded by enamelميناء الاسنان
- Vary among vertebrates in number, distribution in the oral cavity, degree of permanenceالاستمرارية, mode of attachment, & shape



Toothless vertebrates are found in every class of vertebrates and include agnathans عديمة الفكوك, sturgeonsمن الاسماك العظمية, some toadsصغار الضفادع, turtles, birds, & baleen whalesالحيتان البالينية.

Toothed vertebrates:

- Fish - teeth are numerous & widely distributed in the oral cavity & pharynx
- Early tetrapods - teeth widely distributed on the palate; most amphibians & some reptiles still have teeth on the vomer عظم انفي, palatine الحنك.
- Crocodilians, toothed birds, & mammals - teeth are limited to the jaws

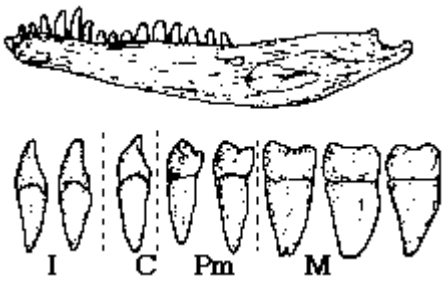
TEETH:

1 - have tended toward reduced numbers & distribution

2 - most vertebrates (through reptiles) have succession تعاقبof teeth

3 - most vertebrates (except mammals) replace teeth in ‘waves’ (back to front; every other tooth)

4 - mammals generally develop 2 sets of teeth: milk (deciduous)لبنية teeth & permanent teeth



Morphological variation in teeth:

- vertebrates other than mammals - all teeth are shaped alike (**homodont dentition**)
- mammals - teeth exhibit morphological variation: incisors, canines, premolars, & molars **(heterodont dentition)**
  - incisorsالقواطع = cutting
  - canines الانياب= piercing & tearingتمزيق
  - premolarsالضواحك & molarsالاضراس = maceratingمضخ

Tongue:

- Gnathostomeفكية الفم fish & primitive amphibians - tongue is a simple crescent-shaped elevation in the floor of the oral cavity caused by the underlying hyoid skeleton & is called the primary tongue
- Most amphibians - primary tongue + glandular field
- Reptiles & mammals - primary tongue + glandular field + lateral lingual swellings
- Birds - lateral lingual swellings منتفخare suppressedمكبوتة & intrinsic الاساسيةmuscle is usually lacking

Tongue mobility:

- Turtles, crocodilians, some birds, & whales - tongue is largely immobilized in the floor of the oral cavity & cannot be extended
- Snakes, insectivorous lizards & amphibians, & some birds - tongue sometimes long and may move in and out of the oral cavity
- Mammals - tongue is attached to the floor of the oral cavity but can still be extended out of the oral cavity

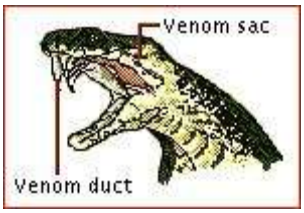
Functions of vertebrate tongues:

- capturing & gathering food (see woodpecker tongue below)
- taste
- manipulate معالجةfluids & solids in oral cavity
- swallowing
- thermoregulation
- human speech

Oral glands - secrete a variety of substances including:

- **Saliva اللعاب**
    - Lubrication ترطيبand binding: the mucus in saliva is effective in binding masticatedمضغ food into a slippery bolus لقمةthat (usually) slides easily through the esophagus without inflicting الحاق الاذىdamage to the mucosa. Saliva also coats تغلفthe oral cavity and esophagus, and food never directly touches the epithelial cells of those tissues.
    - Solubilizes تذويبdry food: in order to be tasted (by taste buds), the molecules in food must be solubilized.
    - Oral hygieneتنظيف: The oral cavity is almost constantly flushed مسحwith saliva, which floats يطفوaway food debris and keeps the mouth relatively clean. Saliva also contains lysozyme, an enzyme that lyses many bacteria and prevents overgrowth of oral microbial populations.
    - Initiates بدايةstarch digestion: in most species, amylase is present in saliva and begins to digest dietary starch into maltose.
    - Provides alkaline buffering and fluid: this is of great importance in ruminantsالمجترات,
        - Evaporative التبخرcooling: clearly of importance in dogs, which have very poorly developed sweat glands - look at a dog panting يلهثafter a long run and this function will be clear.

- poisonسامة (lizards, snakes, and mammals)
- anticoagulantمضاد للتخثر (vampire مصاص الداءbats الخفاش)

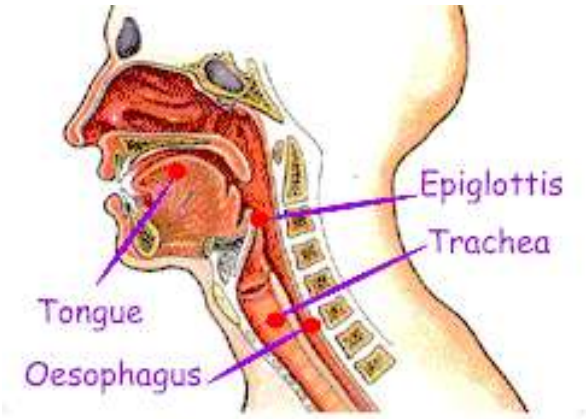


Pharynx - part of digestive tract exhibiting pharyngeal pouches جيوب بلعومية(at least in the embryo) that may give rise to slitsشقوق

- **Fish** - pharynx is respiratory organ
- **Tetrapods**:
    - pharynx is the part of the foregut معي امامي precedingيتقدم the esophagus & includes:

- glottisالمزمار (slit leading into the larynxالحنجرة)
- openings of auditory (eustachianقناة اوستاكي) tubes
- opening into esophagus

Mammals - an epiglottisاللهاة is positioned over the glottis لسان المزمار so that, when a mammal swallows, the larynx is drawn forward against the epiglottis & the epiglottis blocks the glottis(which prevents food or liquids from entering the trachea)

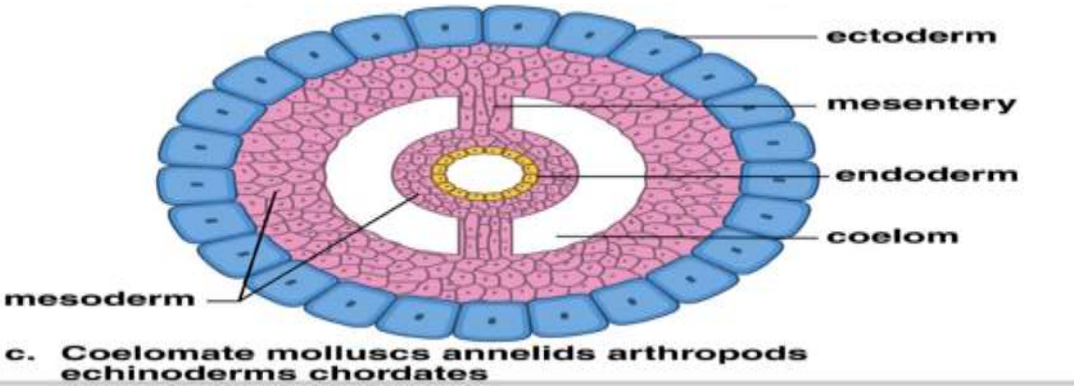


Esophagus:

- a muscular tube connecting the pharynxالبلعوم & the stomach
    - may have diverticulum تجويفcalled the **crop** (حوصلة الطائرin birds

Comparative Anatomy/Bio/Lec9 **Coelom**

Coelom is a body cavity that is different from other cavities in that it is lined with epithelium derives from mesoderm. Coelomic cavities are the spaces that surround the heart, lungs, digestive system, and certain urino-genital organs.



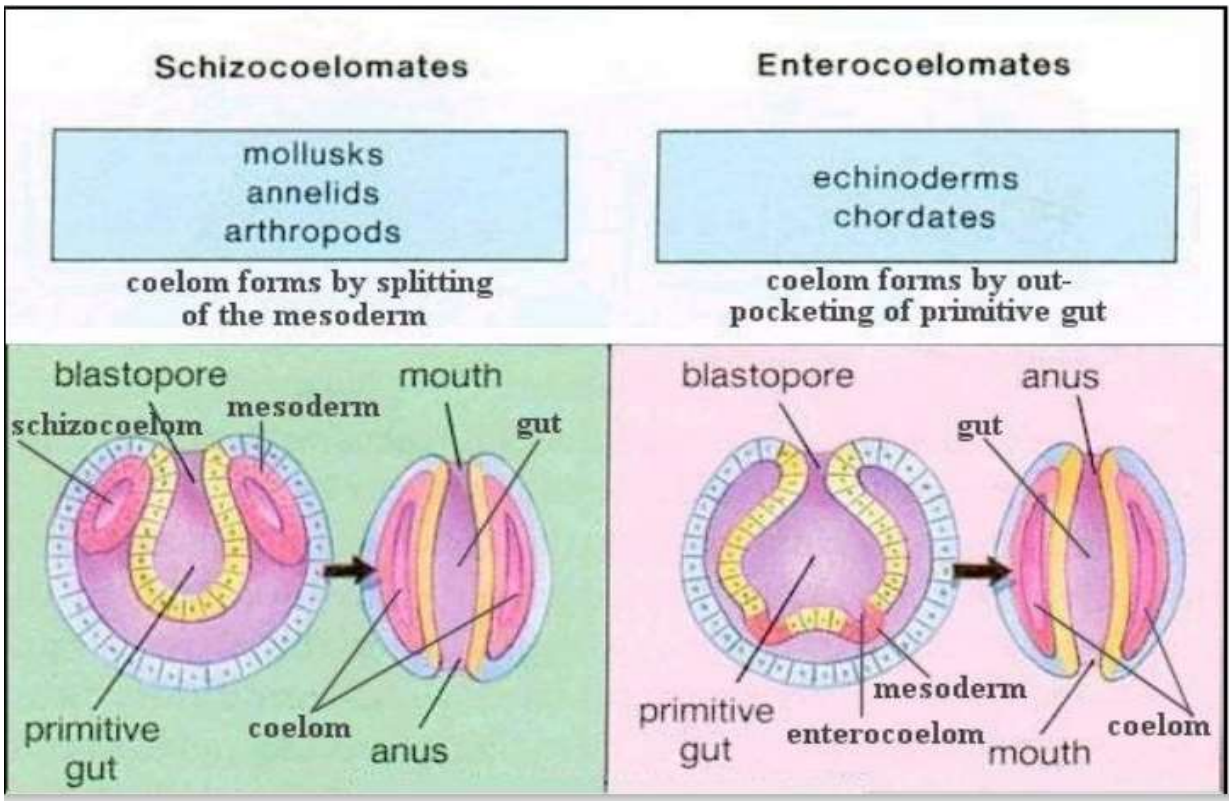
c. Coelomate molluscs annelids arthropods echinoderms chordates

Origin of Coelom:

• The mesoderm starts as lateral plate which splits into somatic and splanchnic mesoderm. In between is a cavity, the coelom.

1. In molluscas, annelids and arthropods, coelom is formed by cavitation or splitting of initially solid mesoderm (schizocoely)

2. In echinoderms, protochordates and chordates, coelom is formed from a series of pouches that pinch off from the dorso lateral wall of the gut tube (Enterocoely)

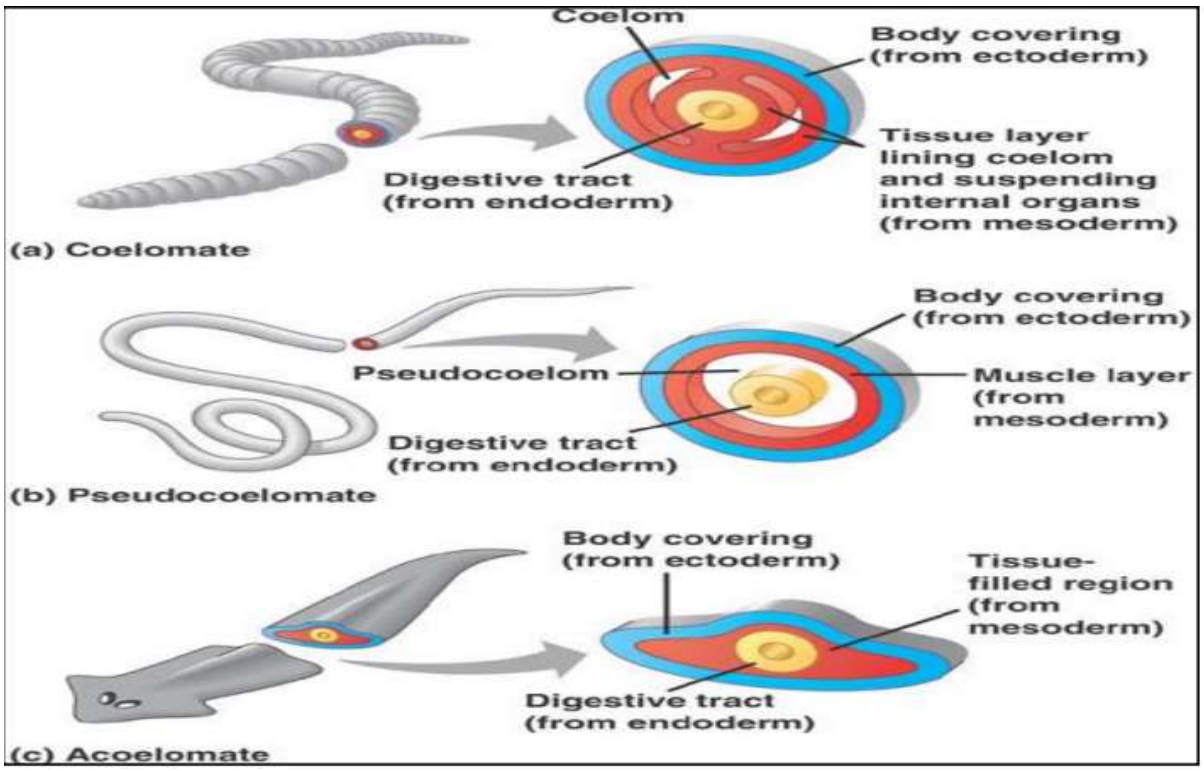


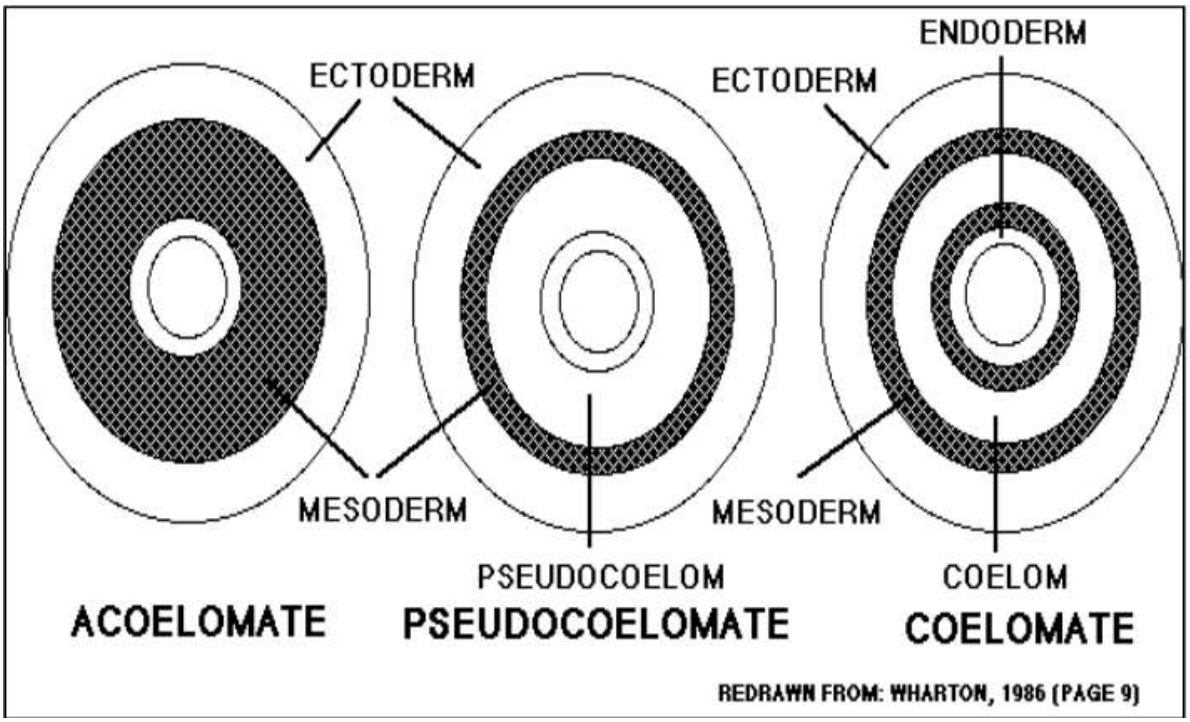
Functions of Coelom

= Movement and expansion of some internal organs like heart, lungs, stomach, urinary bladder and uterus. Lungs can move when the heart beats, the liver and stomach can move down when the lungs fill.

= On the other hand, allow the internal organs to move freely and to change their relative sizes and positions as is required.

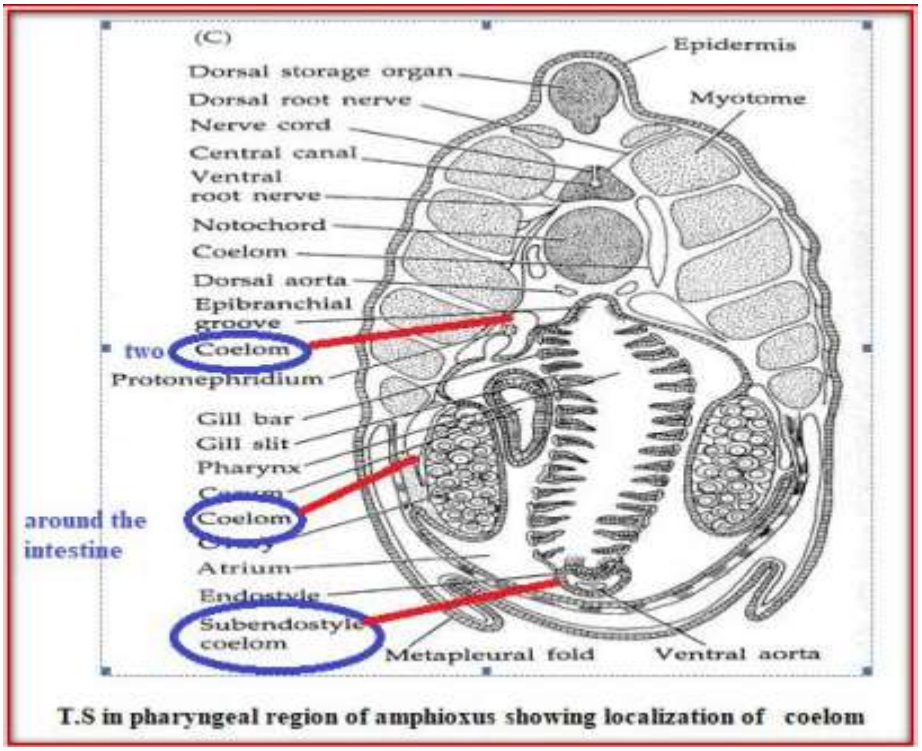
* Classification of animals according to the coelom



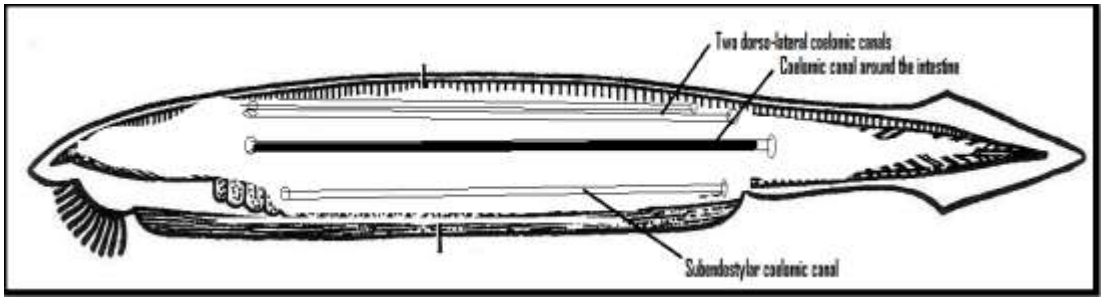


*Coelom Among Vertebrates

In protochordates

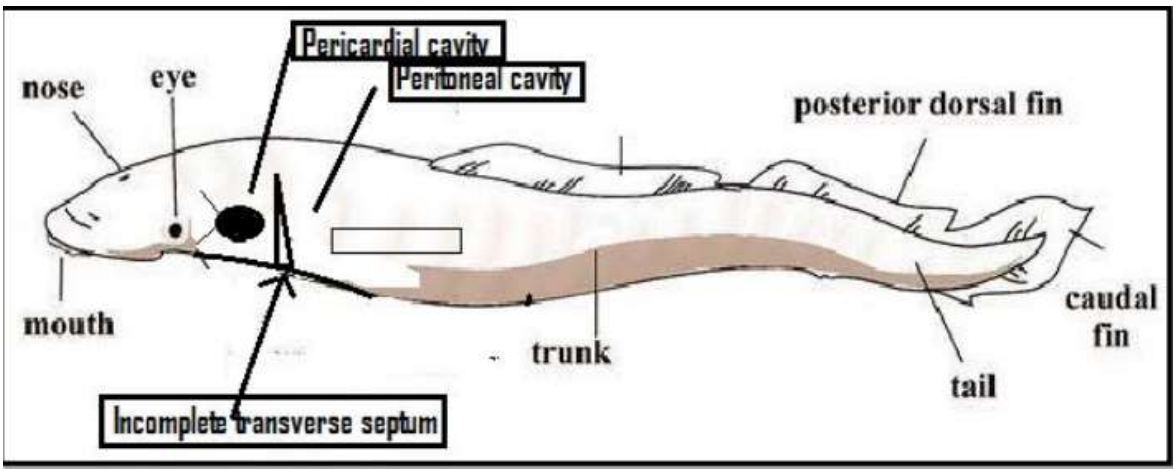


T.S in pharyngeal region of amphioxus showing localization of coelom

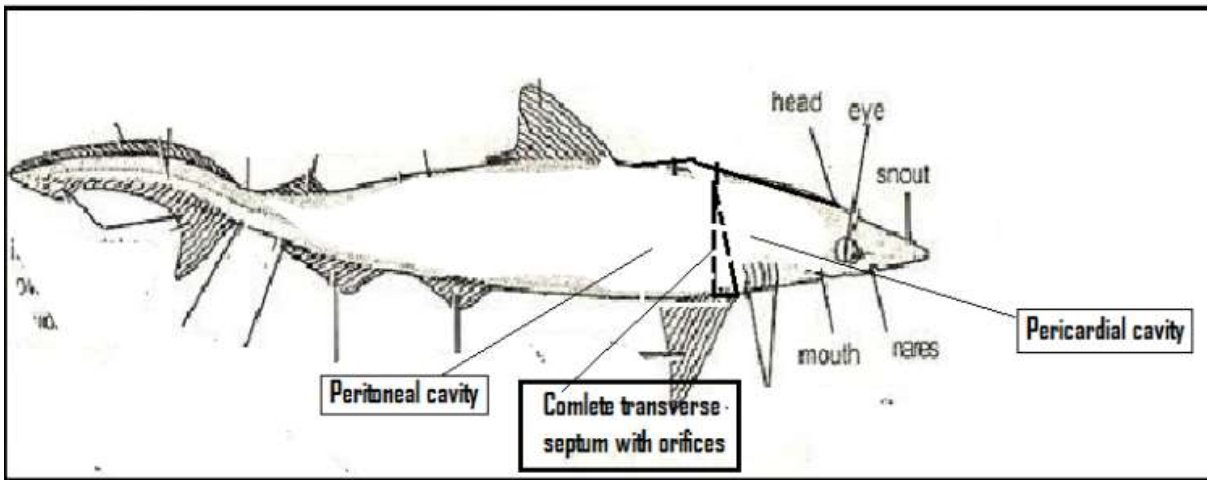


. In Hag fishes (Petromyzon):

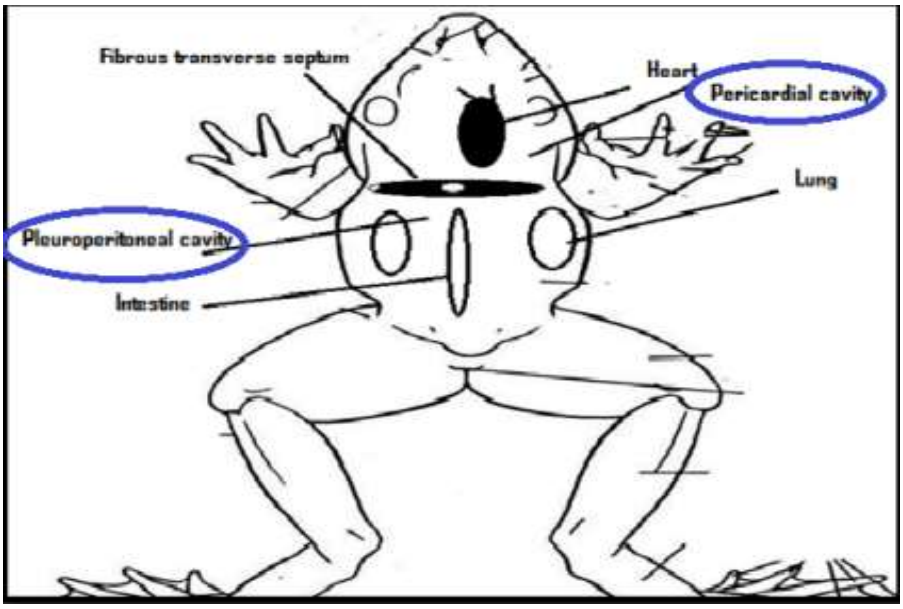
Incomplete transverse septum extends upward on the ventral body wall posterior to the heart, partly separating an anterior pericardial cavity from a large peritoneal cavity.



In dog fish: the developing transverse septum temporarily separates the two cavities and then secondarily develops small orifices به ثقوب .

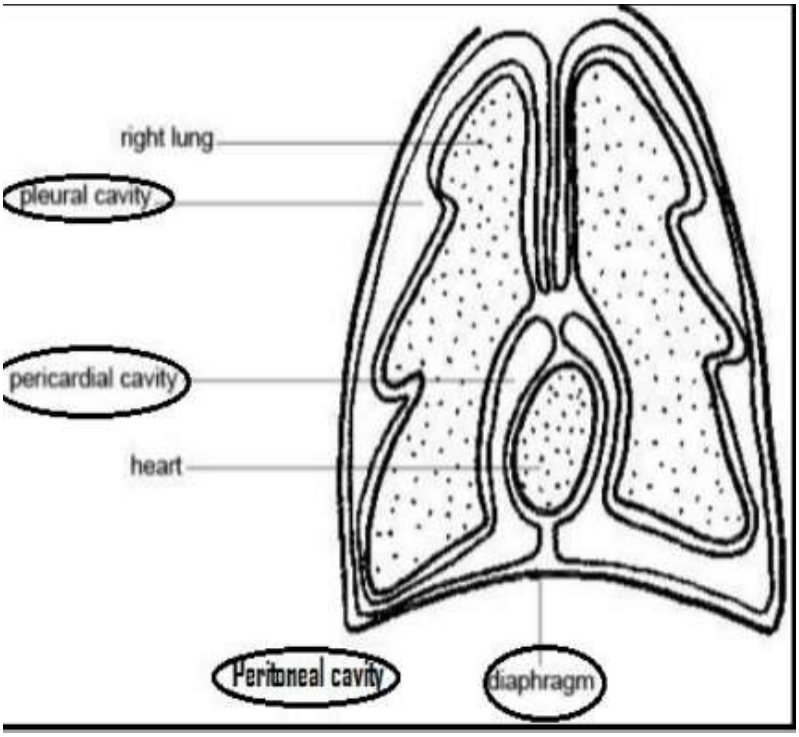


In fishes, amphibian, and some reptiles (as in Lizard): the coelom is partitioned into pericardial cavity that houses the heart and pleuroperitoneal cavity that houses most of the viscera including the lungs. The two coelomic cavities are separated by fibrous transverse septum**.**



**In other reptiles as well as in birds and mammals

In many male mammals caudal outpocketings of the coelom house the testes considering as fourth coelomic division. Also the coelom cavity is found around the uterus to allow expansion.



Mesenteries المساريق

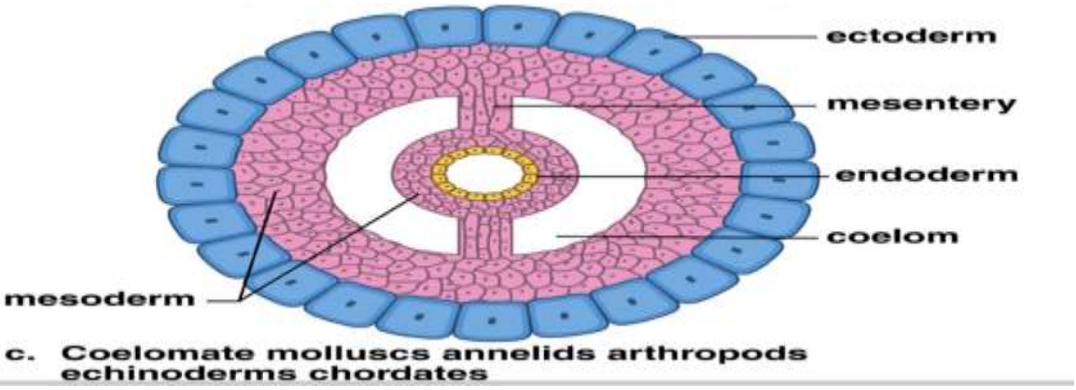
* **Def. They are sheets of serous membranes strengthened by collagenous and elastic fibers that extend from the body wall to the viscera.

Function:

=Support the internal organs.
=Transmit the nerves and blood vessels.
=A site for fat storage in mammals

Comparative Anatomy/Bio/Lec9 **Coelom**

Coelom is a body cavity that is different from other cavities in that it is lined with epithelium derives from mesoderm. Coelomic cavities are the spaces that surround the heart, lungs, digestive system, and certain urino-genital organs.



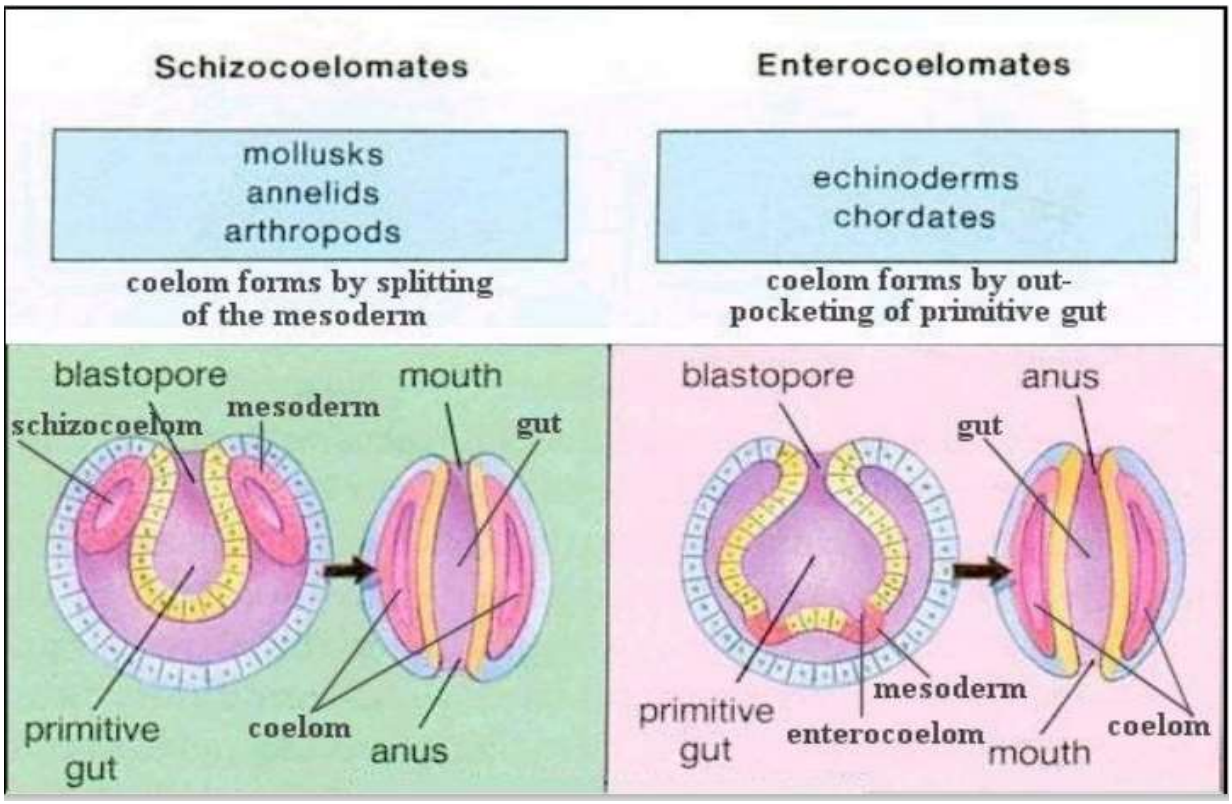
c. Coelomate molluscs annelids arthropods echinoderms chordates

Origin of Coelom:

• The mesoderm starts as lateral plate which splits into somatic and splanchnic mesoderm. In between is a cavity, the coelom.

1. In molluscas, annelids and arthropods, coelom is formed by cavitation or splitting of initially solid mesoderm (schizocoely)

2. In echinoderms, protochordates and chordates, coelom is formed from a series of pouches that pinch off from the dorso lateral wall of the gut tube (Enterocoely)

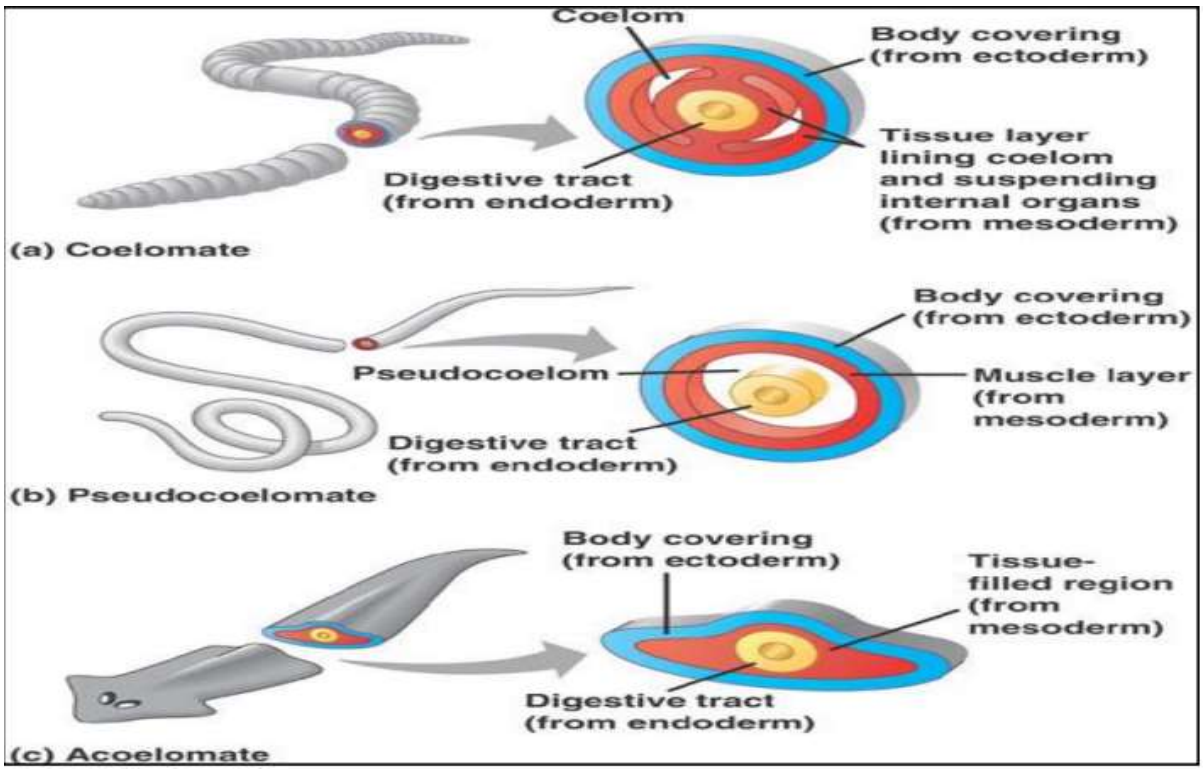


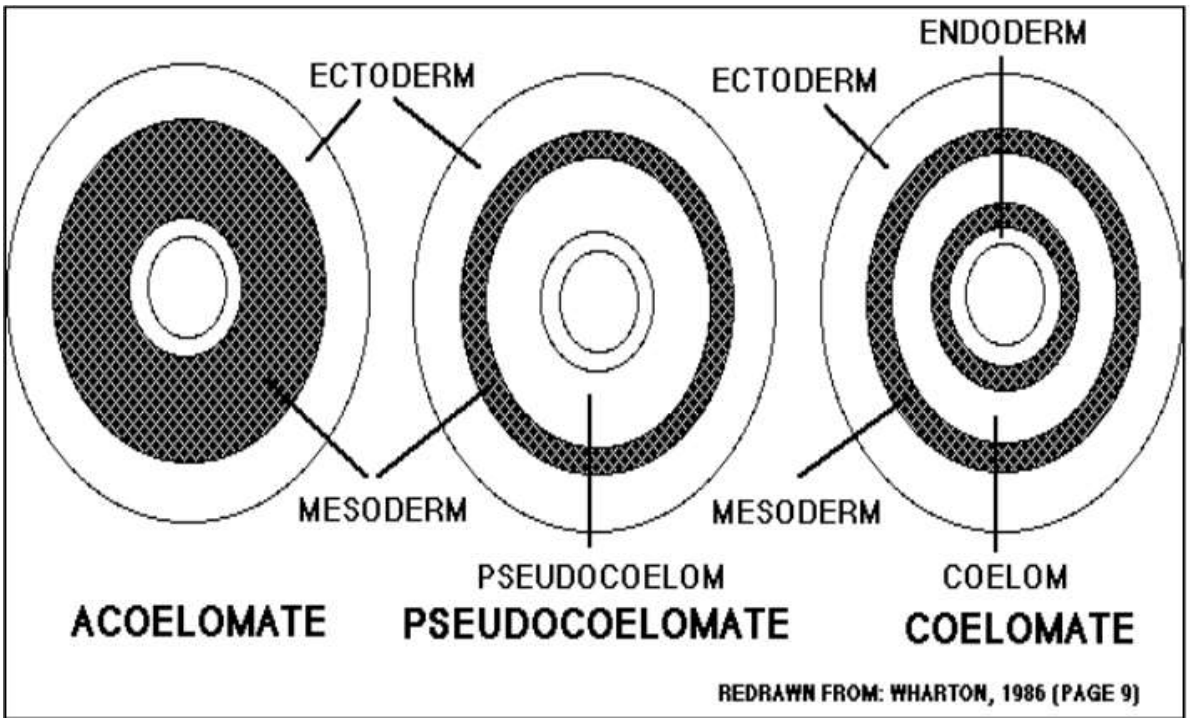
Functions of Coelom

= Movement and expansion of some internal organs like heart, lungs, stomach, urinary bladder and uterus. Lungs can move when the heart beats, the liver and stomach can move down when the lungs fill.

= On the other hand, allow the internal organs to move freely and to change their relative sizes and positions as is required.

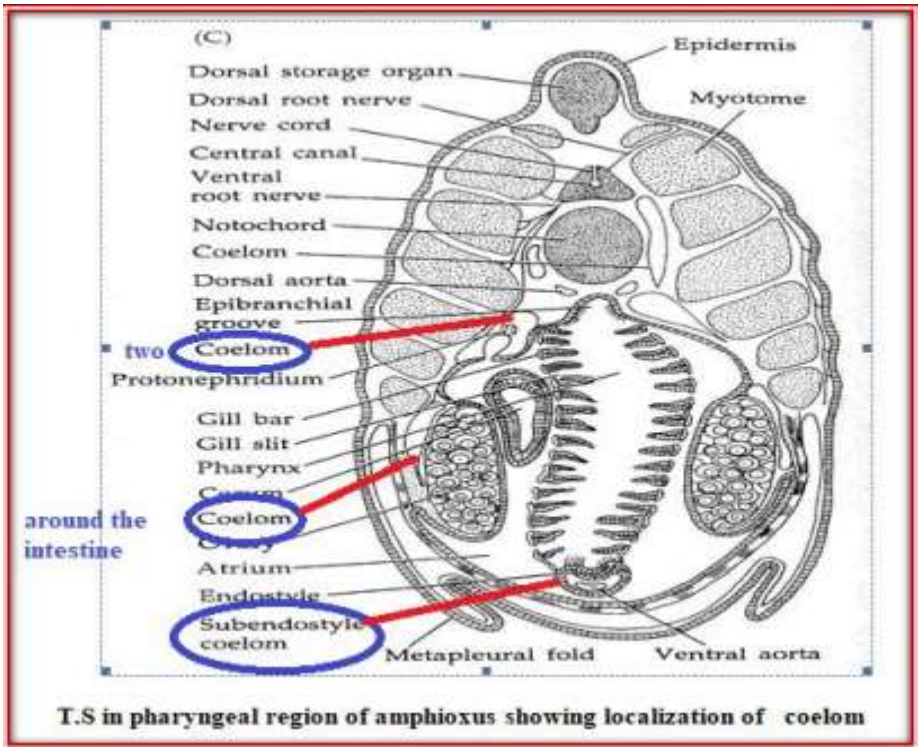
* Classification of animals according to the coelom



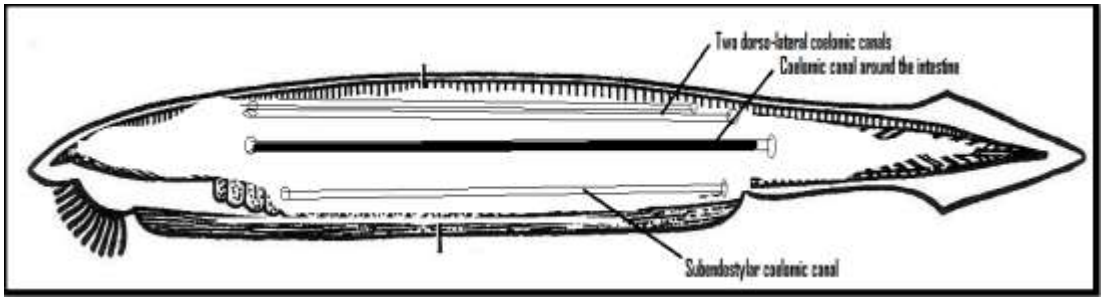


*Coelom Among Vertebrates

In protochordates

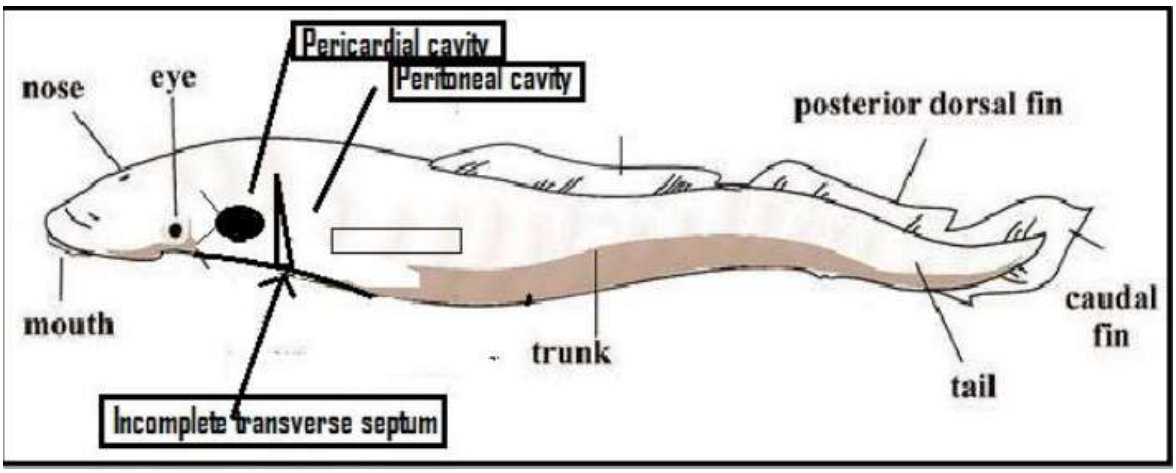


T.S in pharyngeal region of amphioxus showing localization of coelom



. In Hag fishes (Petromyzon):

Incomplete transverse septum extends upward on the ventral body wall posterior to the heart, partly separating an anterior pericardial cavity from a large peritoneal cavity.



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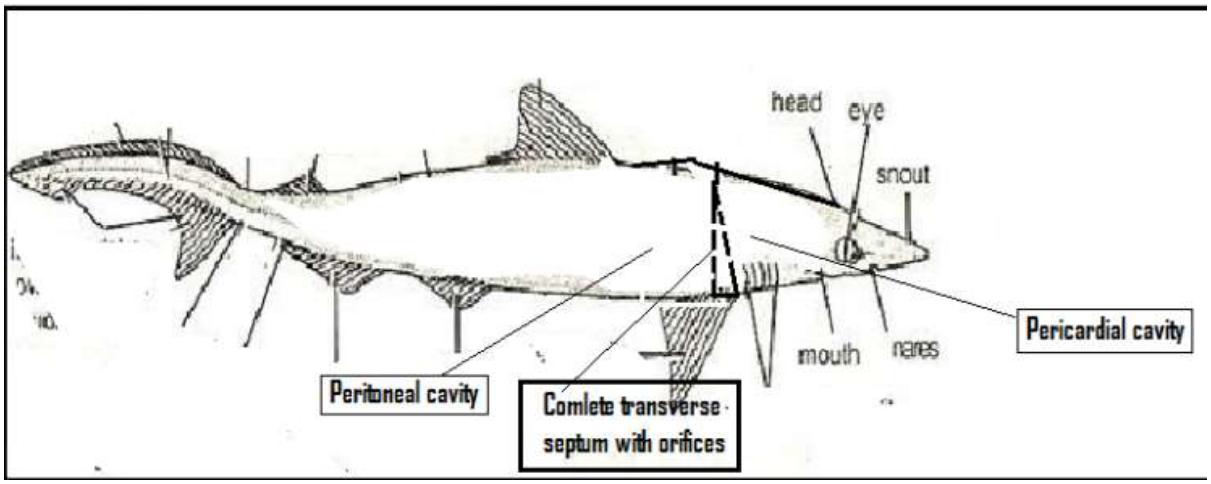

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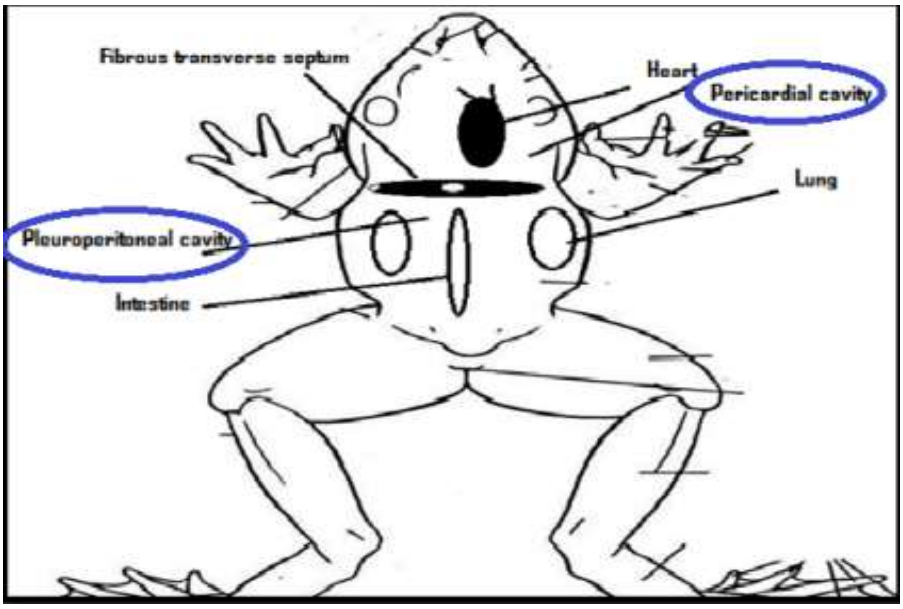

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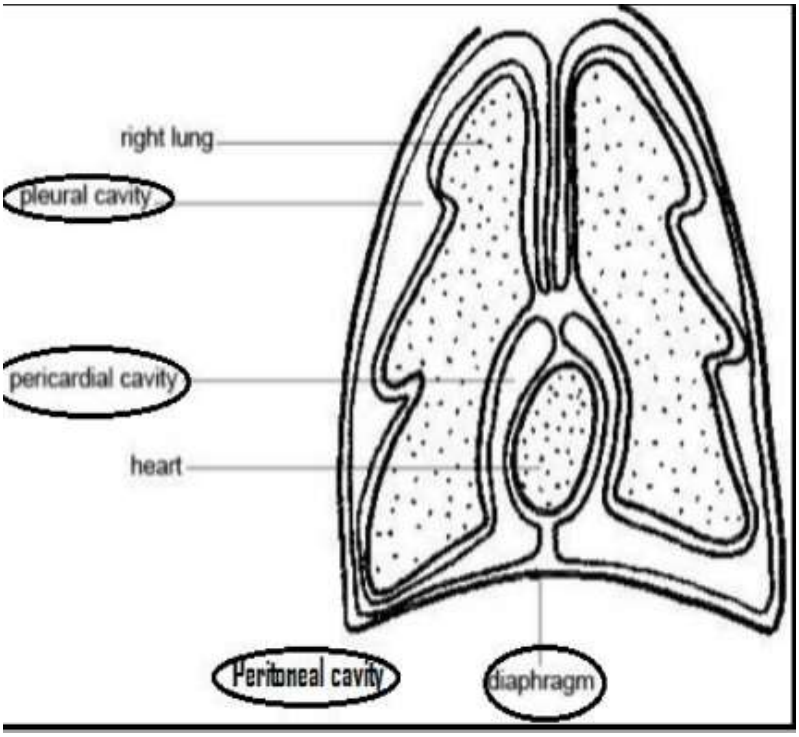

Mesenteries المساريق

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4th stage/Biology **Comparative Anatomy**

The Chordata is the animal phylum with which everyone is most intimately familiar, since it includes humans and other vertebrates .

Comparative anatomy- The study of structure, function of structure, the range of variation in structure and function among vertebrates.

- All chordates have the following features at some stage in their life (in the case of humans and many other vertebrates, these features may only be present in the embryos).

Phylum Chordata possesses three main characters are:

1. Presence of **notochord**, at least at embryonic stage.
2. Pharynx with **pouches or slits** in the wall, at least in the embryonic stage.
3. Presence of **dorsal hollow nerve cord.** A bundle of nerve fibers which runs r organs.

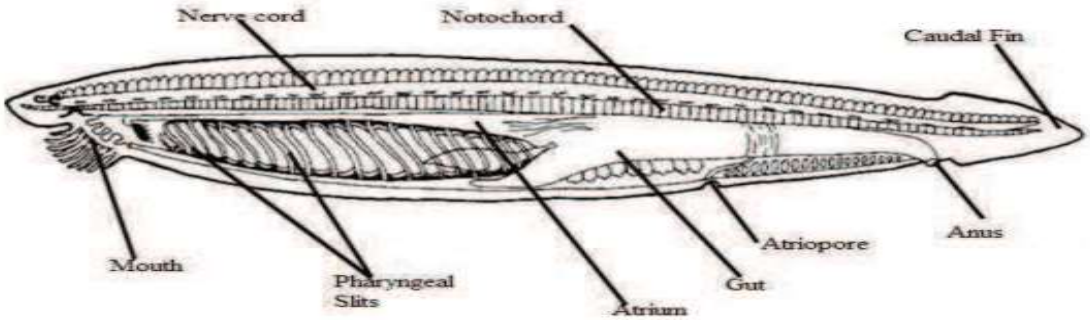


Fig:1- Pharyngeal slits dorsal nerve cord & notochord

Notochord: is a cartilaginous rod like of living cells ventral to central nervous system and locate dorsaly to alimentary canal. It is a tuff gelatinous material which is hard as well as flexible.

Possible invertebrate ancestors for chordates are Annelida & Echinodermata.

Homology: Structures (body parts) which are similar in different species because the species have common descent (origin). They may or may not perform the same function because they live in different environments. e.g. fore limb of cats and whales.

Analogy: Structures do similar function in different organisms, because they evolved in similar environment, but they have different origins. e.g. the wing of bird and butterfly.

Phylum Chordata

Acraniata (protochordates)
1- Subphylum Hemichordata
e.g. Balanoglossus & Dolicoglossus
2- Subphylum Urochordata e.g. Molegula
3- Subphylum Cephalochordata e.g, Amphioxus

Craniata
4- Subphylum Vertebrata

Origin of Chordates :

It is believed that chordates originated from invertebrates. However, it is difficult to determine from which invertebrate group of the chordate developed. It is almost constant that chordate ancestors were soft bodied animals. Hence, they were not preserved as fossil.

The mode of urochordate`s life, leads to the presence of common ancestor or resemble to chordates. The evolution of motile chordates from attached ancestor, may be revolving formation or evolution of tadpole-like larva. The movement of these larval stages may be adaptive processes for species that was sedentary, and this happen because of the need for spread. So the evolution of the motile adult stages may be developed from **Paedomorphosis phenomenon** which means: The evolution **of larval stage into the sexual maturity**. So, the larval sexual maturity may lead to the formation of organisms looks like small fishes, which are able to reproduce sexually. And these may be the first chordates or ancestors of the high chordates.

Binomial Nomenclature: Is the scientific name of an animal, is made up of its genus and specific name. Genus is written with capital letter, and the species with a small letter. This system was first devised by Swedish Linnaeus. e.g. the mouse Mus musculus.

Phylum Chordata is the highest phylum in the animal kingdom. It`s members characterized by the presence of axial skeletal rod like structure, which extends through the animal length, at the dorsal side of the body, and gives a primary supporting for the body, and limits trunk length, called as notochord, which the name of the phylum is derived from it`s name.

Classification of chordates according to the presence of notochord:

Protochordates: characterized by the presence of notochord in most of the developmental stages. The brain is simple without skull, so they are called as Acraniata. They are all marine animals. Vertebrata: members have dorsal notochord in the early developmental stages. Later on, this will change into vertebral column which is more solid than the notochord. The brain is complex structure and covered with skull, so they called as craniate.

Vertebrate Beginnings:

Among the oldest and best known, is the ostracoderms fishes that lived in the late Cambrian period (400-525 million years b.c.). They had bony plates and scales, therefore they were easily fossilized. They were jawless vertebrates and called as Armored fishes.

Subphylum Hemichordata

Hemichordate History:

The scientist Patson (1884), added this subphylum to the chordates. Others thought that it belongs to invertebrates, because their members had worm- like shape & the larva resemble that of echinoderms. It include 80 species live as worm burrowing in the sand. Body is divided into three regions: proboscis, collar, & trunk.

Hemichordata has two classes:

a- Class Enteropneusta.

b- Class Pterobranchia.

a-Class Enteropneusta: (acorn worms)

Animals are dioecious. Their bodies secrete mucus materials. The trunk is divided into 3 parts: the anterior has respiratory pores, the middle has two rows of gonads, and each one opens separately outside the body, the third is alimentary (digestive). Fertilization is externally. Anus is present at the end of trunk. Tail is absent.

The fore gut has short stomochord or pharyngeal diverticulum, which extends from collar into proboscis. Patson considered this structure as supporting notochord of chordates. The ciliated larva is called as tornaria larva.

b- Class Pterobranchia: (has arms carry external gills arranged as feathers)

Small organisms less than 5 cm, live in secreted tubes. Proboscis extended anteriorly forming shield like structure and has stomochord inside it. Animals live in colonies, they secrete tubes around them. Collar has 2-9 arms provided with ciliated tentacles. The larva is called as planula larva.

Subphylum Urochordata

They are also called as tunicates, have flexible outer body cover, is the tunic. They live solitary or colonies. Adult is sessile but larva is planktonic. Adults adhere their bodies on stones. The free part of the body has two siphons, oral for entering water, and atrial for exit water. When the animal is excited, it pushes water through atrial siphon strongly so they are called as sea squirts. Tunicates are monoecious, gonads are present inside the intestine loop.

In adult, the entering water do six functions: respiration- nutrition- carry waste products of excretory & digestive system & mature gametes- and used for defense.

Tunicate tadpole larva:

It has the three main characters of chordates, with well-developed notochord along the tail, free swimming and it is non feeding. After few days, it adheres itself by mucus papillae under the mouth to a substrate. Then it undergoes metamorphosis where the tail degenerates and the organs will rearrange as they in the adult stage.

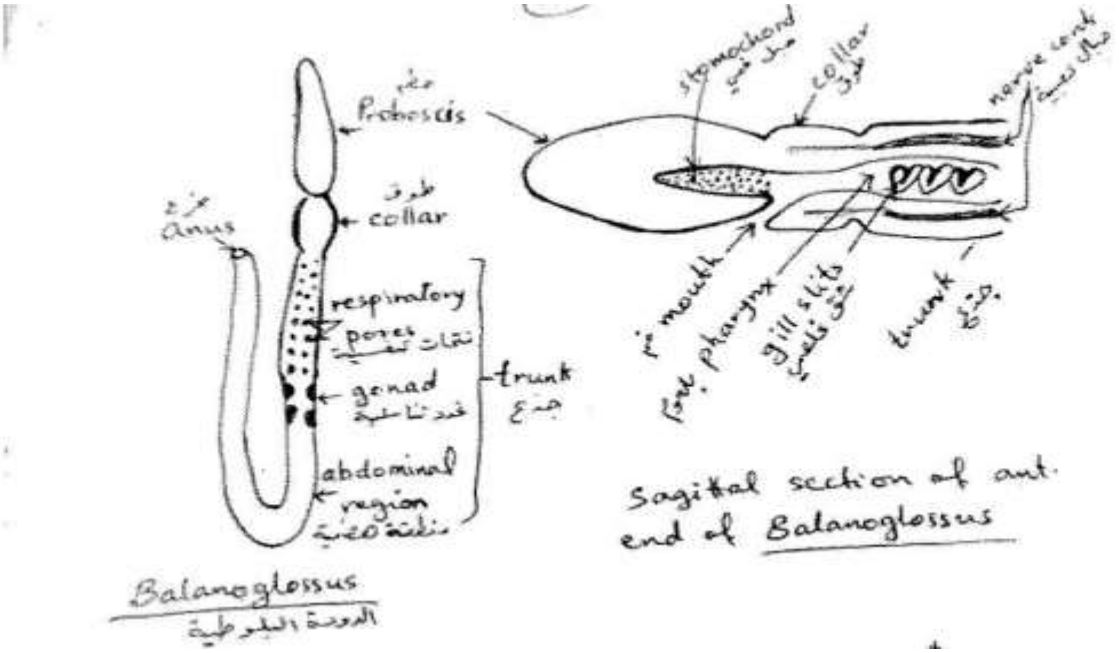
Subphylum Cephalochordata

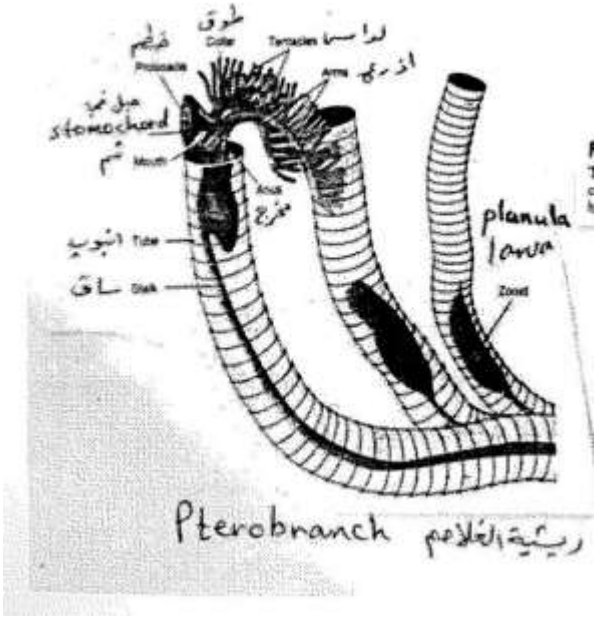
The famous group is the lancelet, genus branchiostoma, e.g. amphioxus. The adult has the shape of tadpole. Adult is transparent, 5 cm & bilaterally compressed. It is a bad swimmer, and spends most of its life in filter feeding position, partially or completely buried in the sand, with the anterior part of the body is outside the sand.

The notochord extends from the head to the tail, so it is called as Cephalochordata. In the anterior end of the body, there is a many mouth parts, help in filter feeding. The mouth leads to a perforating pharynx. Body wall has two laterally folds around pharynx to form the atrium, which opens to the outside by

atriopore for passing the water to outside. Cephalochordata is dioecious. Gonads project inside the atrium cavity. Gametes release to the water in the atrium & leave the body by atriopore.

In adult, the entering water do four functions: respiration- nutrition- carry waste





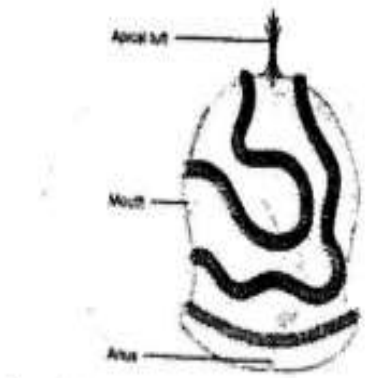
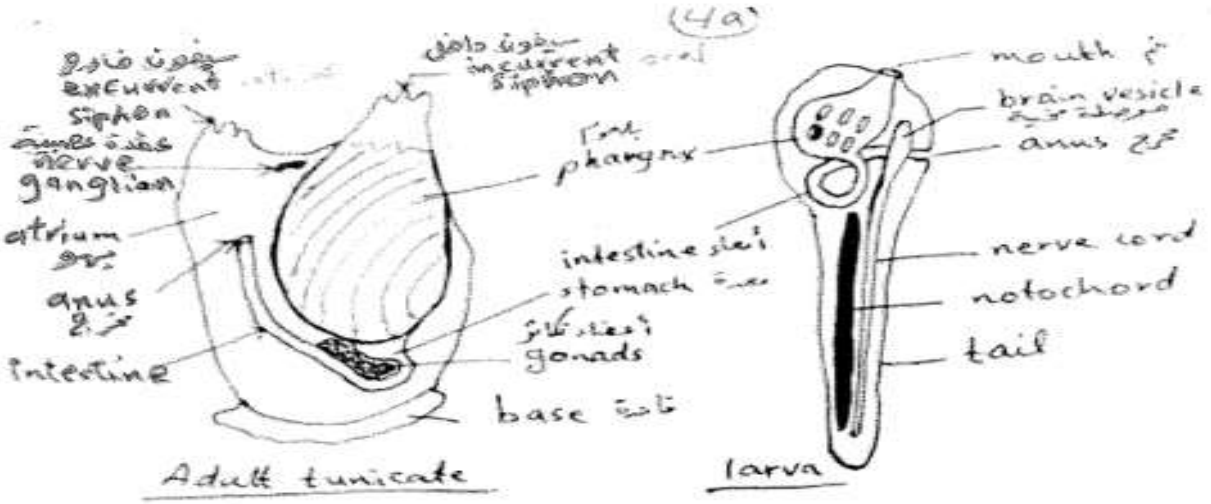


FIGURE 26.4
The Tornaria Larva (Balanoglossus). When larval development is complete, a tornaria locates a suitable substrate, settles, and begins to burrow and elongate.



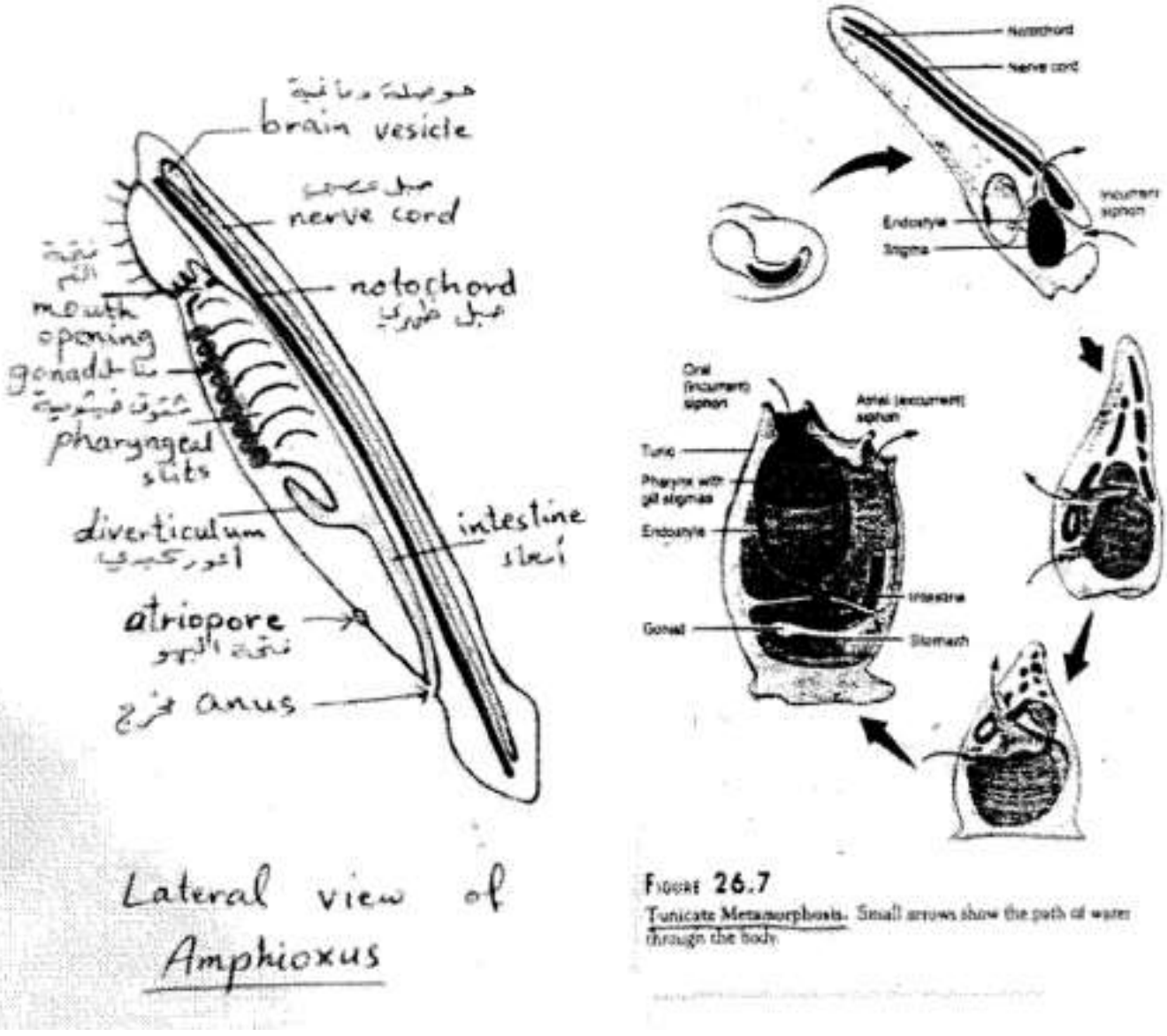


FIGURE 26.7
Tunicate Metamorphosis. Small arrows show the path of water through the body.

Comparative anatomy of Integument (skin)

Because of its importance as the primary interface between an organism and its environment, the skin is designed to perform many functions. These functions include:

1-Support and protect soft tissues against abrasion, microbes
2- Reception and transduction of external stimuli - i.e. heat, chemical, etc.
3- Transport of materials in excretion, secretion, resorption, dehydration, rehydration 4- Heat regulation
5- Respiration
6- Nutrition/nutrient storage - i.e. storage of vitamins, synthesis of Vitamin D
7- Locomotion
8- Coloration - hidden or display
The fundamental structure of skin in all the vertebrates is the same. Epidermis has ectodermal origin, while dermis has mesodermal origin.

1. Protochordata: In Amphioxus the skin is simple without keratin. The epidermis is single layered made of tall or columnar cells. Epidermis has numerous unicellular gland cells which secrete a thin cuticle. Dermis is gelatinous in Amphioxus.

2. Cyclostomata: Epidermis is stratified but has no keratin. It has three types of unicellular gland cells- mucous glands secrete mucous, club cells form cover of injury, and granular cells are of unknown function. Below the epidermis is the dermis formed of collagen and elastic fibres. Star-shaped pigment cells are also present in the cutis.

3. Pisces: The epidermis has several layers of simple cells, but there is no dead stratum corneum. The outermost cells are nucleated and living. Unicellular **goblet or mucous** gland cells are found in the epidermis, as in all aquatic animals.

Multicellular epidermal glands like **poison glands** and light producing organs (**photophores**) may be found. The epidermis rests on a delicate basement membrane. The dermis contains connective tissue, smooth muscles, blood vessels, nerves, lymph vessels, and collagen fibres. The fibres are generally run parallel to the surface. Scales are embedded in the dermis and projected above the epidermal surface.

Scales are of five types: The elasmobranchs have **placoid scales**, some teleost have **ganoid scales**, while most Teleost have cycloid and **ctenoid scales**. Extinct fishes had **cosmoid scales**. Many bony fishes show more brilliant colours than any other group of animals, due to **chromatophores** in the dermis: They contain pigments which produce colours & cause variations of colours, containing brown, black, red, yellow, or orange pigment.
4. Amphibia: The epidermis is stratified; the st. corneum made of flattened, highly keratinised cells. Such a dead layer appears first in amphibians, and is best formed in

those which spend a considerable time on land. This is an adaptation to terrestrial life; it protects the body & prevents any excessive loss of moisture.

The dermis is relatively thin, it is made of two layers, an upper loose st. spongiosum and a lower dense and compact st. compactum. Connective tissue fibres run both vertically and horizontally.

There are two kinds of glands, they are multicellular **mucous glands** and **poison glands** in the dermis, but they are derivatives of the epidermis. The mucous glands produce mucus which not only forms a slimy protective covering but also helps in respiration.

The poison glands found in toads as parotid glands produce a poison which is protective, keep the enemies away. In the upper part of the dermis are chromatophores which have black melanophores and yellow, these produce the colour of the skin.

5. Reptilia: The integument is thick and dry. It prevents any loss of water. It has almost no glands, this is an adaptation to prevent evaporation of water.

The epidermis has a well-developed st. corneum which makes the skin dry and prevents any loss of body moisture, thus, well adapted to a terrestrial life. The epidermis produces horny scales. **Scales** are shed periodically.

The scales often form spines or crests. Below the epidermal scales are dermal bony plates in tortoises, crocodiles, and some lizards. These are retained for life and are not shed off.

The dermis is thick and has an upper loose connective tissue layer and a lower layer separating the two is a horizontal layer of fibrous connective tissue. The upper layer has abundance of chromatophores in snakes and lizards like fishes and amphibians.

Reptiles essentially lack skin glands. Many lizards have scent glands near the cloaca.

6. Aves: The integument is thin, loose, dry, and devoid of glands except for **a uropygial gland** at the base of the tail which secreted oil to lubricate the feathers, especially in aquatic birds & **salt glands.** The stratified epidermis is delicate, except feet where it is thick scales. **Feathers** have many types: **flight** f. on **wings** & **tail- contour f**. cover all body- **down f.** for insulation- & **filoplumes f.** specialized for display.

7. Mammalia: The skin is elastic and waterproof and is much thicker than in other vertebrates, especially the dermis is very thick and tough and is used for making leather. The epidermis is thickest in mammals and is differentiated into 5 layers- stratum corneum, st. lucidum, st. granulosum, st. spinosum and st. germinativum or Malpighian layer.

The outer layer of st. corneum containing keratin, its cells lose their nuclei. In places of friction, such as soles and palms, the st. corneum is very thick & modified in various

mammals to form epidermal scales, hairs, claws, nails, hoofs, horns, & antlers, finger prints. Below the st. corneum is a refractive st. lucidum in certain regions only.

Lastly there is a st. germinativum . layer which rests on a thin basement membrane. The Malpighian layer forms new cells continuously which move towards the surface and become flat and keratinised till the st. corneum has flat, cornified cells made only of keratin. This layer is sloughed off continuously and replaced by new cells. In man some branching dendritic cells or melanoblasts lie between the epidermis and dermis, they contain pigment.

The epidermis forms hairs, sweat glands, sebaceous glands and mammary glands. Hairs form an epidermal covering. Shafts of hair project above the skin and their roots are embedded in hair follicles, into each of which opens a branching sebaceous gland. Hairs form an insulating layer which prevents a loss of body heat, thus, hairs keep up the body temperature. Sebaceous glands are outpushings of the wall of hair follicle and produce an oily substance which keeps the hair supple and prevents its wetting in water. Mammary glands are modified sebaceous glands. They are functional only in females for producing milk for the young.

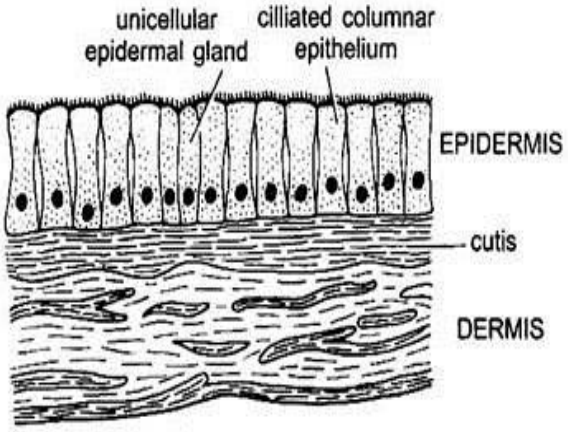


Fig. 41.10. V.S. of skin of a young *Amphioxus.*

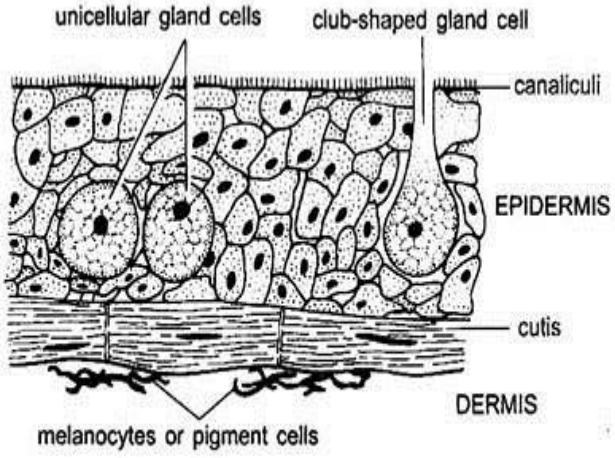


Fig. 41.11. V.S. of skin of a larval cyclostome.

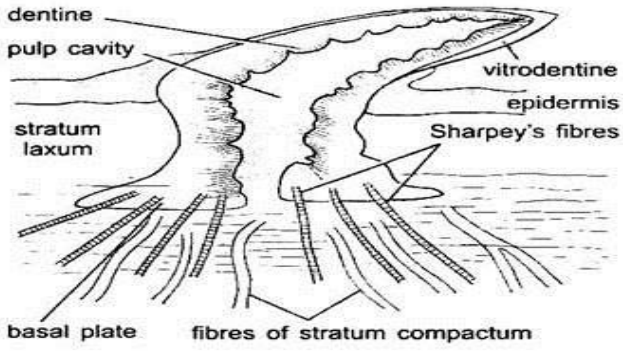


Fig. 41.12. V.S. of integument of shark.

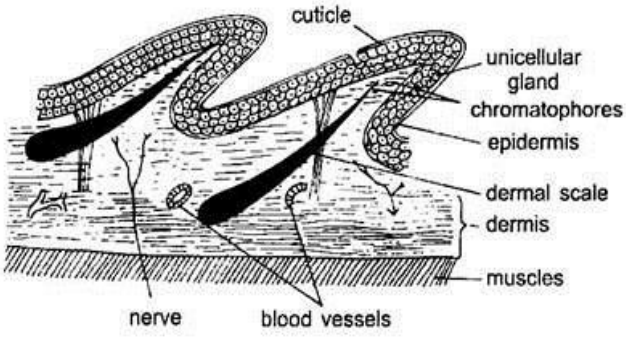


Fig. 41.13. V.S. of skin of bony fish.

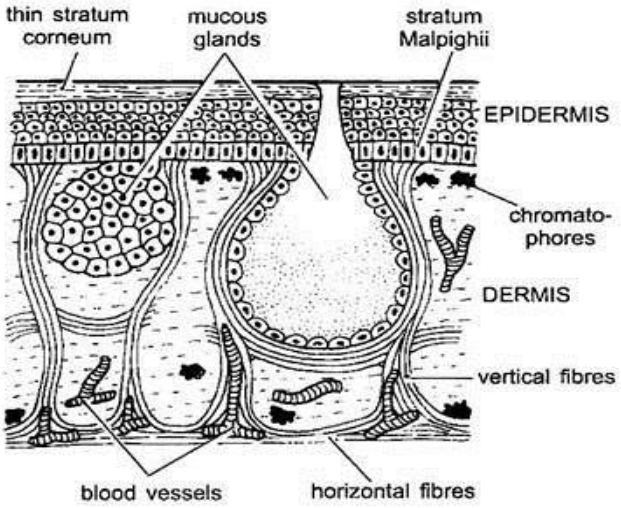


Fig. 41.15. V.S. of skin of frog.

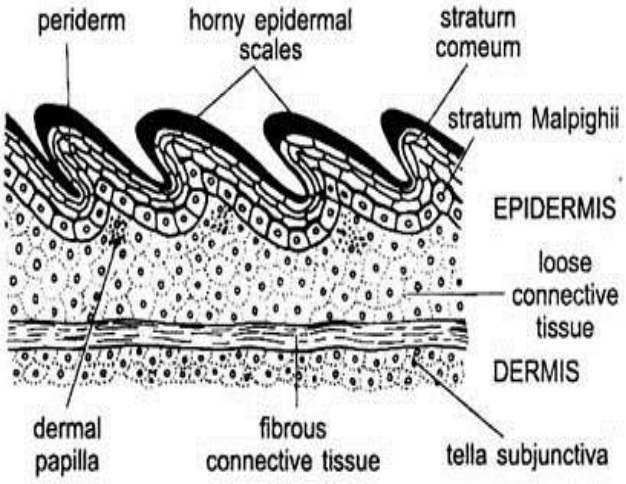


Fig. 41.17. V.S. of skin of lizard.

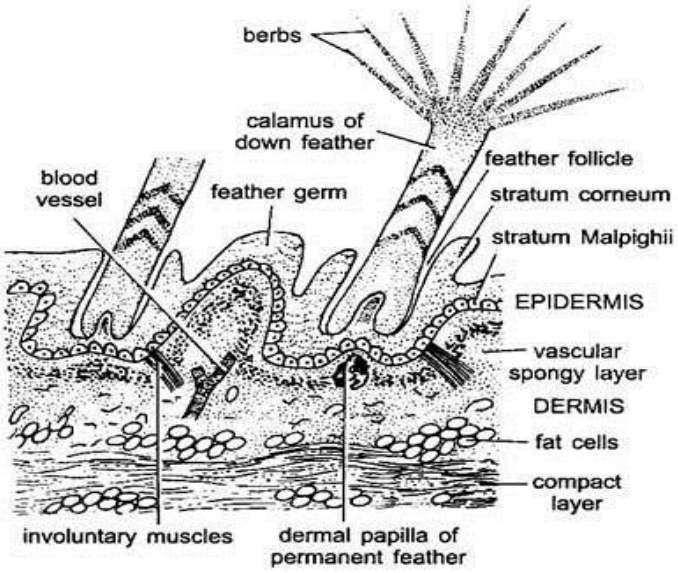


Fig. 41.18. V.S. of skin of a bird.

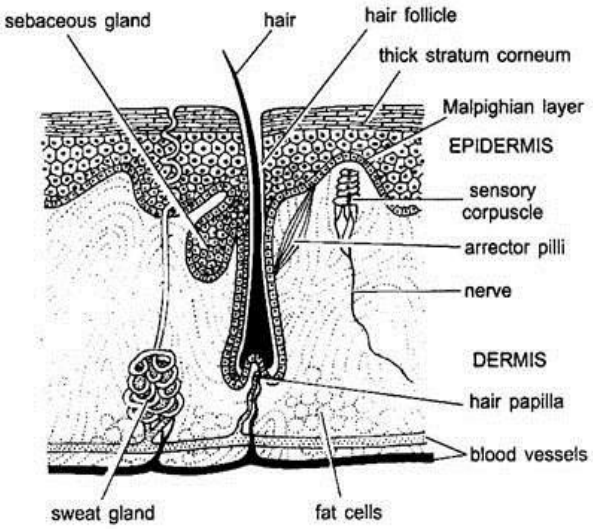
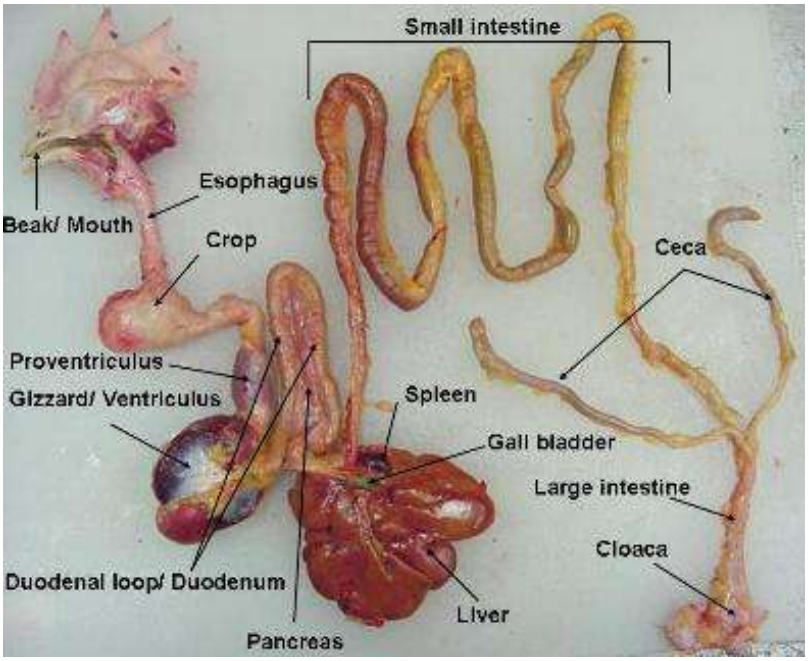


Fig. 41.19. V.S. of skin of a mammal.

Comparative Vertebrate Anatomy Dr: Ilham Al-Saleem
Digestive System

Stomach = muscular chamber(s) at end of esophagus

- serves as storage & macerating مرطبsite for ingested solids & secretes digestive enzymes
- Vertebrate stomachs:
    - **Cyclostomes** :weakly developed; similar to esophagus
    - **Fish:** amphibians, & reptiles - increasing specialization (more differentiated from the esophagus)
    - **Birds** : **proventriculus** (glandular stomach) and **ventriculus** (muscular stomach, or gizzardقانصة)

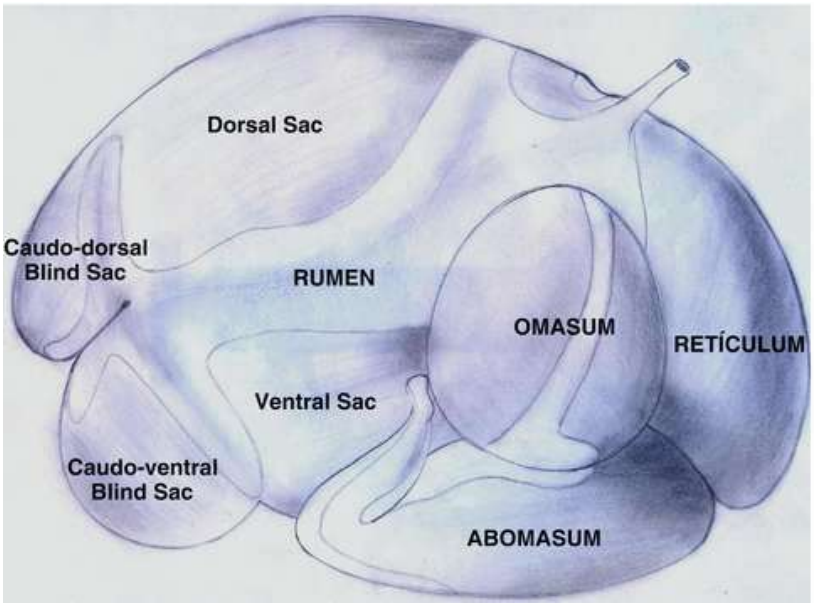


The digestive system of birds

    - Mammals - well-developed stomach; **ruminants**المجترات have multichambered stomachs:

- **Reticulo-rumen (reticulumالقلنسوة and rumenالكرش)**
- **Reticulum** and **rumen** are often discussed together since each compartmentحجرة is separated by a low partitionتقسيم. Eighty percent of the capacity of the stomach is related to the reticulo-rumen. The contents of the reticulum and rumen intermix تختلطfreely. The rumen is the main fermentation تخمير vat حجرةwhere billions of microorganisms attack and break down the relatively indigestible عسر الهضمfeed components of the ruminant's diet.
- **Omasum**القبة او الكرش الثالث

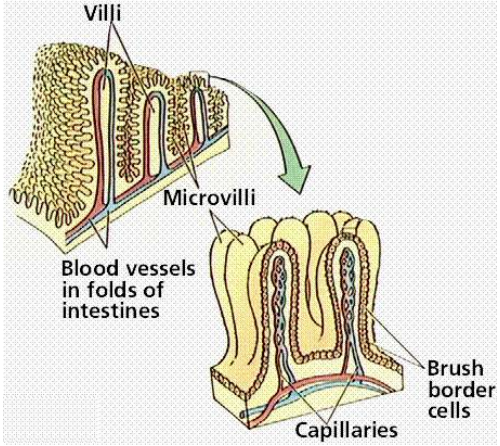
- After fermentation in the reticulum and rumen, food passes to the omasum. The omasum acts as a filter pump to sort liquid and fine food particles. Coarse fiber particles are not allowed to enter the omasum. Also, the omasum may be the site for absorption of water, minerals and nitrogen.
- **Abomasum(المعدة الرابعة)المنفحة**
- The abomasum is the true stomach and the only site on the digestive tract that produces gastric juices (HCl and the enzymes, pepsin and rennin). Ingesta الماكولonly remains here for 1 to 2 hours.



Anatomy of **Reticulo-rumen**

The **intestine**

The intestine is located between the stomach & the cloaca المبرزor anus & is an important site for digestion & absorption. Vertebrate intestines are differentiated to varying degrees into small & large intestines.

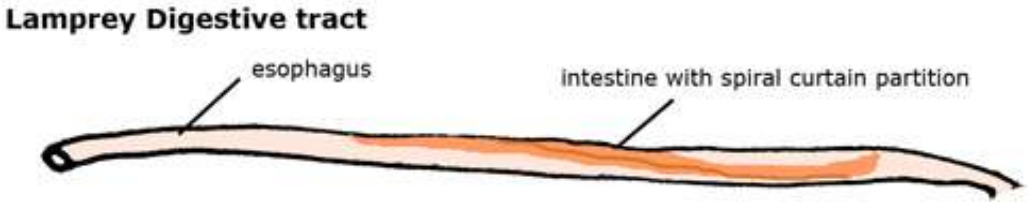


Fishes - relatively straight & short intestine in cartilaginous fishes & in primitive bony fishes (lungfish & sturgeon). However, the intestine of cartilaginous fishes has a **spiral valve**.

Amphibians : intestines differentiated into coiled small intestine and short, straight large intestine

Reptiles & Birds : coiled small intestines & a relatively short large intestine (that empties into the cloaca)

Mammals : small intestine long & coiled and differentiated into duodenum, jejunum, & ileum. The large intestine is often relatively long (but not as long as the small intestine). A cecum is often present at the junction of the small & large intestines in herbivores.



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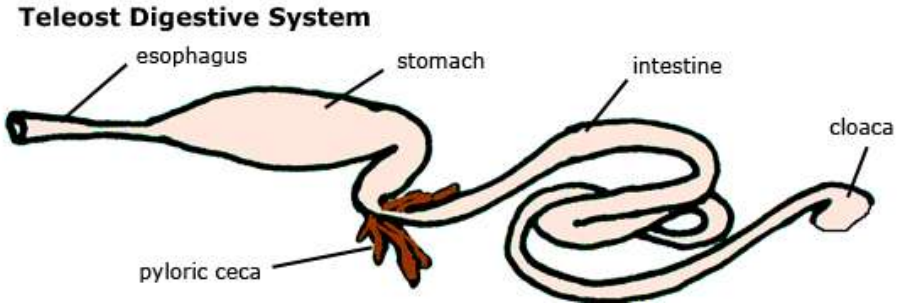

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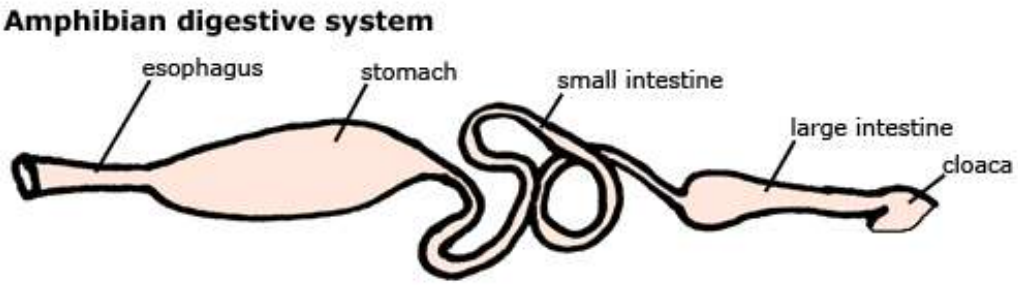

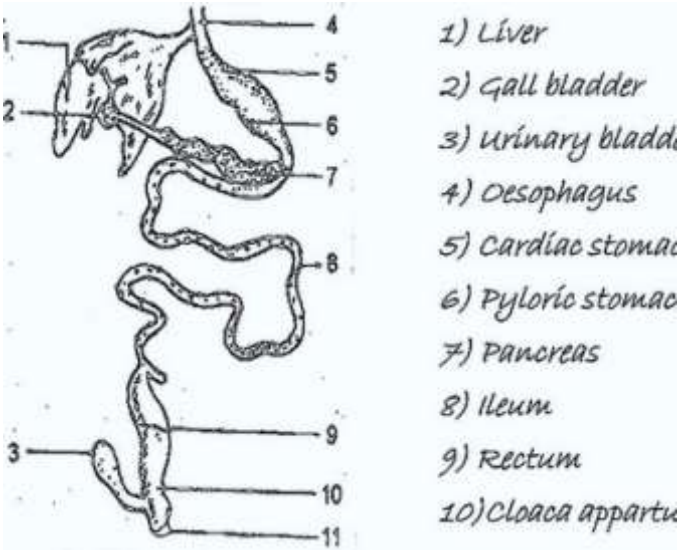

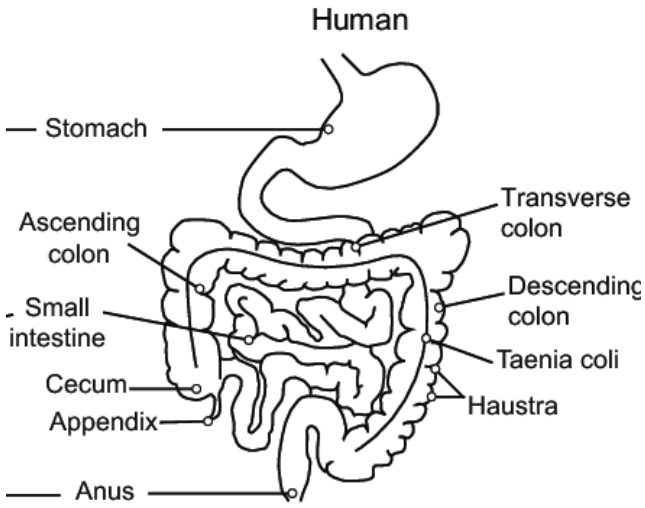

Reptile digestive system **Human digestive system**

Accessory organs - Liver, gall bladder, & pancreas

- Liver & gall bladder
  - liver produces bile which is stored in the gall bladder (cyclostomes, most birds, and some mammals, including cervids, have no gall bladder)
  - bile aids in digestion by emulsifying استحلابfats (breaking fats down into tiny particles that permits more efficient فعالةdigestion by enzymes)
- Pancreas - secretes pancreatic juice (bicarbonate solution to neutralize acids coming from the stomach plus enzymes to help digest carbohydrates, fats, and proteins) into the intestine

Ceca -الاعور blind diverticula ردب that serve to increase the surface area of the vertebrate digestive tract

- **Fishes** - pyloricبابي & duodenal cecaالاعور are common in teleosts نهائية التعظم these are primary areas for digestion and absorption .

- **Tetrapods** - ceca الاعورare present in some herbivores; may contain bacteria that aid in the digestion of cellulose

Cloaca مبرز،مدرر:

- chamber at end of digestive tract that receives the intestine, & urinary & genital ducts, & opens to the exterior via the ventفتحة
- shallow or non-existent in lampreys, ray-finned fishes, & mammals (except monotremes احادية المسلك)
- if no cloaca is present, the intestine opens directly to the exterior via anus