PRACTICAL OF FISH BIOLOGY

For students

4th Grade Zoology

Second semester

(406 Z)

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FACULTY OF SCIENCE
Zoology department

Ichthyology: the study of fishes. (Greek *Ichthys* = fish)

Fish extremes:

- **Largest (SW): whale shark (12 m)**
- **Smallest: fish range between (8.0 mm) and (7.9 mm).**

***Fish characters:**

Fishes are animals that are:

1. most always **aquatic**
2. most always **cold-blooded**
3. most always **gill-breathing**
4. **craniates**
5. Possess **fins** that are usually developed, (never pentadactyl limbs) .

What's the difference between "fish" and "fishes"?

"**Fish** "can be both singular and plural, but in all cases it refers to a single species . "**Fishes** "is always plural and always refers to more than one species .

Fish

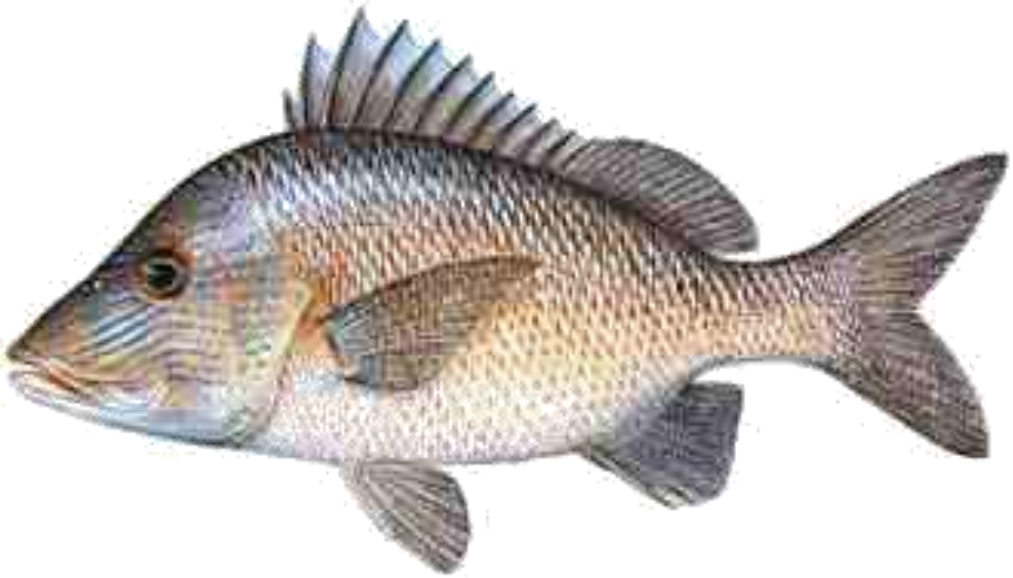
Fishes

External description of fish

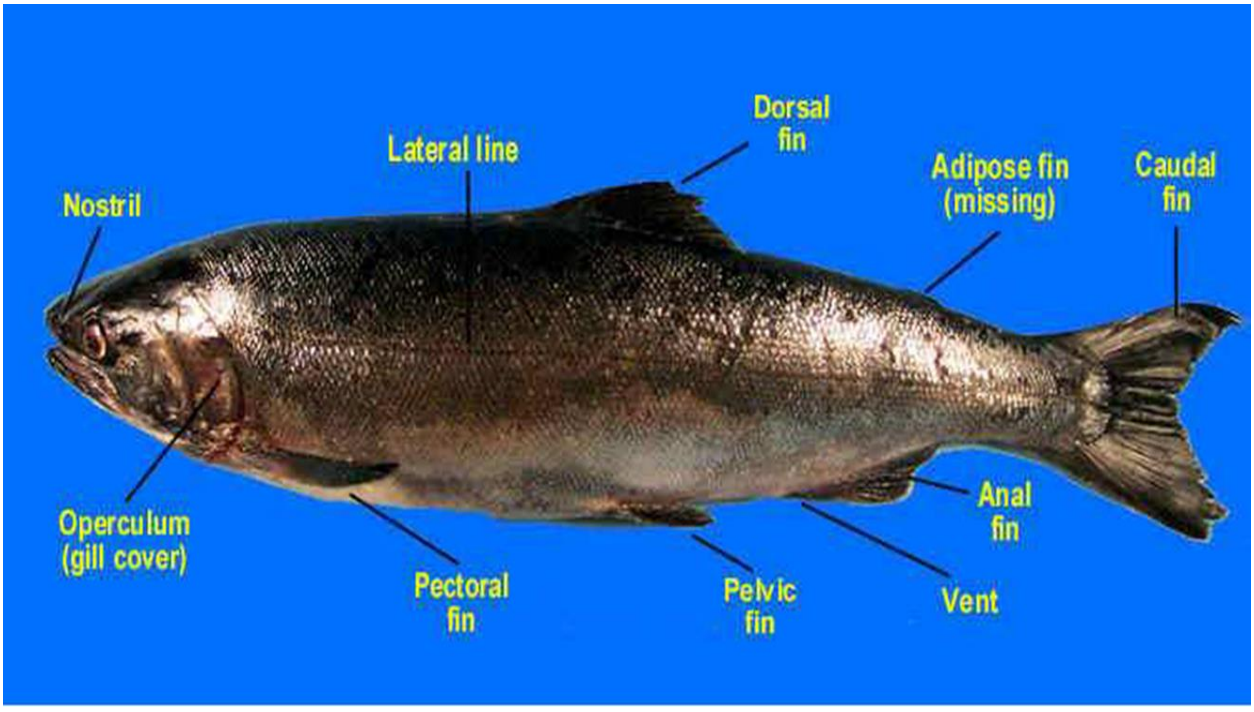
DORSAL VIEW "TOP

BILATERAL

SYMMETRY



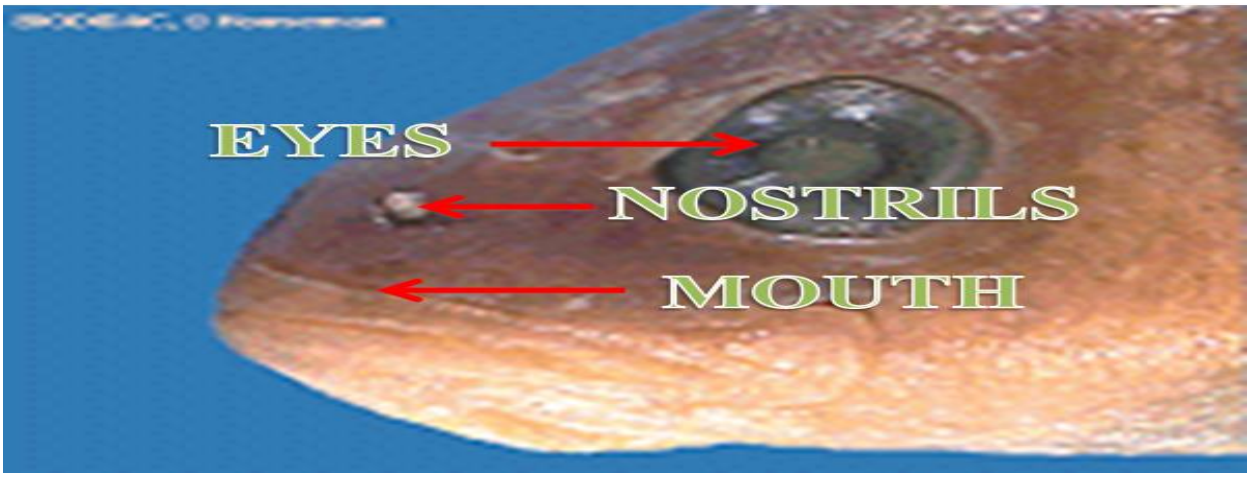
VENTRAL VIEW "BOTTOM"

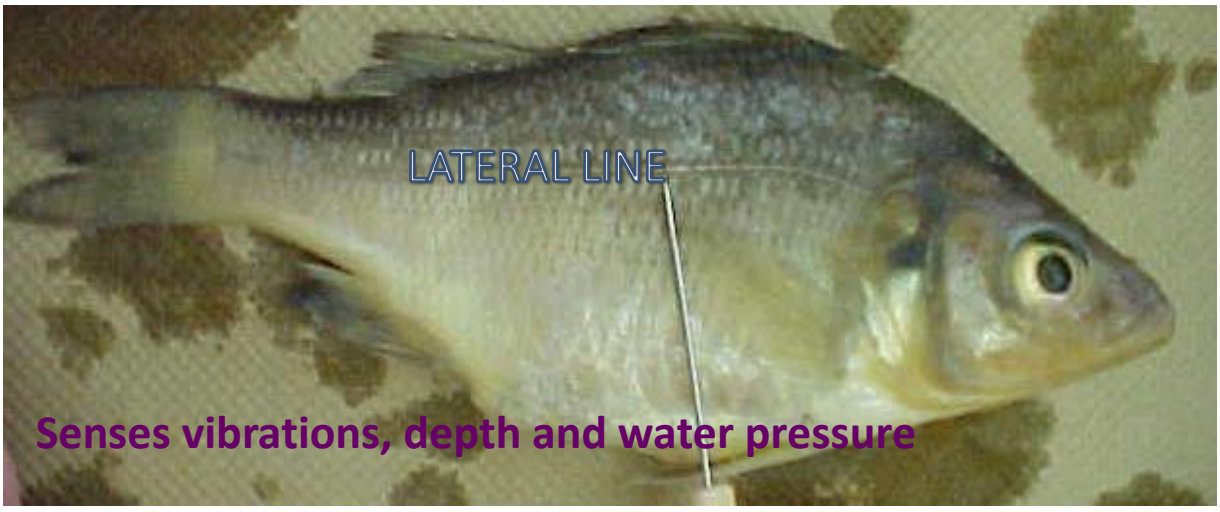


SCALES

OPERCULUM

Water goes in through mouth out through a slit behind operculum





Senses vibrations, depth and water pressure

*External description of fish:

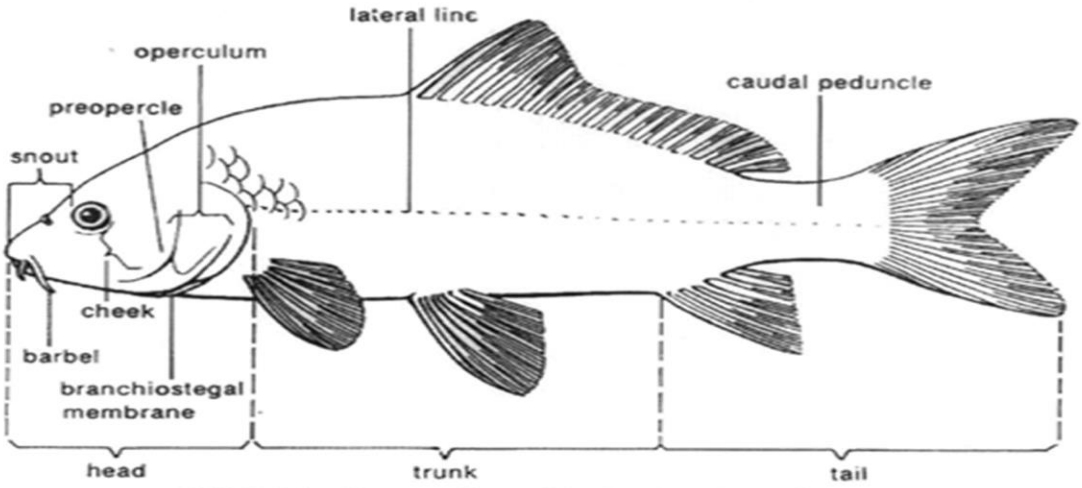


FIGURE 2–1. Diagram of bony fish, showing external features.

***The color:**

- Dorsal surface & Ventral surface

***Body shape:**

- Cylindrical (Fusiform).
- Dorsoventrally depressed (Flattened from top to bottom).
- Bilaterally compressed (Flattened from side to side).

Body size:

- Large - median - Small

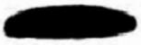
***Head shape:**

- Cylindrical.
- Dorsoventrally depressed.
- Bilaterally compressed.

Head size:

- Large - median - Small

BODY SHAPE

Crosssection	Fish	Shape	Locomotion
	 Tuna	Fusiform	Fast-swimming in open water.
	 Tautog	Compressiform	Quick speed for short distances.
	 Skate	Depressiform	Swims like a flying bird.
	 Pipefish	Filiform	Slithers through the water like a snake.

*__Eyes:__

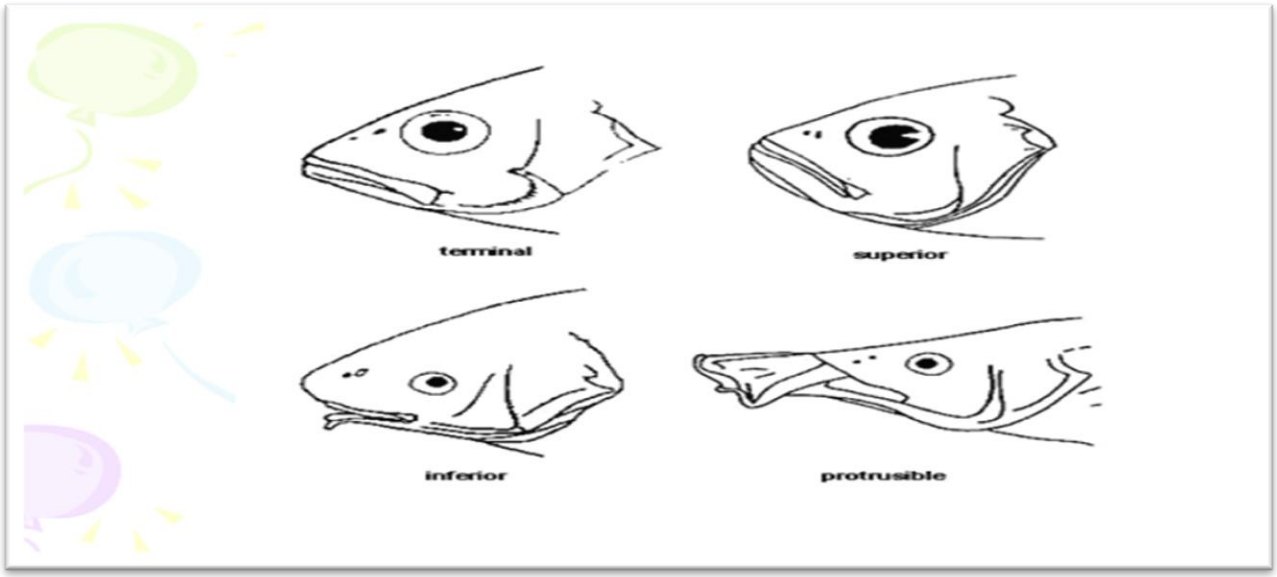
- **Shape**: (round – oval)
- **Position**: one on each side, two on the dorsal surface
- **Size**: (small – medium - large)

*__Nostrils (Nasal opening):__

- **Shape**: (round – oval)
- **Position**: One or two on each side on the dorsal surface
- **Size**: (small – medium - large)

***Mouth:**

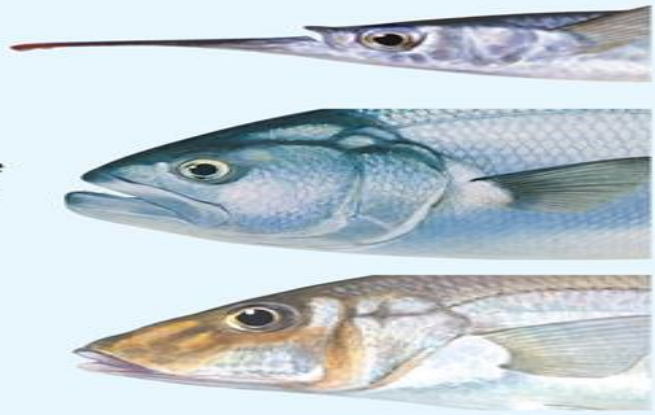
- **Position:** Terminal - Sub terminal- superior(dorsal)-inferior (ventral)
- **Size**: narrow - wide
- **Type**: Protracted or non-Protracted



Superior – the mouth is positioned towards the surface and the fish feed on what is above them, e.g., garfish and snook.

Terminal – the mouth is positioned in the middle of the head and the fish either chase prey or feed on what is ahead of them, e.g., tuna and tailor.

Inferior – the mouth is positioned towards the bottom and the fish prey upon or scavenge/graze benthic food sources, e.g., whiting and cobbler.



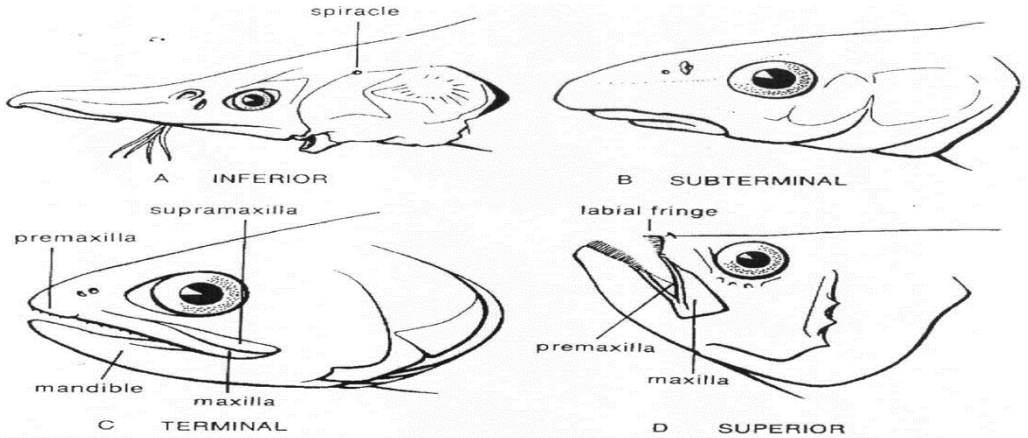
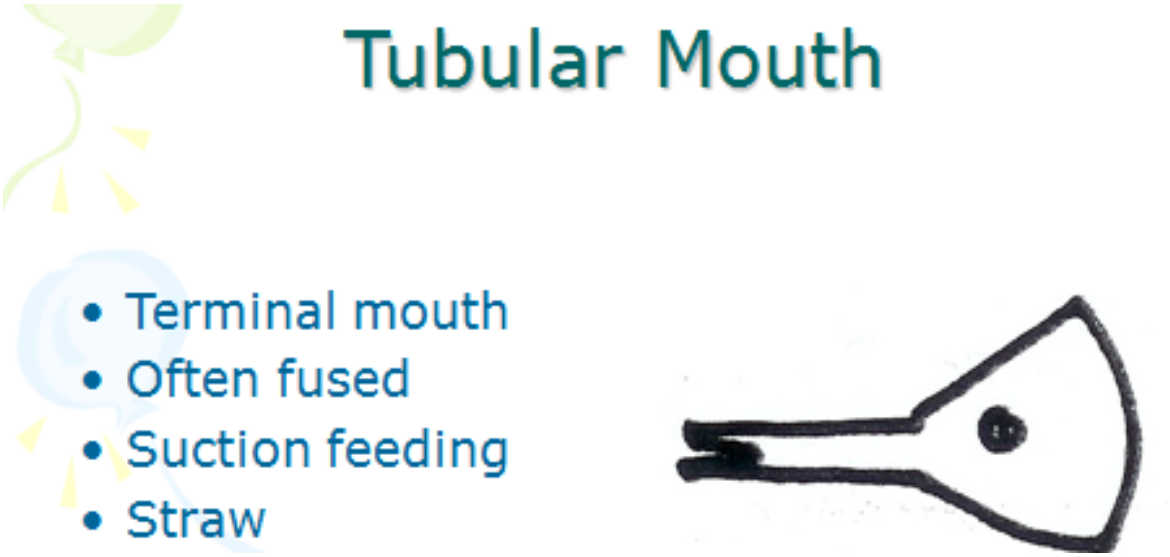


FIGURE 2–2. Examples of mouth positions in fishes. *A*, Inferior (sturgeon); *B*, subterminal (dace); *C*, terminal (trout); *D*, superior (sandfish). (*D*, based on Jordan and Evermann, 1900.)

***Snout**: Normal or Tubular or Elongated.



***Teeth:**

Absent or Present

If Present: A- position

<u>Upper jaw</u>:

Premaxillary – Maxillary – Vomerine – Palatine.

<u>lower jaw</u>:

Mandibular - Tongue

B- type

Canine ناب - molars ضرس - Incisor قاطع

<u>If canine</u>:

Uni cuspid سن واحد – Bicuspid – poly cuspid.

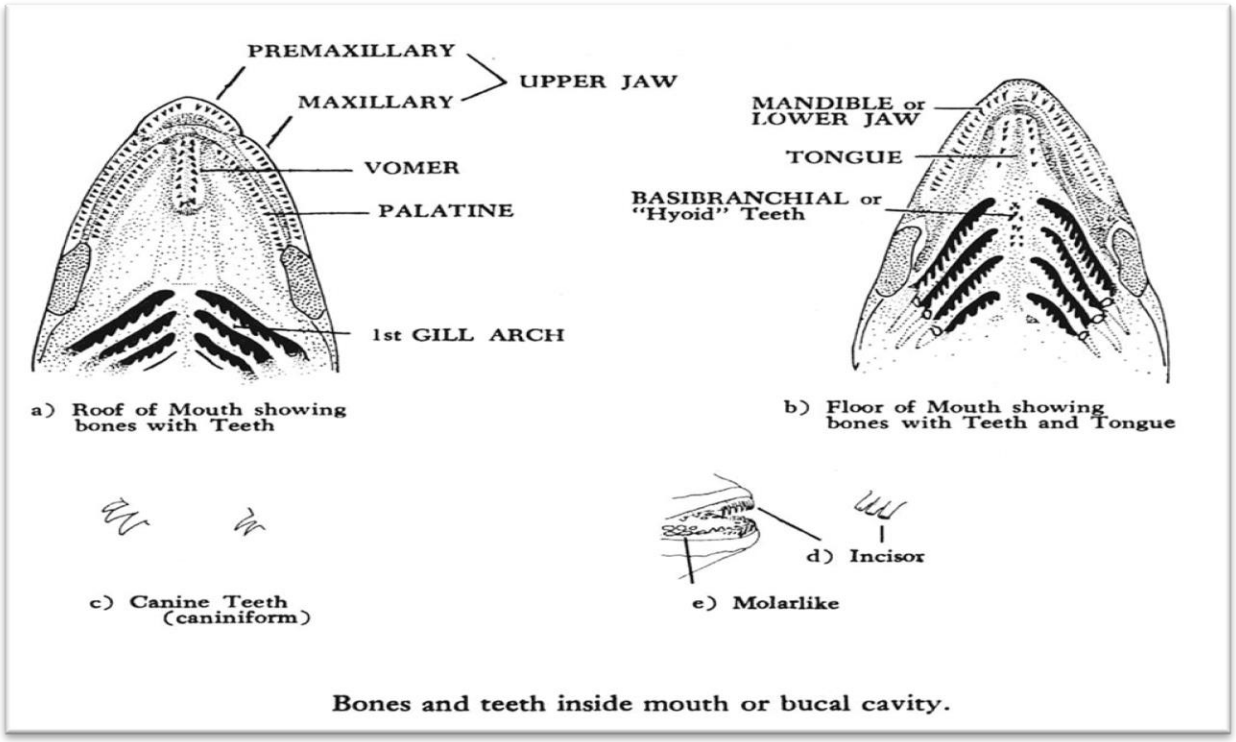
***Barbles:** Absent or Present

If Present: A- Number:

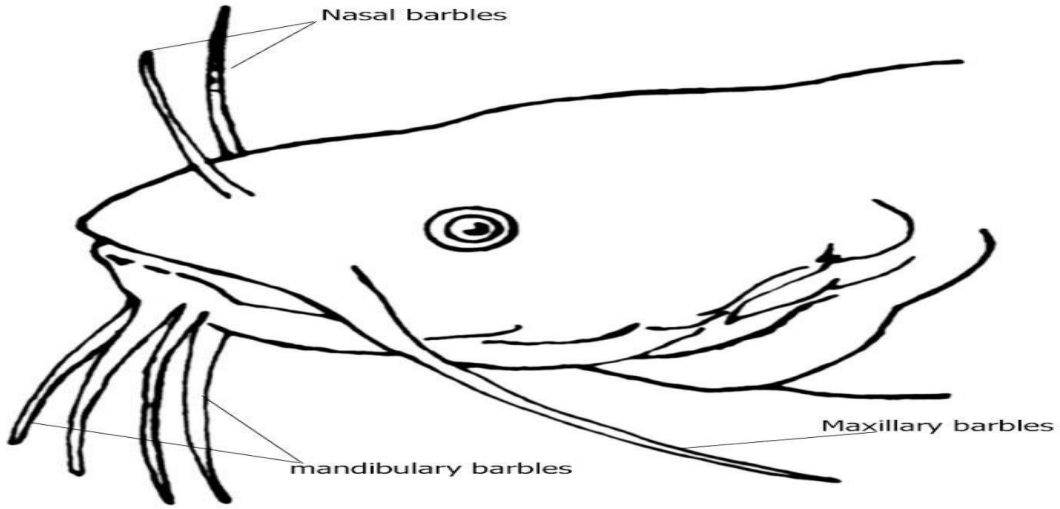
One nasal pair, One maxillary pair, Two mandibular pairs

B- Length: Short & Long

C- Branched: Branched & Not branched.



Bones and teeth inside mouth or bucal cavity.



***Operculum**

A- Connected with isthmus.

B- Separated

Overlapped & not overlapped.

Fins

***Paired fins**:

Pectoral fins:

shape: fin rays with (week – strong) spine or without.

Position: lateral, ventro-lateral, dorso-lateral

pelvic fins:

shape: fin rays with (week – strong) spine or without.

Position: ventral, ventro-lateral.

Position it for pectoral fin: posterior(abdominal), thoracic (both in the same region).

***Unpaired fines**

Dorsal fin:

Shape:(One or two parts) fin rays with spines or without spines / adipose.

Anal fin:

shape: fin rays with (week – strong) spine or without.

Position: ventral.

Caudal fin:

Shape: Pointed - Rounded - Truncate – Oval - Crescentic - Biforked.

***Fin rays:**

A- Type: simple branched

B- Number:

Rays …….. Arabic number

Spine…… Lattin number

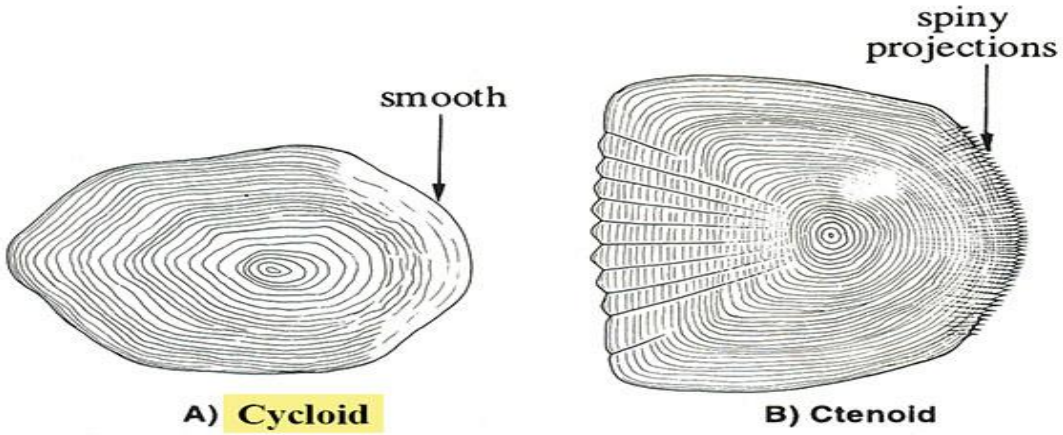
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV

***Lateral line:** One or two on each side.

Scales:

Absent & Present

If Present: Cycloid & **Ctenoid**



Scales

***Stomach:**

Fish stomachs differ in shape from group to group.

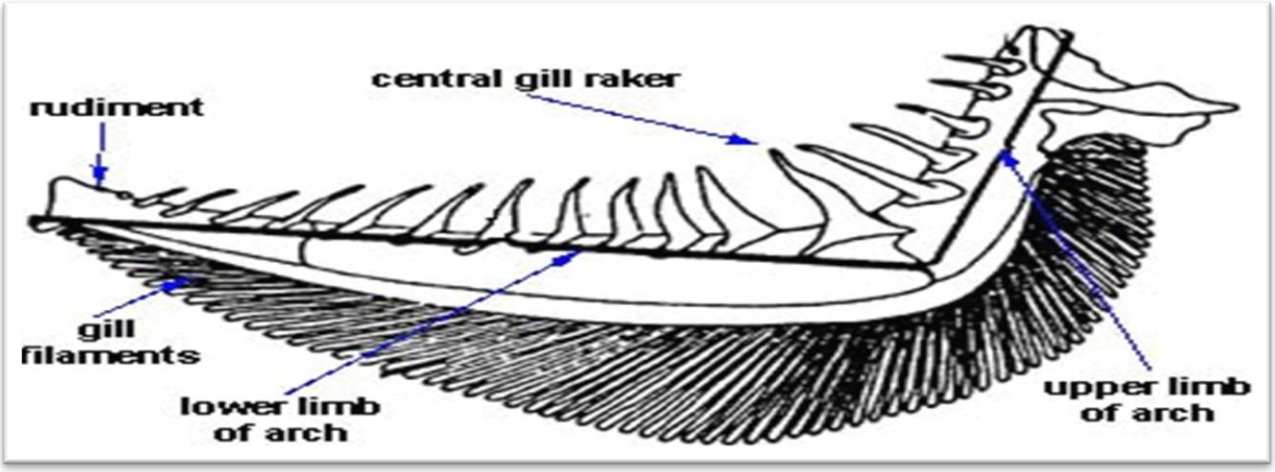
- The predators have elongated stomachs.
- Omnivorous generally have saclike stomachs.

***Intestine**:

- The predators have shortened intestines. (1/3-2/3 body length).
- herbivores, or plant eaters, have long intestines, sometimes consisting of many folds coiled (2-15x body length).

***Gill rakers:**

- long, fine, closely spaced in filter feeders.
- short and stubby in eaters of invertebrates
- shorter, widely spaced in piscivores.



*Measurements

- **The weight**
- **Body width**
- **Fulton condition factor (K factor):** It is a tool for determination of health of population and food supply.

K= (fish weight $_{gm}$/ (Forked length)^3. If no forked length, we use the **total** body length.

- **<u>Relative length of gut (RLG):</u>**

RLG= (Absolute length of gut/Slandered length of the body) × 100.

- **Gono-somatic index (GSI):**

It is a tool for measuring the sexual maturity of animal.

GSI = (Gonads weight $_{gm}$/fish weight $_{gm}$) × 100.

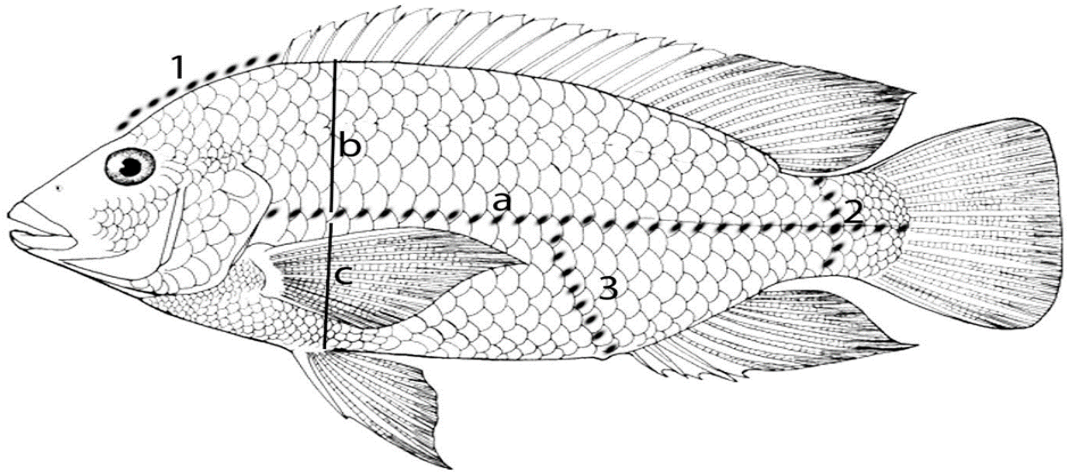
- **Scale Number: Sf * a**

Scale formula (Sf): a (b/c)

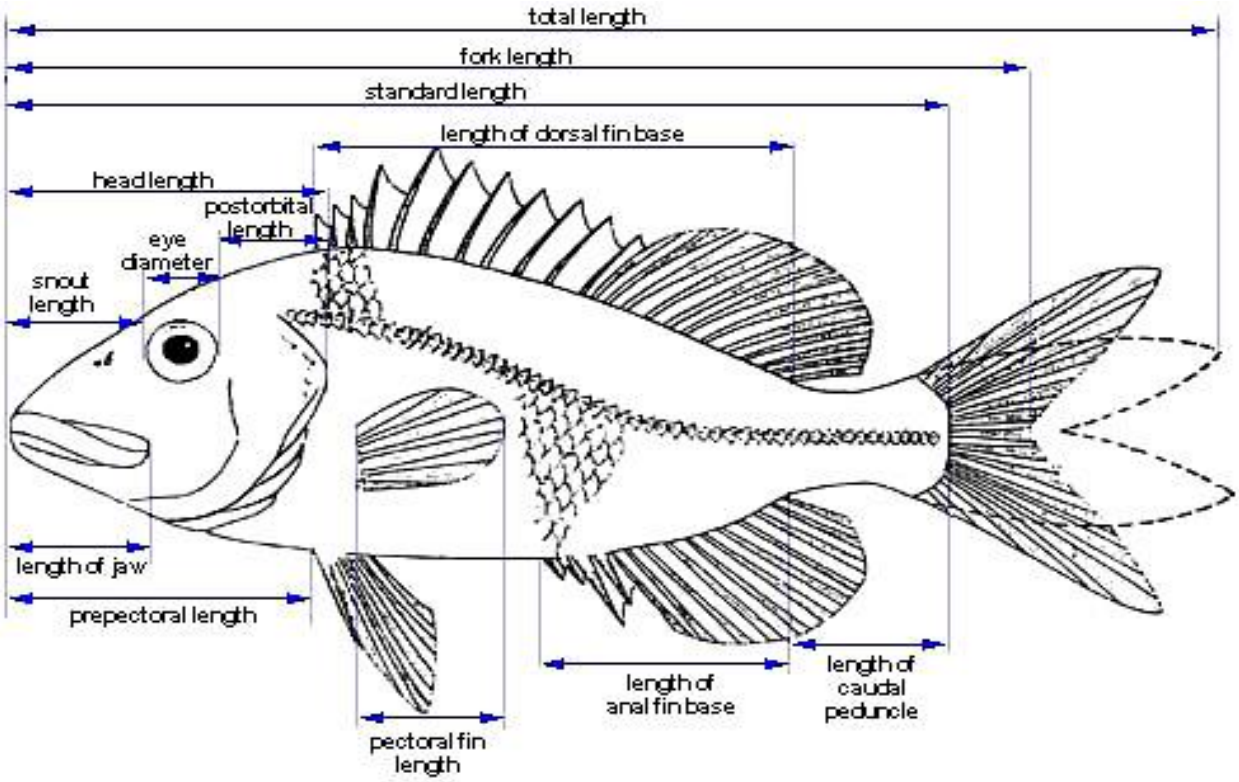
a= number of scale from the end of operculum to the end of caudal peduncle (OR : No. of scale on lateral line).

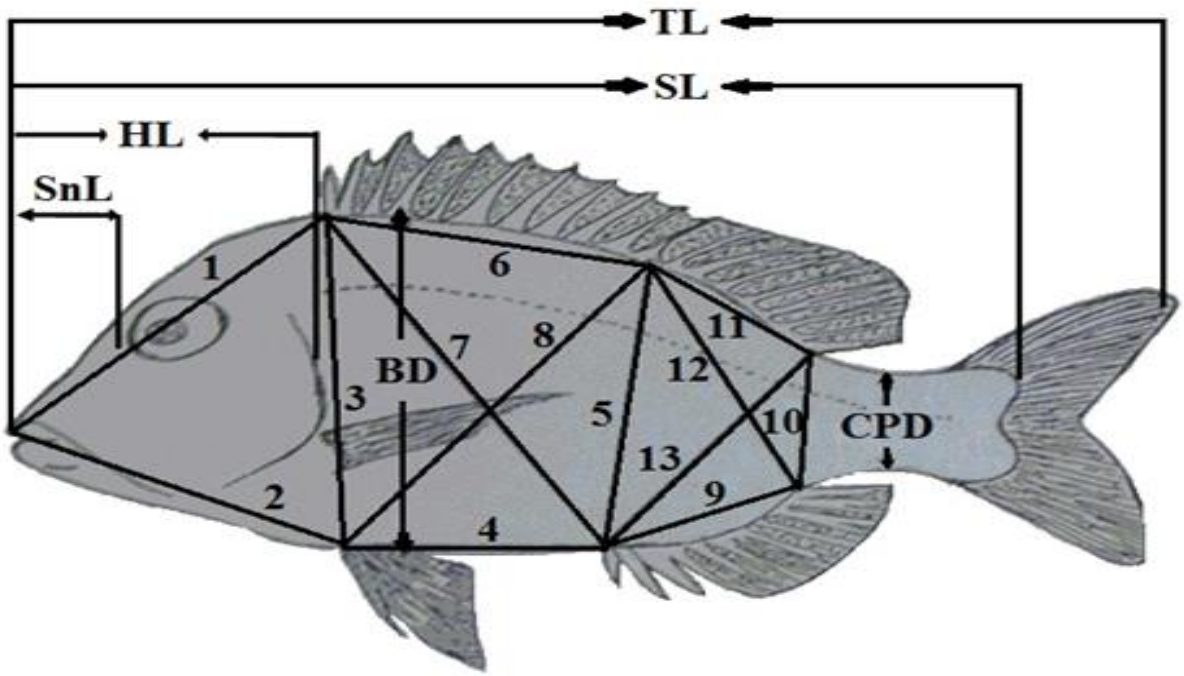
b= No. of scale from the beginning of dorsal fin to lateral line (oblique line)

c= No. of scale from the beginning of pelvic fin to lateral line (oblique line)



External measurements:





<u>Report consists of</u>:

1. **Description of External characters**

2. **Measurements (external-internal)**

3. **Pictures for all Body and head (dorsal, ventral, lateral) also scales, teeth, gill rakers, gonads.**

4. **comment:**
   - **habitat**
   - **adaptation**
   - **feeding**
   - **reproduction**

- **Morphometric measurements (definition of measurements in the attached diagram):**

Measurement	Abbreviation	In cm	Type of measurement
Total length	TL		***Reference length***
Fork length	FL		***Reference length***
Standard length	SL		***Reference length***
Head length	HL		***Reference length***
Length of snout	SnL		
Diameter of the eye	ED		
Postorbital length	POL		
Length of jaw	L J		
Body depth	BD		
Caudal peduncle depth	CPD		
Caudal peduncle length	CPL		
Pre-pectoral length	PRPL		
Pectoral fin length	Pf L		
Dorsal fin basal length	DFBL		
Anal fin basal length	AFBL		

Measurement	Abbreviation	In cm
The weight		
Body width	B w	
K factor:	KF	
Length of intestine	L in	
Relative length of the gut =Absolute length of the gut /Standard length of the body	(**R.L.G.)**	

Gono somatic index = (Wt. of gonads / Wt. ofbody) * 100	**(G.S.I.)**	
Scale formula: a (b/c)	(Sf)	
Scale number: Sf * a	S N	
Hepato somatic index = W t. of liver/ w t. of body) *100	H.S. I	

Color	dorsal:
	ventral:
Type of scales	
Lateral line	
Body (size and shape)	

Head characters:

Head shape – size		
Type of mouth (position and shape)		
Eye position		
Types of Barbles		
Nasal opening (position and shape)		
Types of teeth – position	upper jaw:	Lower jaw:
Gill raker numbers on the first left gill arch:		
Operculum (type)		

Fins

1. Dorsal

Shape/Single/Divided	
Color	
Modifications if found	
Origin/ Position	
Number of rays	
Number of spines	

2.Anal

Shape	
Color	
Modifications if found	
Origin/ Position	
Number of rays	
Number of spines	

3.caudal

Shape	
Color	
Modifications if found	
Origin / Position	
Number of rays	
Number of spines	

Pectoral fins:

Shape	
Color	
Modifications if found	
Origin / Position	
Number of rays	
Number of spines	

Pelvic:

Shape	
Color	
Modifications if found	
Origin / Position	
Number of rays	
Number of spines	

Fish Dissection

Objectives of dissection:

- There are both similarities and differences between the internal structures of humans and fish.
- Dissecting a fish will allow the student to see the insides and compare the organs a human body.

For example

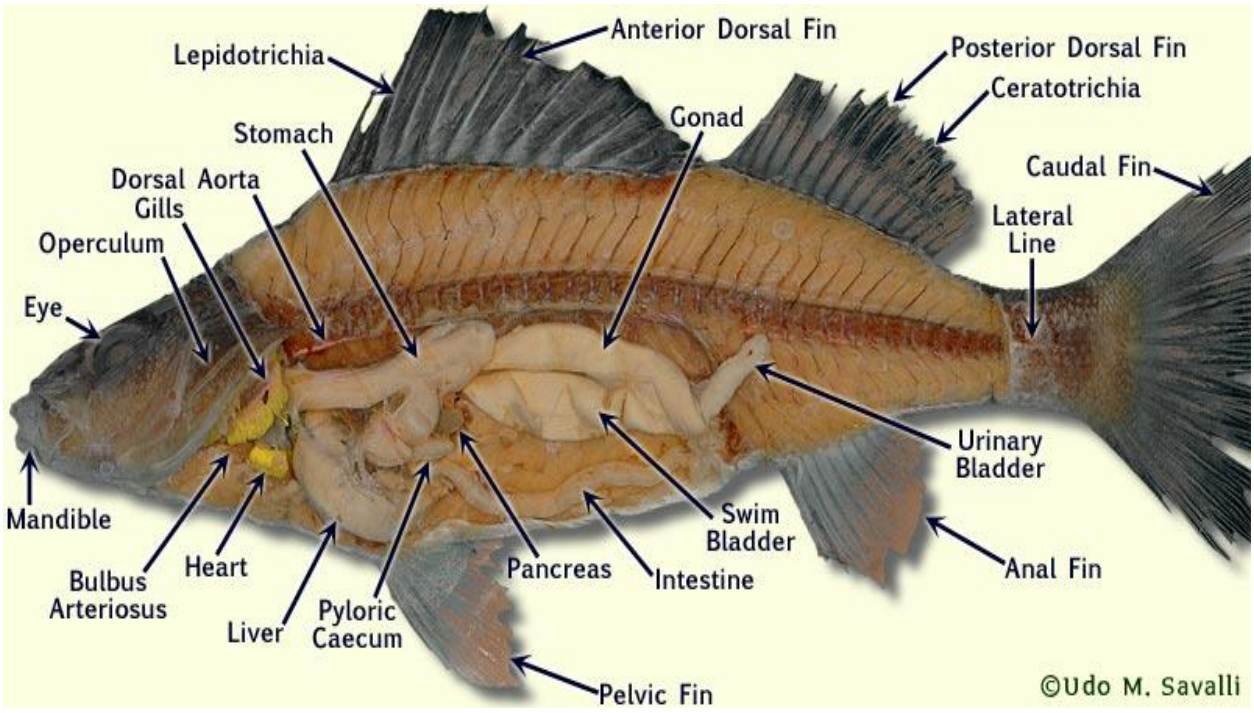
- ❖ fishes have "noses" (called **nares**) that don't look anything like our own, yet their purpose is to smell chemicals in the water.
- ❖ the **internal anatomy** will look very different from our own, however, most of the major organs are the same (e.g., **heart, stomach, liver, spleen**) and have the **same basic function**.
- ❖ A few internal structures, like the **swim bladder**, are of course unique to fishes.

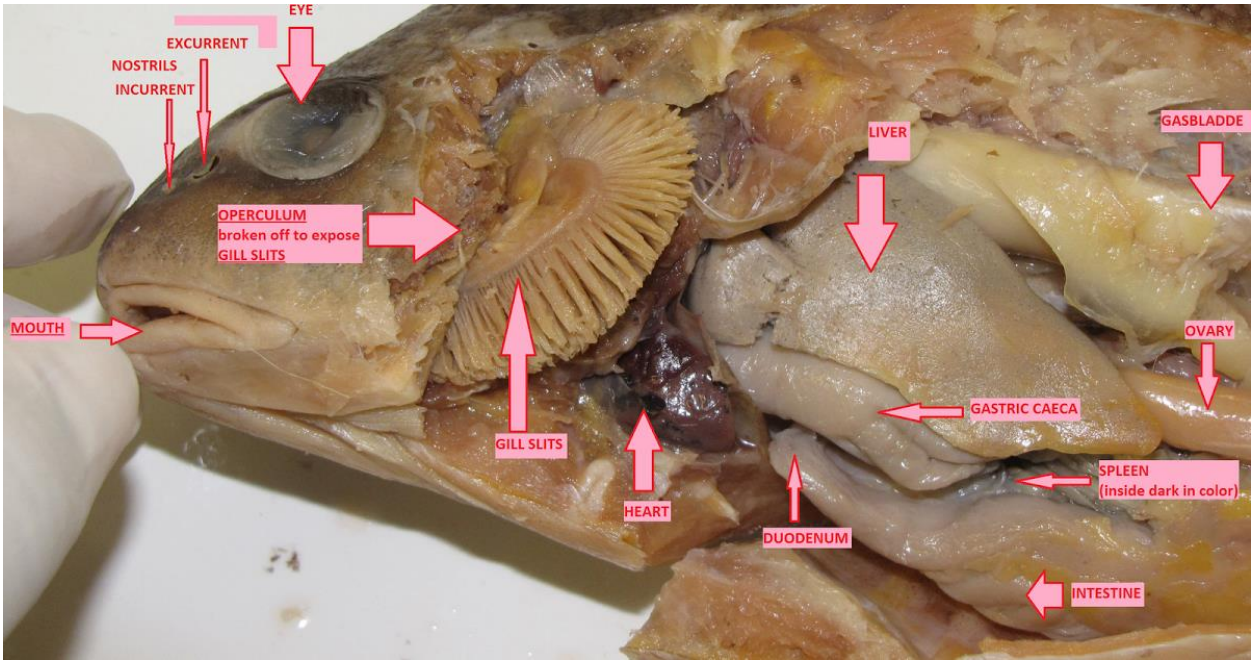
.

In this lesson we will be examining the external and internal anatomy of a bony fish and comparing this to a human

Fishes do have a few specialized structures that have no counterpart to humans.

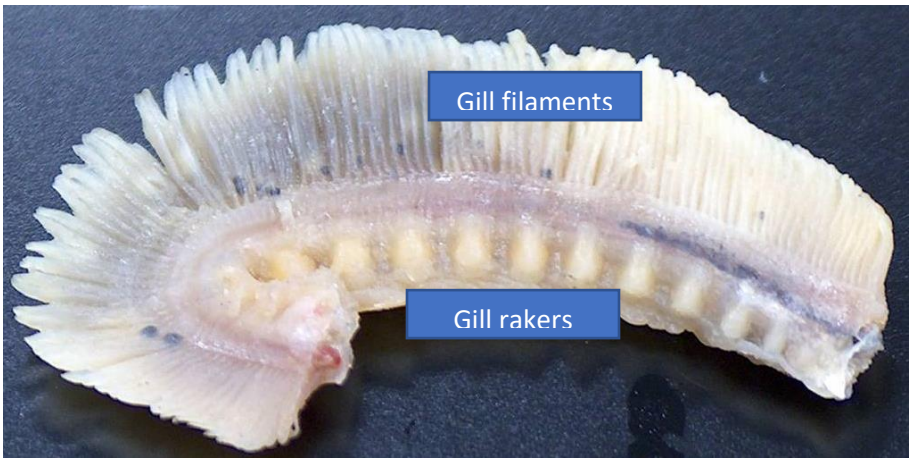
- ➢ The **lateral line:** detects physical vibrations in the water that allows the fish to sense other animals and objects in the water, even if they can't be seen.
- ➢ Many types of fishes use inner ear stones, called **otoliths**, to detect changes in body position

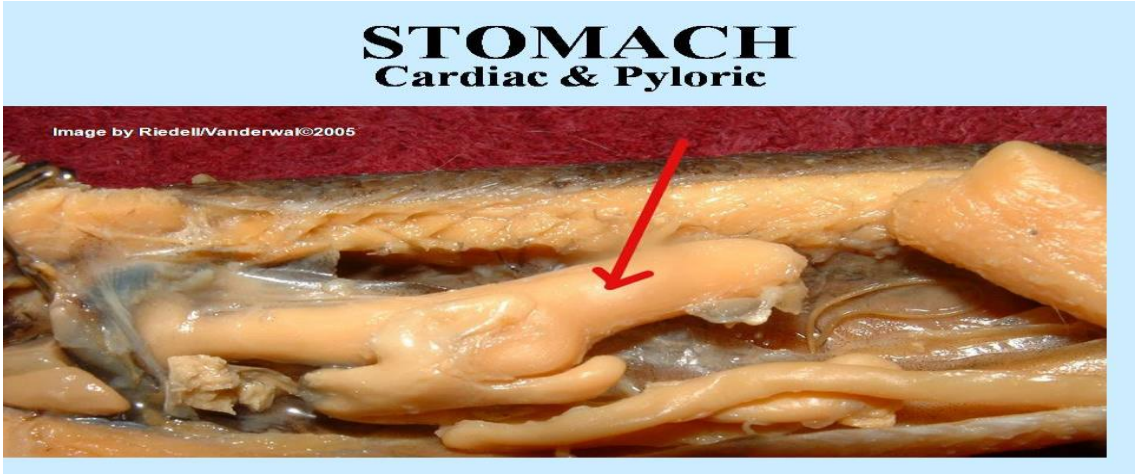

Lepidotrichia
Anterior Dorsal Fin
Posterior Dorsal Fin
Ceratotrichia
Gonad
Stomach
Dorsal Aorta
Gills
Caudal Fin
Lateral Line
Operculum
Eye
Urinary Bladder
Mandible
Swim Bladder
Bulbus Arteriosus
Heart
Pancreas
Intestine
Anal Fin
Liver
Pyloric Caecum
Pelvic Fin
©Udo M. Savalli

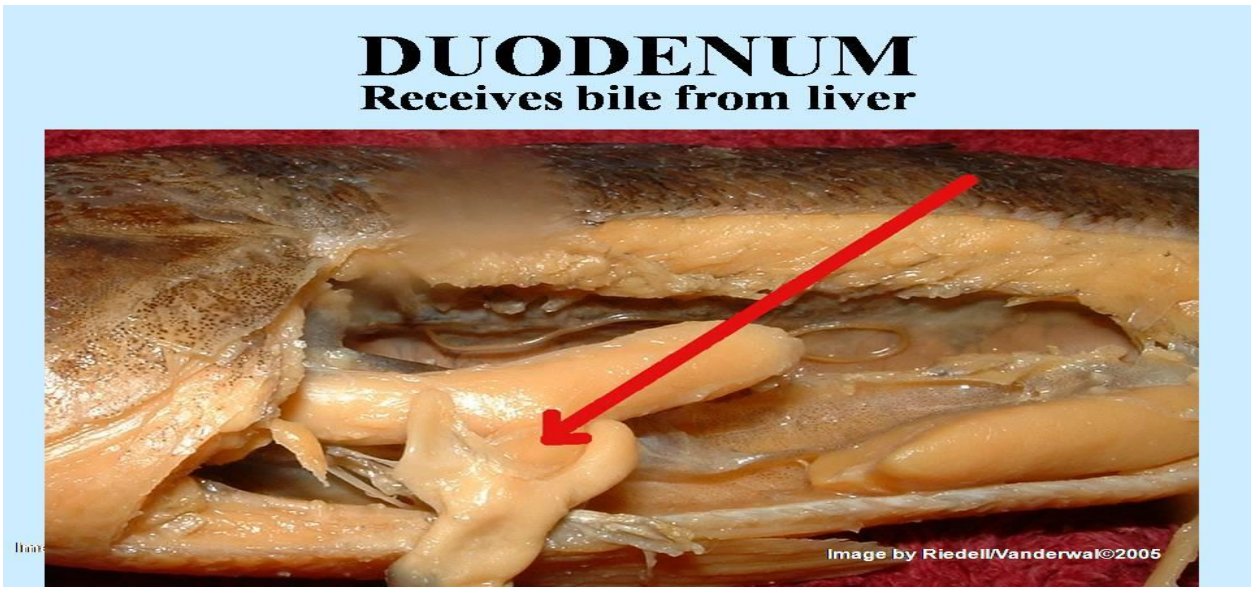

EYE
EXCURRENT
NOSTRILS
INCURRENT
LIVER
GASBLADDE
OPERCULUM
broken off to expose
GILL SLITS
MOUTH
OVARY
GASTRIC CAECA
GILL SLITS
HEART
SPLEEN
(inside dark in color)
DUODENUM
INTESTINE

FUNCTIONS OF GILLS:

1. **Gas exchange**
2. **Excrete Nitrogen waste as ammonia.**





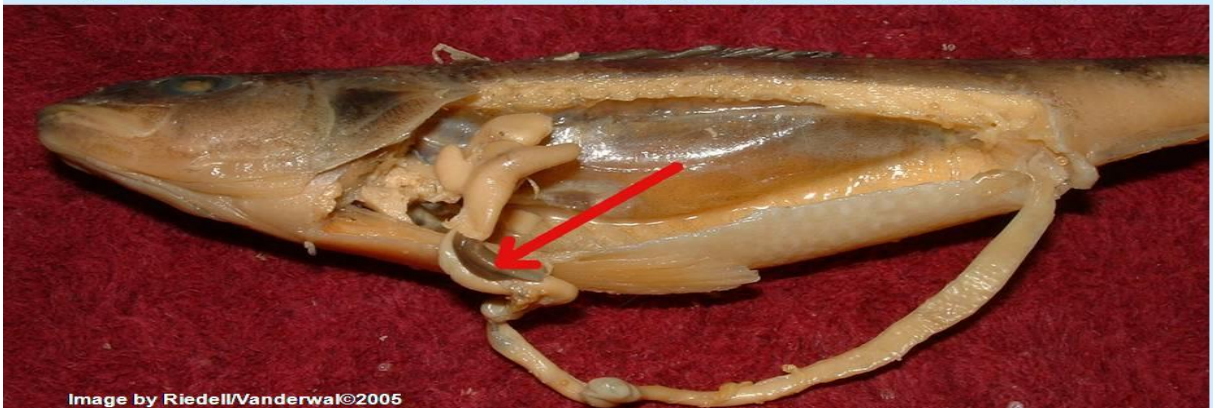

DUODENUM
Receives bile from liver
Image by Riedell/Vanderwal©2005


INTESTINE
Absorbs nutrients.


LIVER
improved digestive gland

SPLEEN-

Produces new RBC's
Processes & destroys old worn out RBC's
Stores RBC's for release when needed



SWIM BLADDER

controls buoyancy

KIDNEY

Collects and removes nitrogen waste (ammonia)
Osmoregulation –maintain water/ion balance

HEART

Atrium receives blood from Sinus venosus

Ventricle – pumping chamber

Conus arteriosus-smoothes flow of blood out of heart

BRAIN

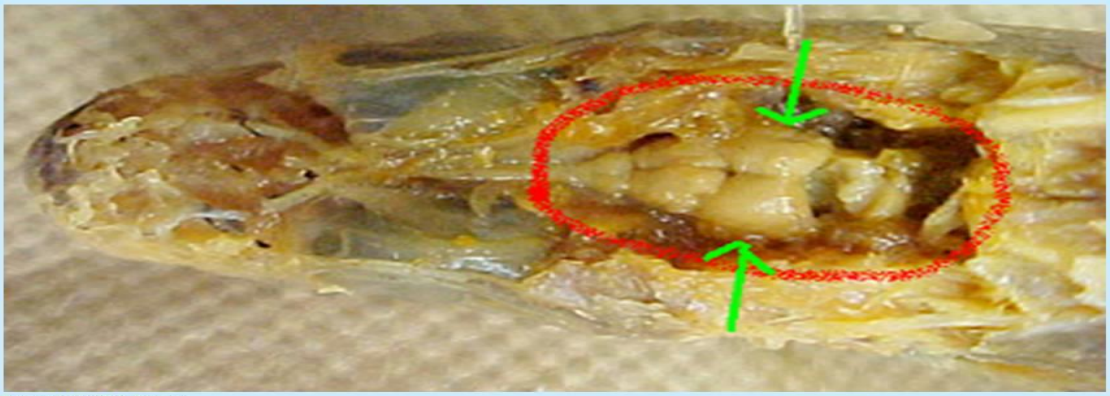


Image modified from:
http://www.flushing.k12.mi.us/srhigh/tippetti/biology/perch/index.html

Modifications of Fins

Fins

• Structure supports an independent evolutionary history of cartilaginous and bony fishes.
• Most fish have two sets of paired fins and four unpaired fins.
• Fins are used to propel الدفع, stabilize للاتزان and maneuver (تناور فى خدع العدو)

Internal Support for Fins:
• Supports have independent evolutionary history in bony & cartilaginous fish
• Fin rays are internal supports for fins
– Ceratotrichia (cartilaginous)
• Stiff صلب, unbranched, unsegmented
– Lepidotrichia (bony fish)
• Flexible, branched, segmented
• True spines may occur that emerge into fins.

Paired fins:

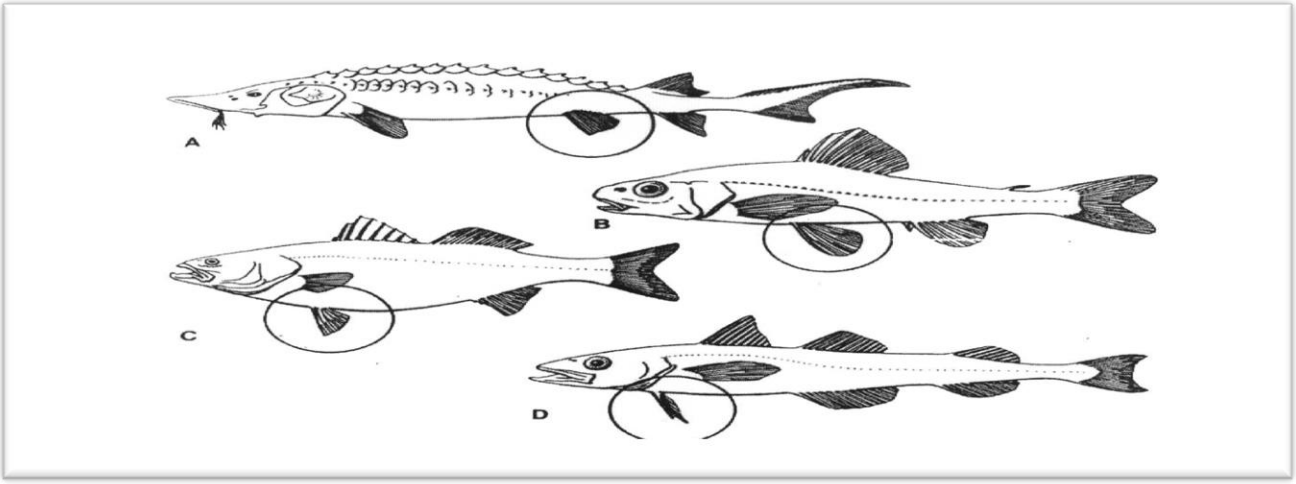
• Pelvic fins:
– Most variable in position:
1– Ancestral, = ventral, toward posterior.
2– Derived = thoracic.
3– Rarely in front of pectoral.

• Pectoral fins:
– Usually on sides.

Modifications:

- Pectoral fins modifications as wings, filaments,
  - wings: it helps the fish to fly in water for breathing or eating.
  - Filaments: it helps the fish to stand and walk.
- Pelvic and pectoral also modified into:
  - leg-like structure for walking

(Position of pelvic fins in fishes)



- Pelvic fins modifications as sucking devices

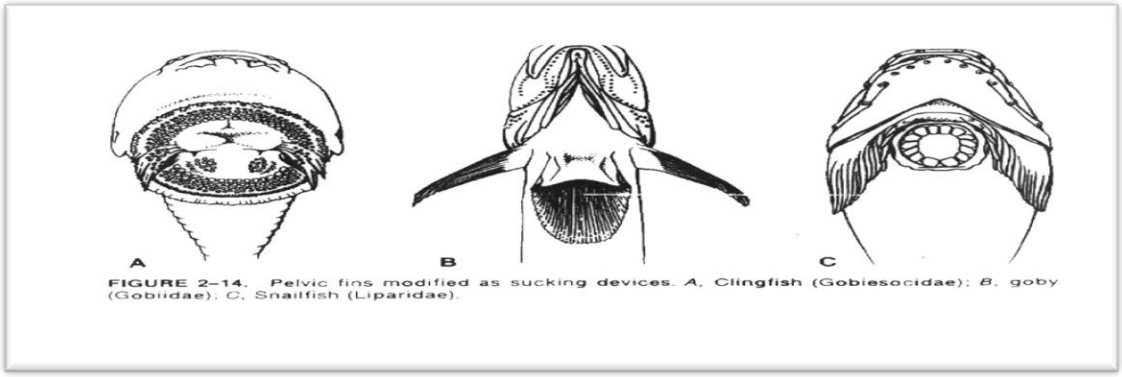


FIGURE 2–14. Pelvic fins modified as sucking devices. *A*, Clingfish (Gobiesocidae); *B*, goby (Gobiidae); *C*, Snailfish (Liparidae).

Modified dorsal fins:

1.sucking disc. 2.fishing rod and lure.

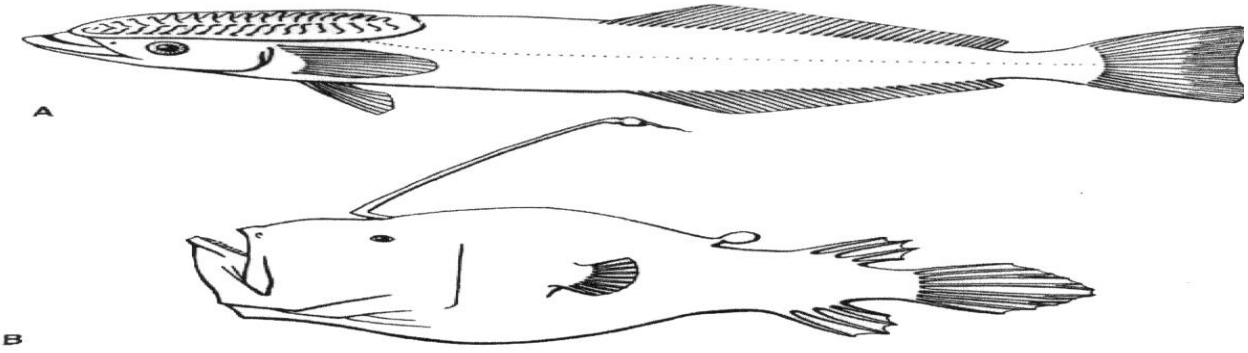


FIGURE 2–15. Modified dorsal fins. *A*, Sucking disc (remora, Echeneidae); *B*, fishing rod and lure (angler, Ceratiidae); (*B* based on Jordan and Evermann, 1900.)

EVOLUTIONARY TRENDS IN FISH MORPHOLOGY

Evolutionary trends:

- A shift in position of the paired fins (pectoral and pelvic fins).
- An increase in overall spininess (e.g., fins and scales).
- Changes in body shape.

THE PRIMITIVE FISH BODY PLAN:

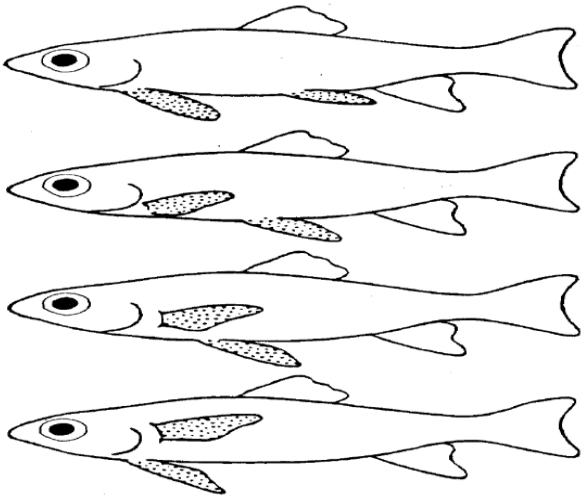
Long, skinny head and body, fins placed posteriorly, without spines, generally large adult body size; built for speed in open water; examples might include tarpon, herring, sardines, anchovies, salmon and trout.

THE DERIVED FISH BODY PLAN:

Short, deep head and body, fins placed far forward, full of spines, and generally small adult body size; built for maneuverability in complex, tight, crowded habitats; examples include squirrelfishes, cichlids, basses, surgeon fishes, angel and butterfly fishes, and a vast diversity of additional groups.

Shift in position of the pectoral and pelvic fins:

- Pelvic fins are abdominal in primitive bony fishes, but come to lie beneath the pectoral fins (thoracic) in derived fishes.
- Pectoral fins are inserted horizontally and low on the body in primitive fishes, but more vertically and high on the body in derived fishes.



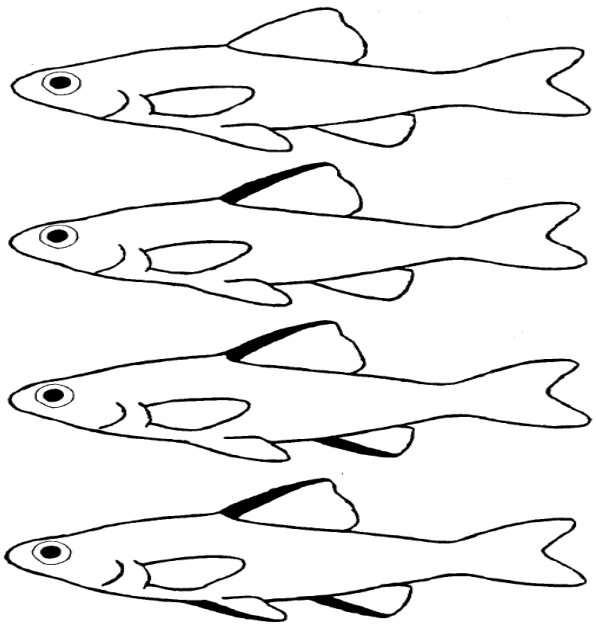
Primitive

Derived

Increase in overall spininess:

For example, the acquisition of fin spines:

- in primitive bony fishes: the fins are supported by soft pliable rays.
- in derived bony fishes: they are supported by stiff sharp spines.



Primitive

Derived

Difference between primitive and advanced fish:

primitive fish:

- Long body.
- Pelvic fin faraway pectoral fin.
- pliable rays.

advanced fish or derived:

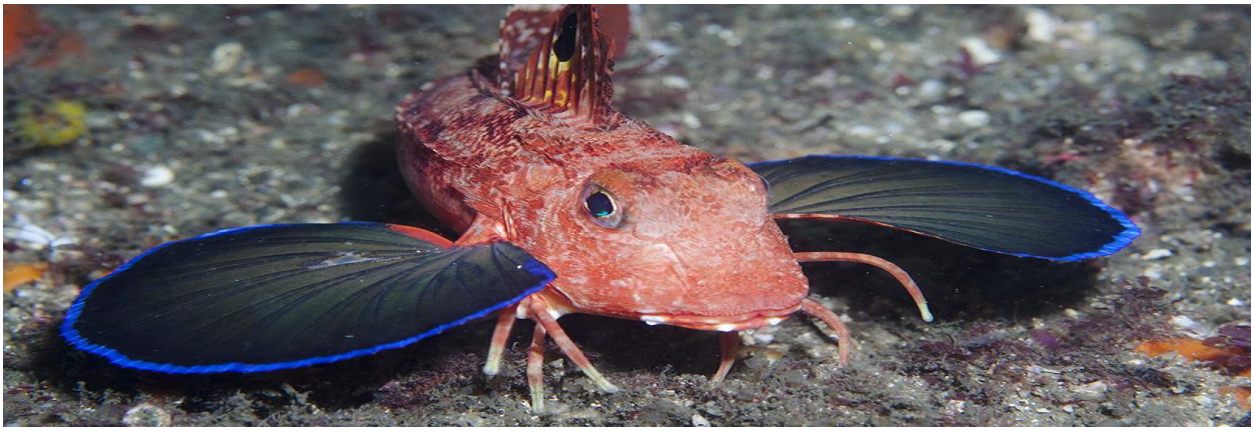
- Small body.
- Pelvic fin close to pectoral fin.
- Hard spines.

Pictures of Modifications

- Pelvic fins: modified into sucking, which helps a fish hold on to objects on the bottom.

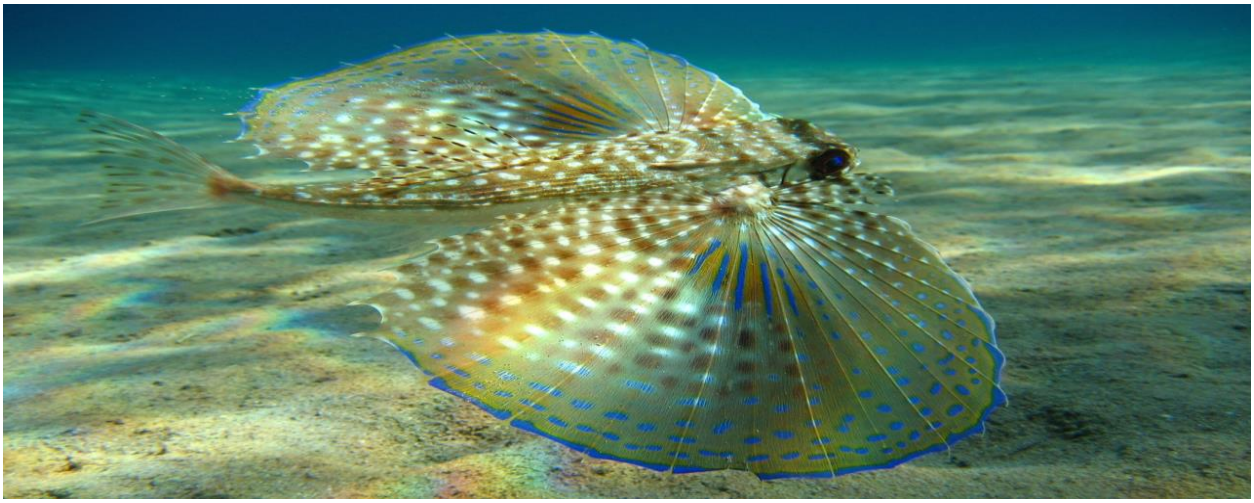
- Pectoral fins modified into wings for gliding in water, pelvic fins modified into filaments for supporting for standing on seafloor .

- sea robin use their Pectoral fins for gliding around in the currents of water. Use their pelvic fins that modified into six finger-shaped spines that beneath pectoral fins to walk on the seafloor, also to find tier prey.



- Pectoral fins modified into filaments, pelvic fins modified into leg-like structure for supporting on seafloor and walking.

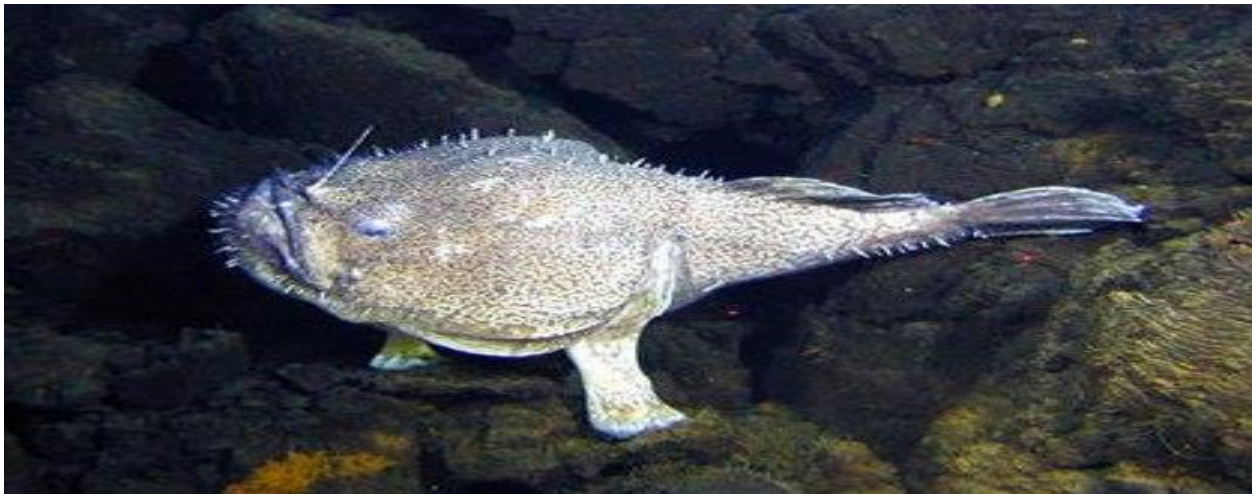
- Pectoral fins modified into wings for gliding over the water.



- Pectoral fins modified into wings for gilding in water. Advanced (indicate reasons).

- Pectoral and pelvic modified into legs-like structure for walking.

- Advanced(present strong spines- small body)
- pectoral fins modified into legs –like structure for walking.



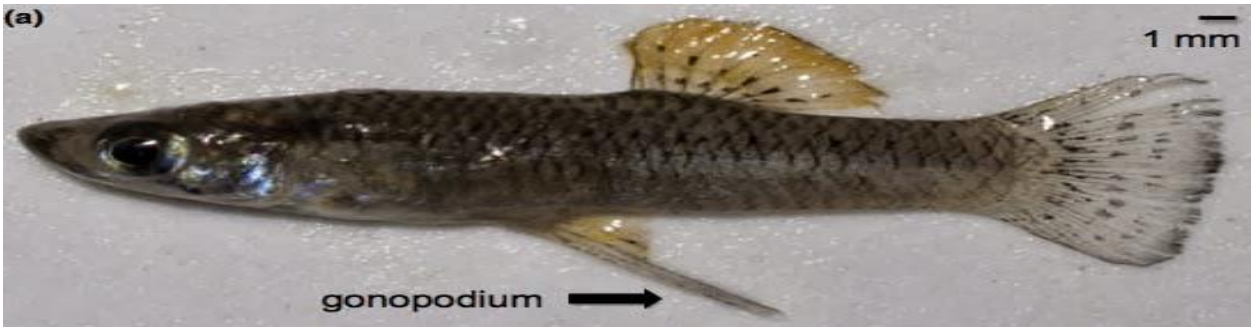
- Pectoral fins, pelvic fins and caudal fins modified into strong spines as leg- like structure supporting for standing and walking.

- Dorsal fin modified into sucking disc.

- Dorsal fin modified into a lure or rod which helps to attract the prey , advanced: small body – spines).

- Part of dorsal fin modified into light organ &advanced.

- Anal fin modified into gonopodium help in reproduction.



1-Prehensile tail used for coiling round the sea weeds.

2-Tubular mouth and snout used as sucking device.

3-Advanced:

1-with an exoskeleton of bony rings.

2-small body.

- Advanced: Small body- spines-pelvic close to pectoral.

- Color for adaptation &Advanced (Small body- spines).

- Advanced: Small body- pelvic close to pectoral fins.

- Primitive: long body- long distance between pelvic and pectoral fins- not spines- dorsal fins divided into several parts.

- Advanced: small body-spines- pelvic fins close to pectoral fins
- Caudal fins: lunate used it for maintaining rapid speed for long duration.

Color: for adaptation

Pectoral fins: modified into large structure used for Crawl on the sand of sea floor.

Histology of bony fishes

Histological sections in different fish organs showing basic structures of each organ pointed by arrow in the following photo sections.

Name of section:

***Section of bony fish liver showing:**

figure1-cords of hepatocytes, central vein and bile duct.

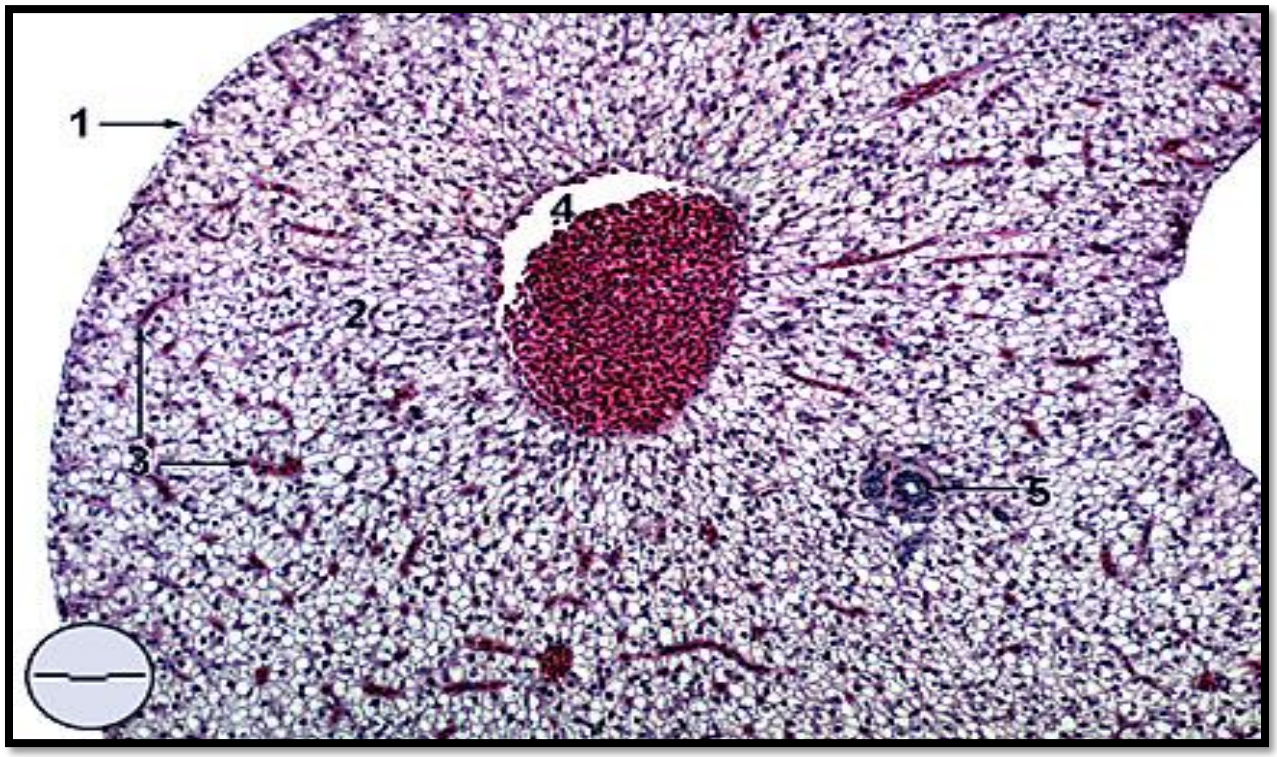


Figure 2. Cords of hepatocytes and central vein, transverse section (Formalin, H&E, Bar = 84.8 µm). 1. liver capsule; 2. cords of hepatocytes; 3. sinusoids containing red blood cells; 4. central vein; 5. bile duct.

figure2- sinusoid and bile duct

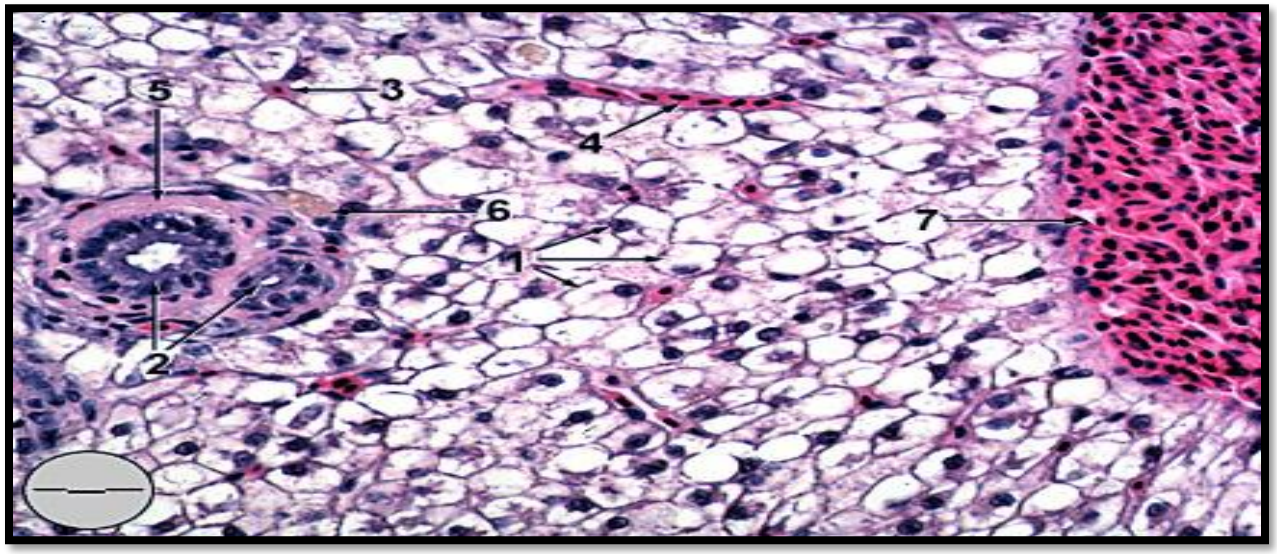


Figure 3. Sinusoids and bile ducts (Formalin, H&E, Bar = 22.8 µm).
1. hepatocytes with glycogen vacuoles and eccentric nuclei; 2. transverse section of bile ducts; 3. transverse section of a sinusoid comprised of six hepatocytes surrounding a capillary; 4. sagittal section of a sinusoid capillary; 5. connective tissue; 6. tissue macrophage; 7. central vein.

figure3- sinusoid and bile canaliculi.

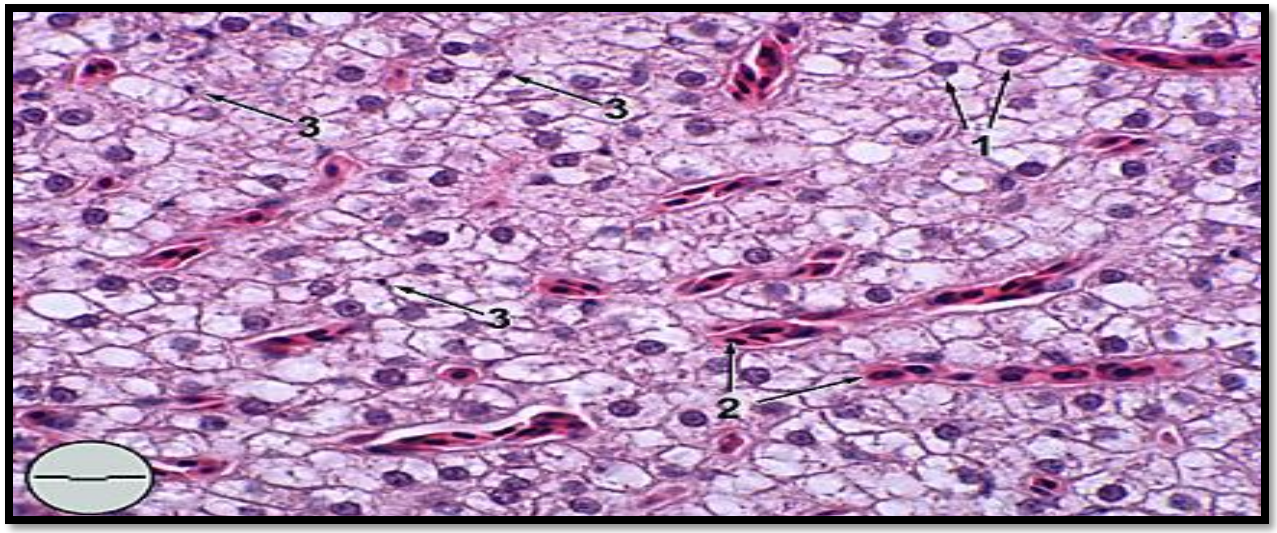


Figure 4. Sinusoids and bile canuliculi (Formalin, H&E, Bar = 15.3 µm).
1. hepatocytes; 2. sagittal section through sinusoids; 3. bile duct canuliculi.

Name of section:
Transverse section of bony fish kidney showing:
figure1- glomerulus, Bowman´s space.

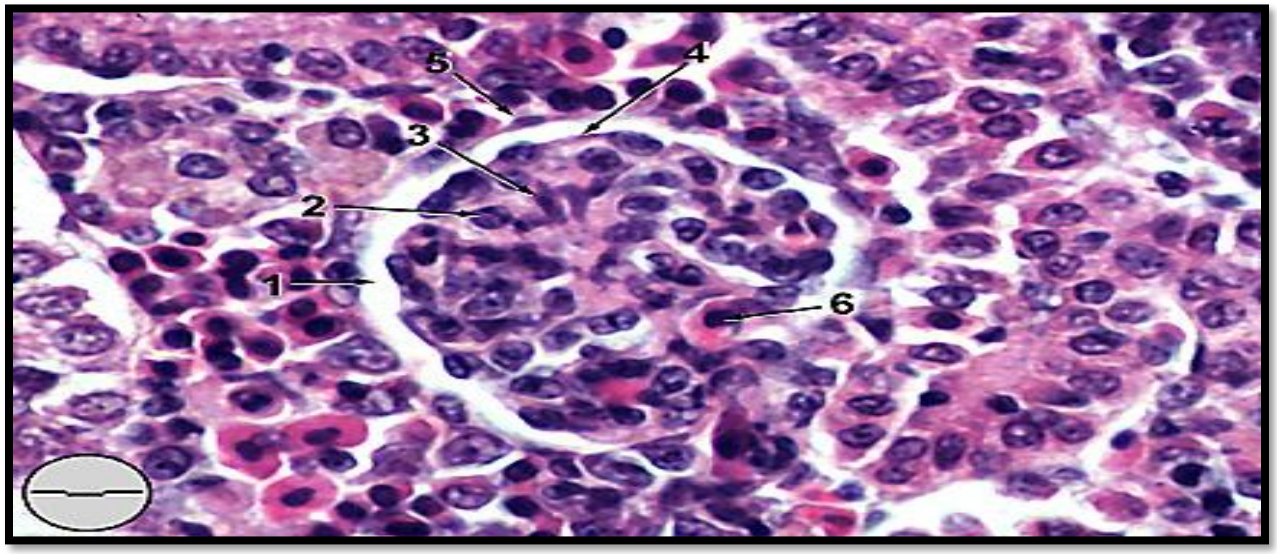


Figure 2. Glomerulus (Formalin, H&E, Bar = 10.7 µm). 1. Bowman's space; 2. endothelial cell; 3. mesangial cell; 4. visceral epithelium of the renal capsule; 5. parietal epithelium of the renal capsule; 6. red blood cell in capillary.

figure2-kideny tubules, collecting duct and brush border.

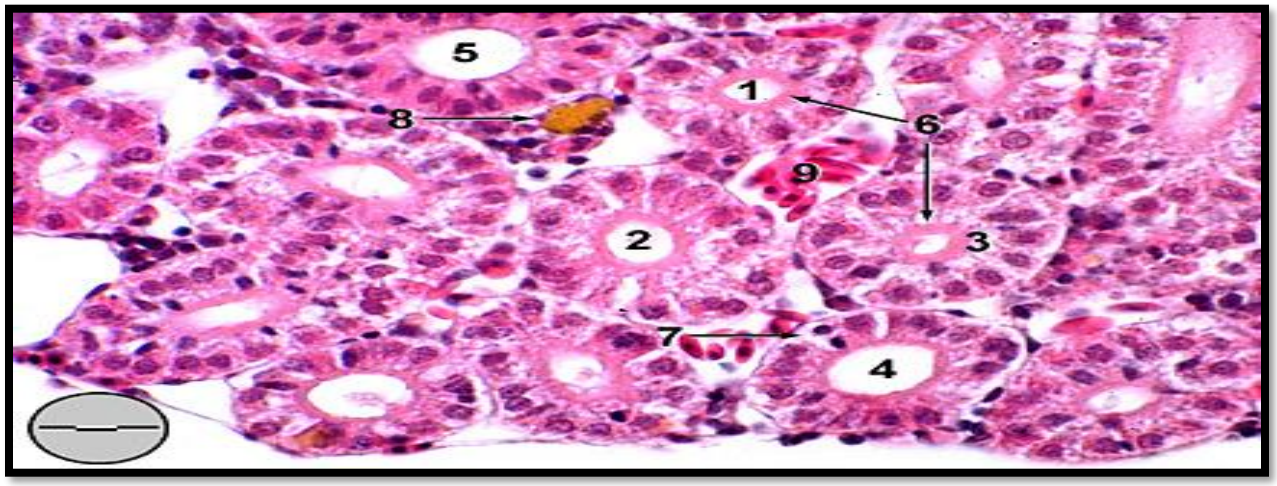


Figure 3. Kidney tubules, transverse section (2) (Formalin, H&E, Bar = 16.7 µm) 1. first proximal tubule; 2. second proximal tubule; 3. intermediate tubule segment; 4. distal tubule; 5. collecting duct; 6. brush border; 7. mitotic epithelial cell; 8. melanomacrophage; 9. red blood cells.

Name of section:
Transverse section of bony fish gills showing:

figure1: gill filament, sagittal section.

RESPIRATORY CHAPTER: Gill filament, sagittal section

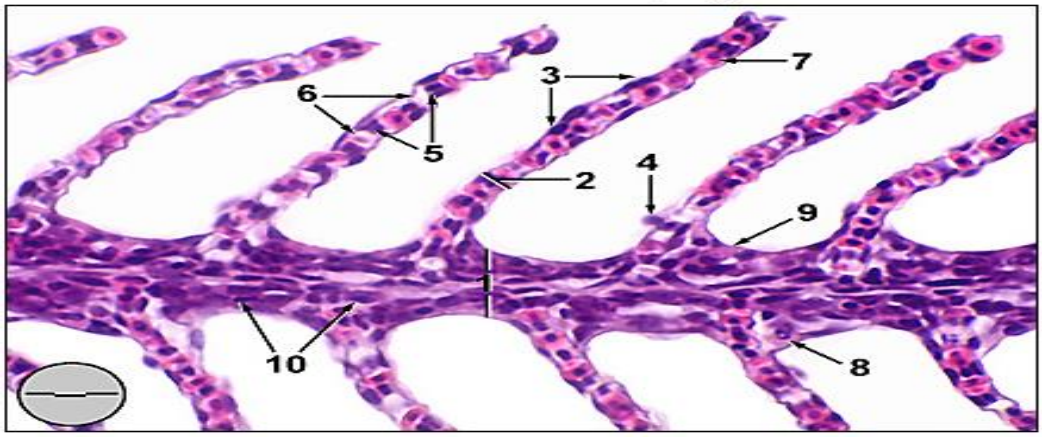


Figure 4. Gill filament, sagittal section (Formalin, H&E, Bar = 16.7 µm). 1. primary lamella; 2. secondary lamella; 3. epithelial cell; 4. mucous cell; 5. pillar cell; 6. lacuna (capillary lumen); 7. erythrocyte within capillary lumen; 8. chloride cell; 9. rodlet cell; 10. undifferentiated basal cell.

figure2: gill filament, sagittal section through cartilaginous support.

RESPIRATORY CHAPTER: Gill filament, sagittal section through cartilaginous support

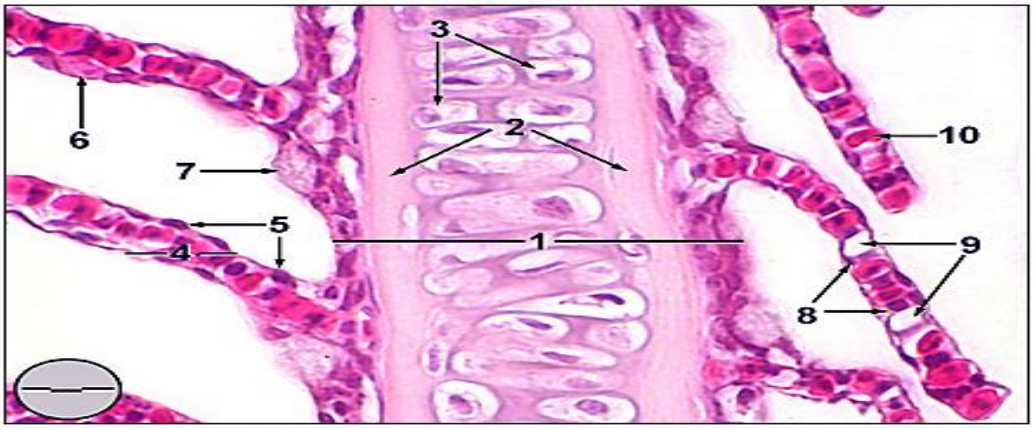


Figure 6. Gill filament, sagittal section through cartilaginous support (Formalin, H&E, Bar = 15.6 µm). 1. primary lamella; 2. extracellular cartilaginous matrix; 3. chondrocytes; 4. secondary lamella; 5. epithelial cell; 6. mucous cell; 7. chloride cell; 8. pillar cell; 9. lacuna (capillary lumen); 10. red blood cells within lacuna.

Transverse section of herbivorous fish stomach showing:

Different layers that formed stomach.

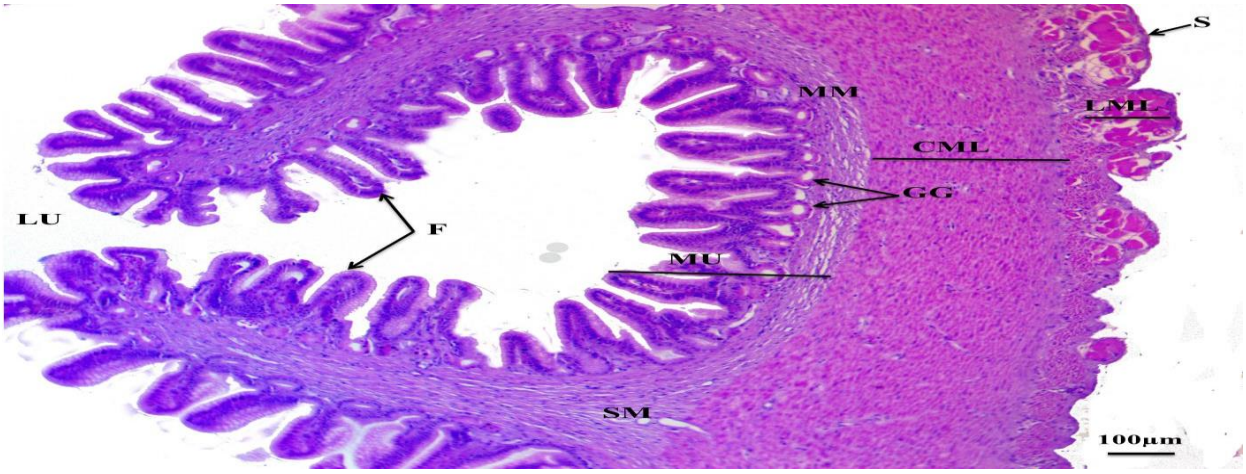


Fig. 3: Transverse section of the posterior region of the stomach of *S. rivulatus* showing MU: mucosa, SM: submucosa, CML: circular muscle layer, LML: longitudinal muscle layer, S: serosa, MM: muscularis mucosa, GG: gastric gland, LU: lumen and F: mucosal folds (H&E, ×100).

Transverse section of herbivorous fish intestine showing:

Different layers that formed intestine.

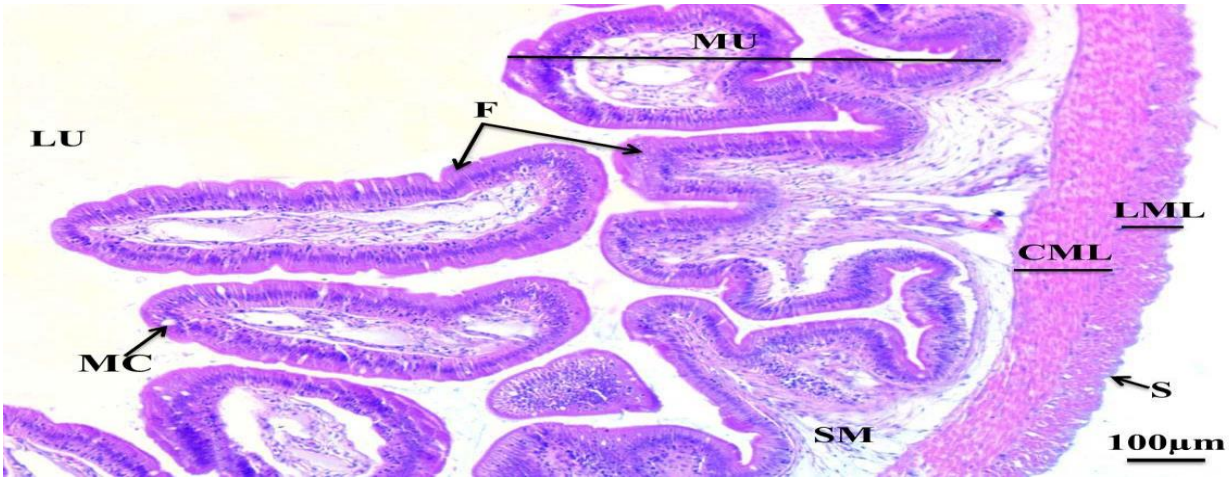
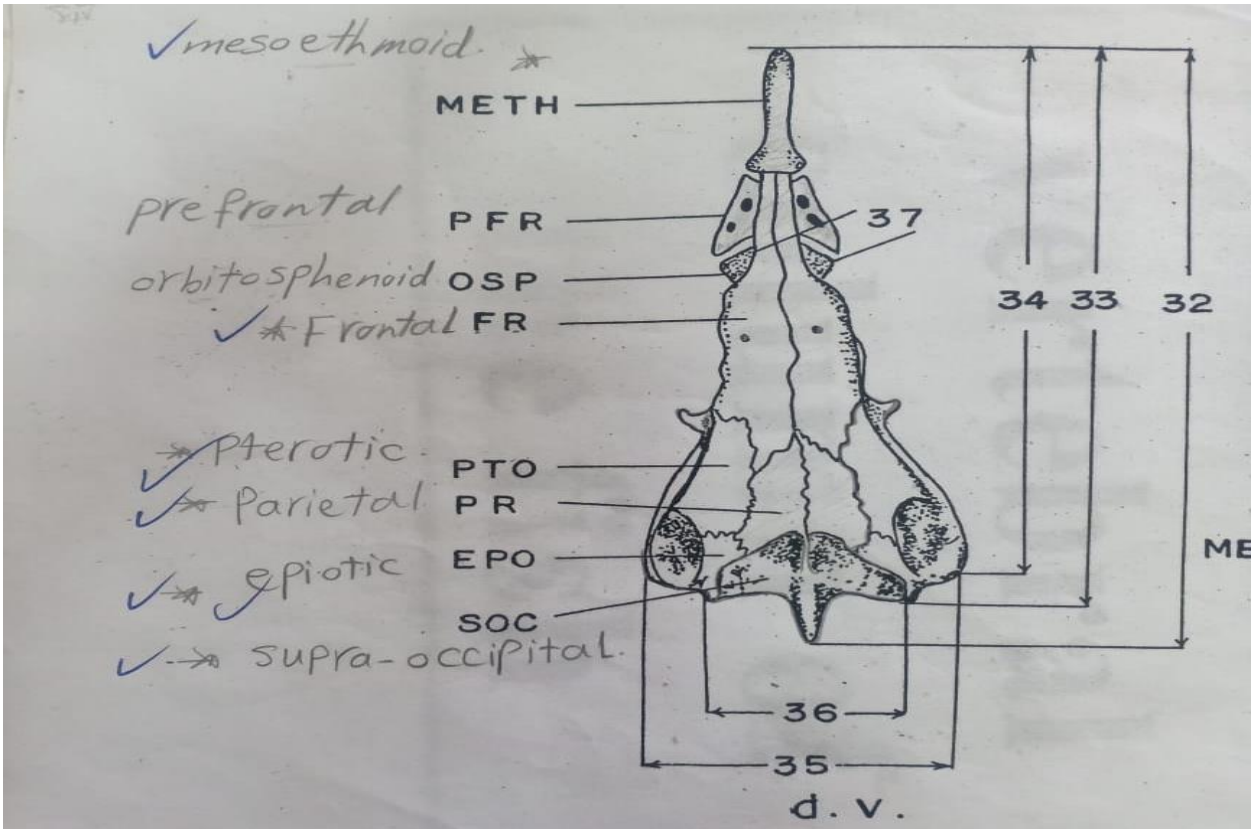


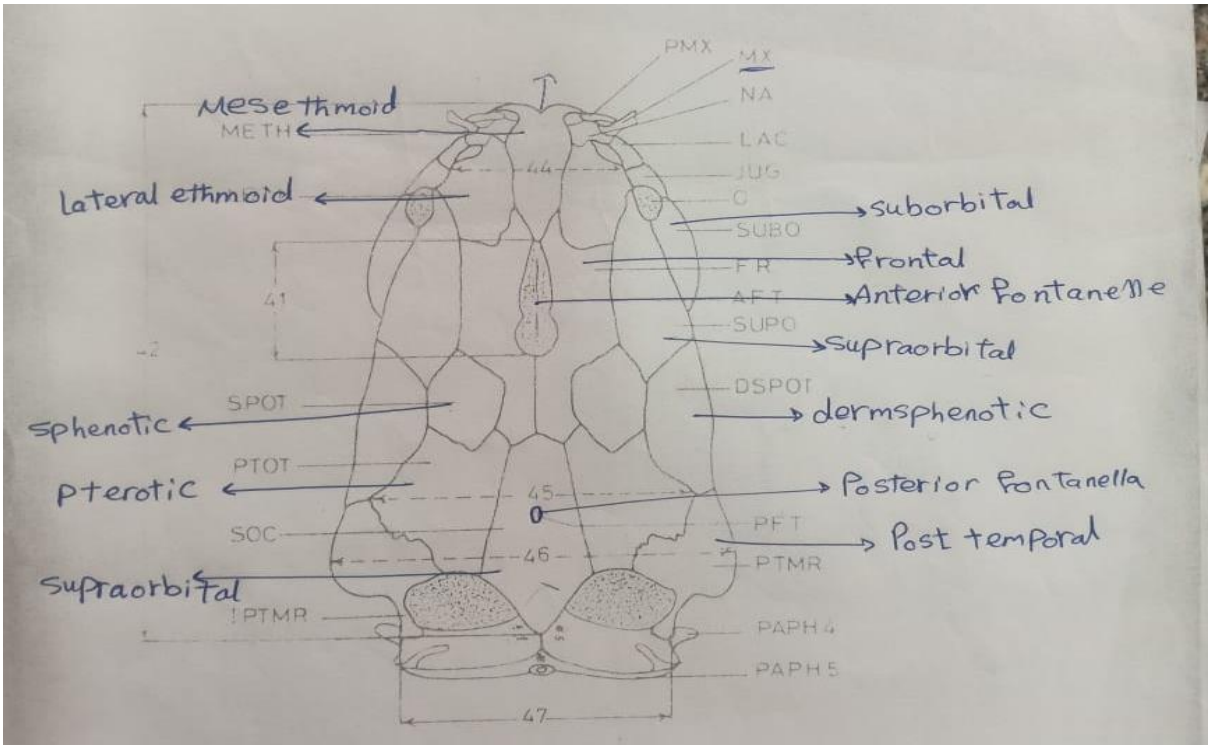
Fig. 5: Photomicrograph of transverse section of intestine of *S. rivulatus* showing MU: mucosa, SM: submucosa, CML: circular muscle layer, LML: longitudinal muscle layer, S: serosa, F: mucosal folds, MC: mucous cells, and LU: lumen (H&E, ×100).

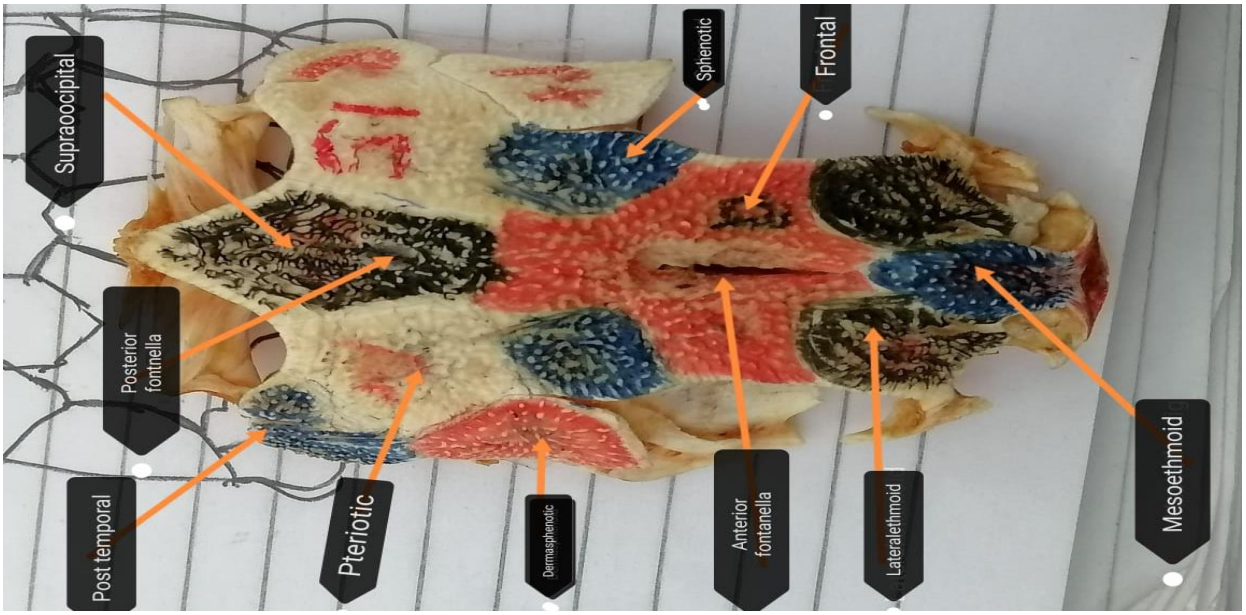
Skull of bony fishes

1. Dorsal view of skull of *Mormyrus kannume* .



2. Dorsal view of skull of *Clarias lazera*





3. Dorsal view of *Synodontis schall*

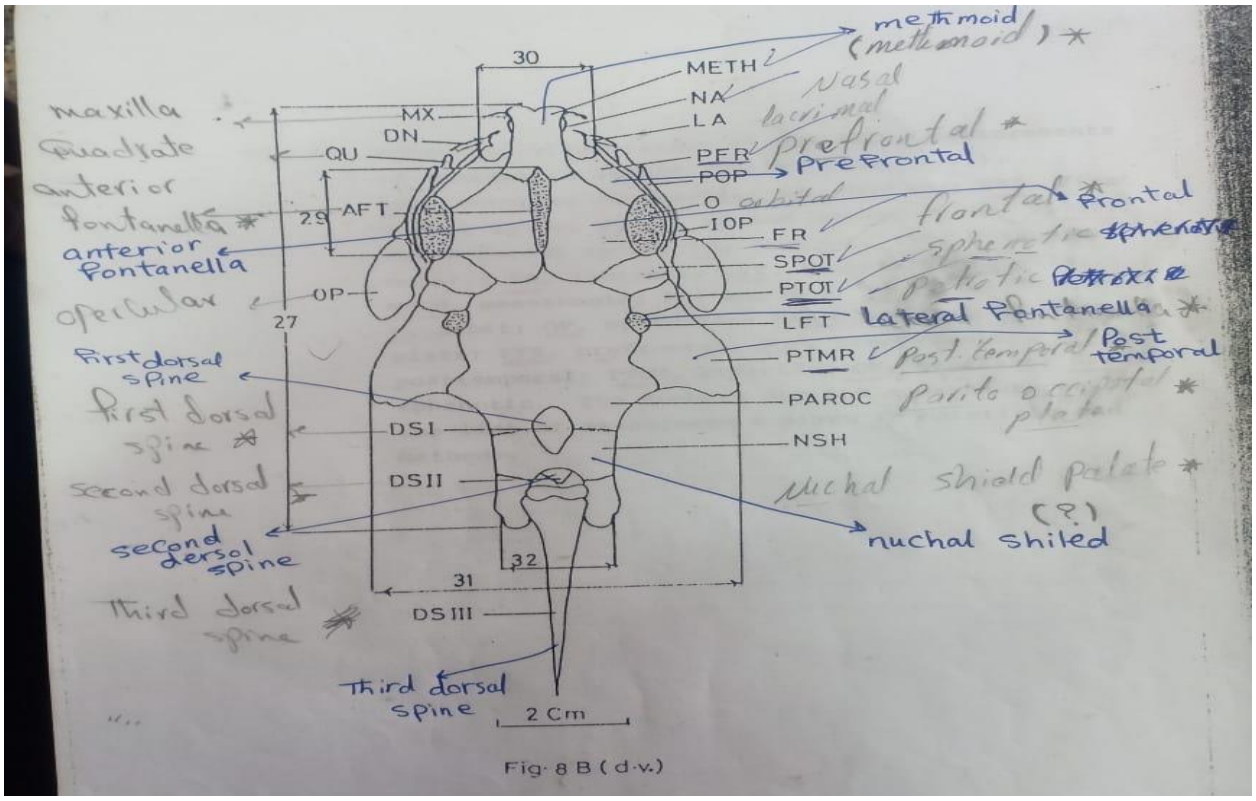
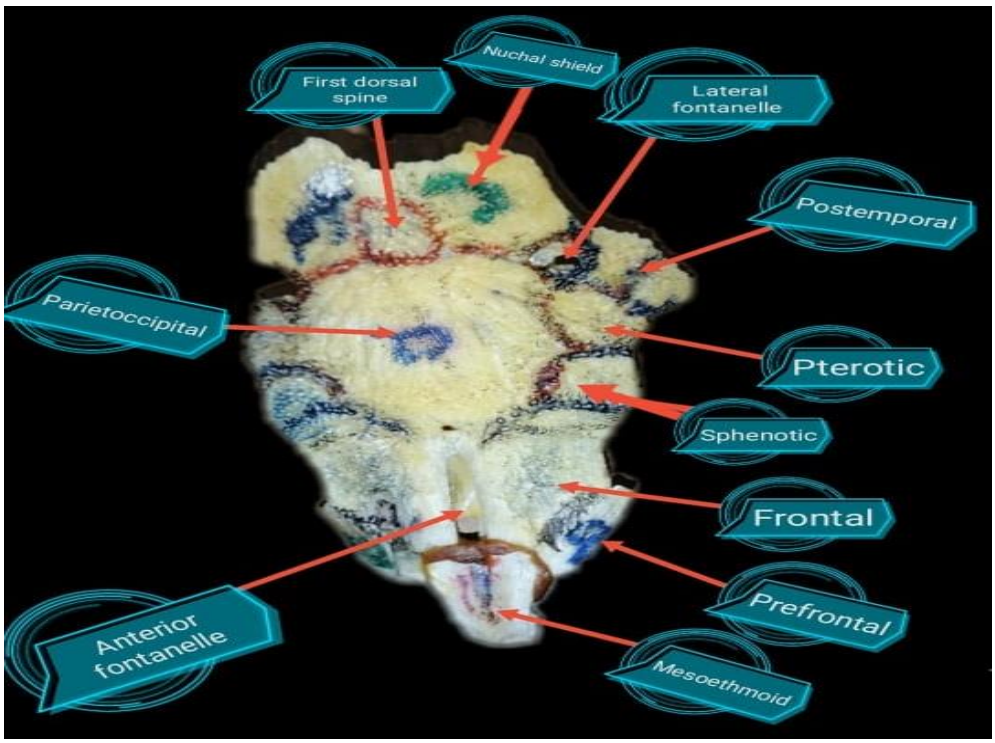


Fig. 8 B (d.v.)



Taxonomy

Classification of some bony fishes:

Kingdom : Animalia

Subkingdom : Eumetazoa

Phylum : Chordata

Subphylum : Vertebrata

Superclass : Gnathostomata

Class : Osteichthyes

- **Oreochromis niloticus niloticus البلطي النيلي**

Class : Osteichthyes

Subclass : Teleostei

Order : Perciformes

Family : Cichlidae

e.g. : Oreochromis niloticus niloticus

- **Lates niloticus قشر البياض**

Class : Osteichthyes

Subclass : Teleostei

Order : Perciformes

Family : Latidae

e.g. : Lates niloticus

- **Clarias lazera القرموط**

Class : Osteichthyes

Subclass : Teleostei

Order : Siluriformes

Family : Clariidae

e.g. : Clarias lazera

- ***Malapterurus electricus*** **الرعاش**

Class : Osteichthyes

Subclass : Teleostei

Order : Siluriformes

Family : Malapteruridae

e.g. : Malapterurus electricus

- ***Bagrus bayad*** **بقر البياض**

Class : Osteichthyes

Subclass : Teleostei

Order : Siluriformes

Family : Bagridae

e.g. : Bagrus bayad

- **Synodontis schall** **الشال**

Class : Osteichthyes

Subclass : Teleostei

Order : Siluriformes

Family : Mochokidae

e.g. : Synodontis schall

- ***Chrysichthyes auratus*** **الزمار**

Class : Osteichthyes

Subclass : Teleostei

Order : Siluriformes

Family : Claroteidae

e.g. : Chrysichthyes auratus

- ***Labeo niloticus*** **الليبس**

Class : Osteichthyes

Subclass : Teleostei

Order : Cypriniformes

Family : Cyprinidae

e.g. : Labeo niloticus

- ***Mormyrus kannume*** ***القنومة***

Class : Osteichthyes

Subclass : Teleostei

Order : Osteoglossiformes

Family : Mormyridae

e.g. : Mormyrus kannume