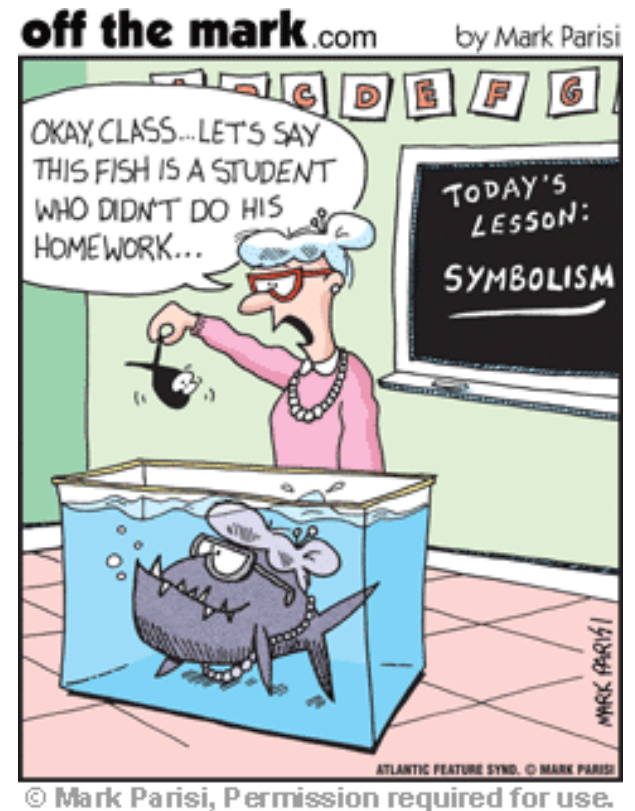


ANATOMY, PHYSIOLOGY & ECOLOGY OF FISHES



What is „FISH“

JAWLESSS



JAWED

Cartilaginous



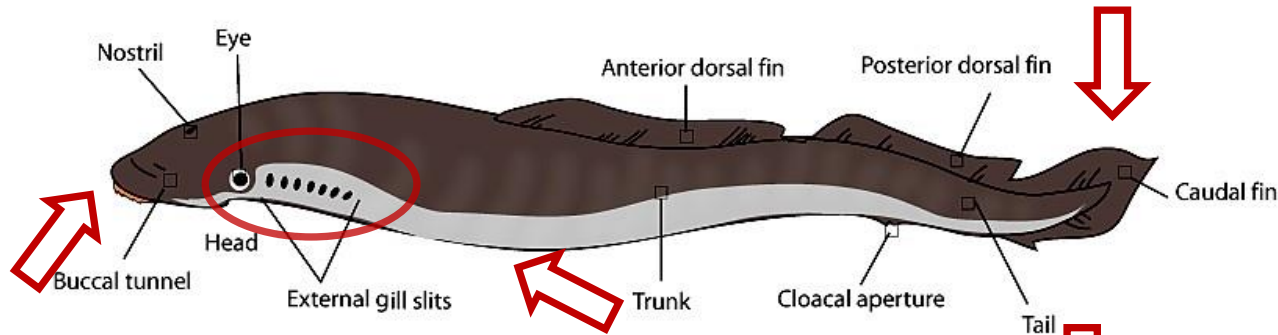
Bony



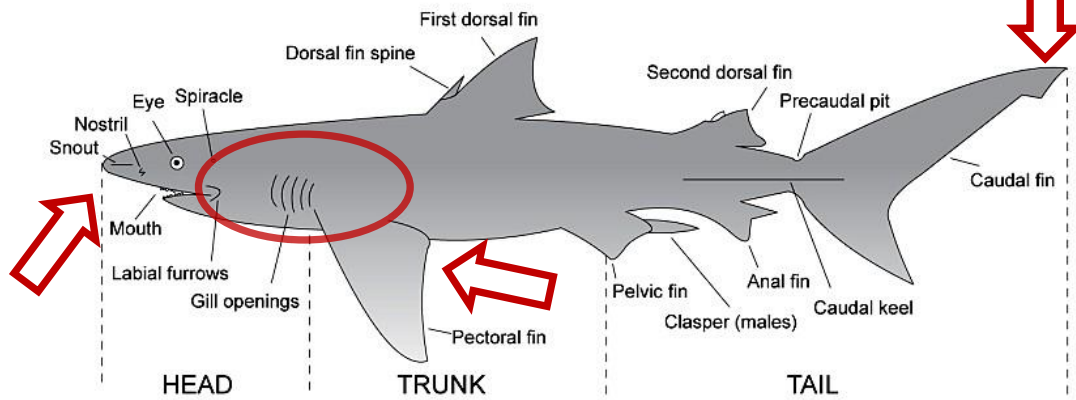
Part I - ANATOMY



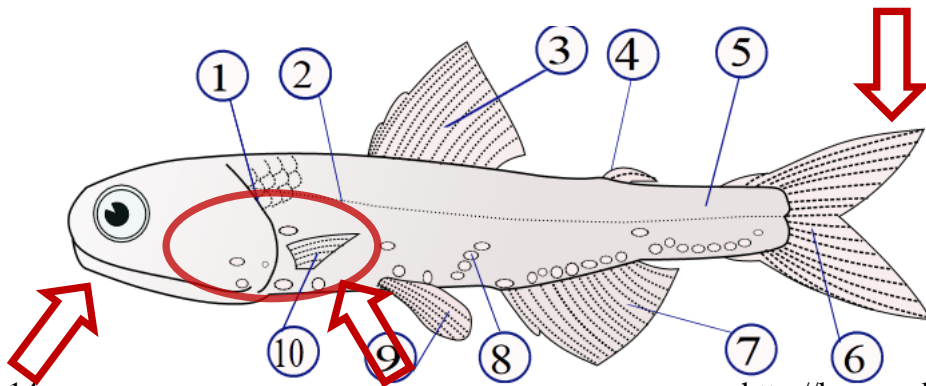
GENERAL ANATOMY OF FISHES



Lampreys

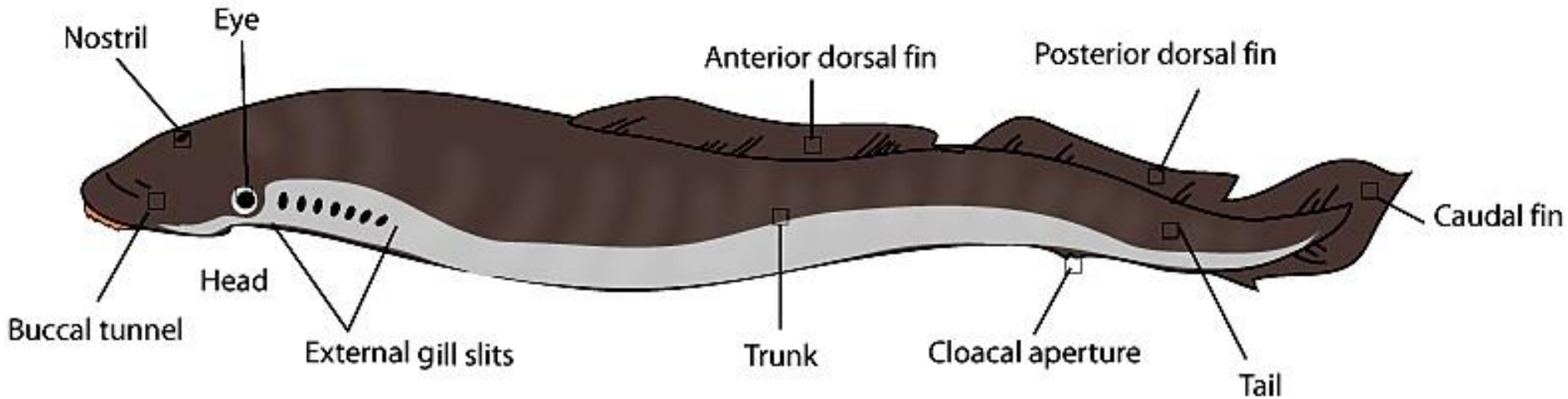


Elasmobranchs
Shark+skates



Bony fish

GENERAL ANATOMY - LAMPREY



No jaws – oral disk - suck

No real bones

No scales

No paired fins

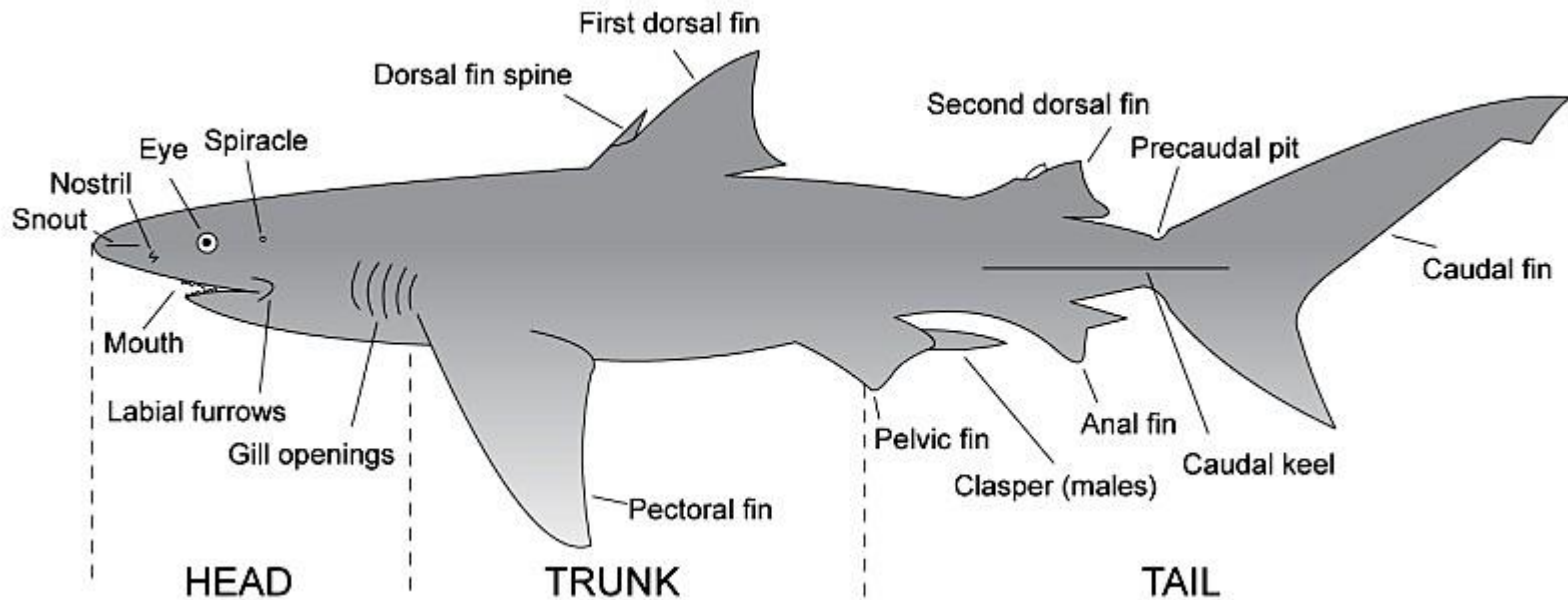
No paired nostrils

7 external gill slits



source: **Wikipedia**

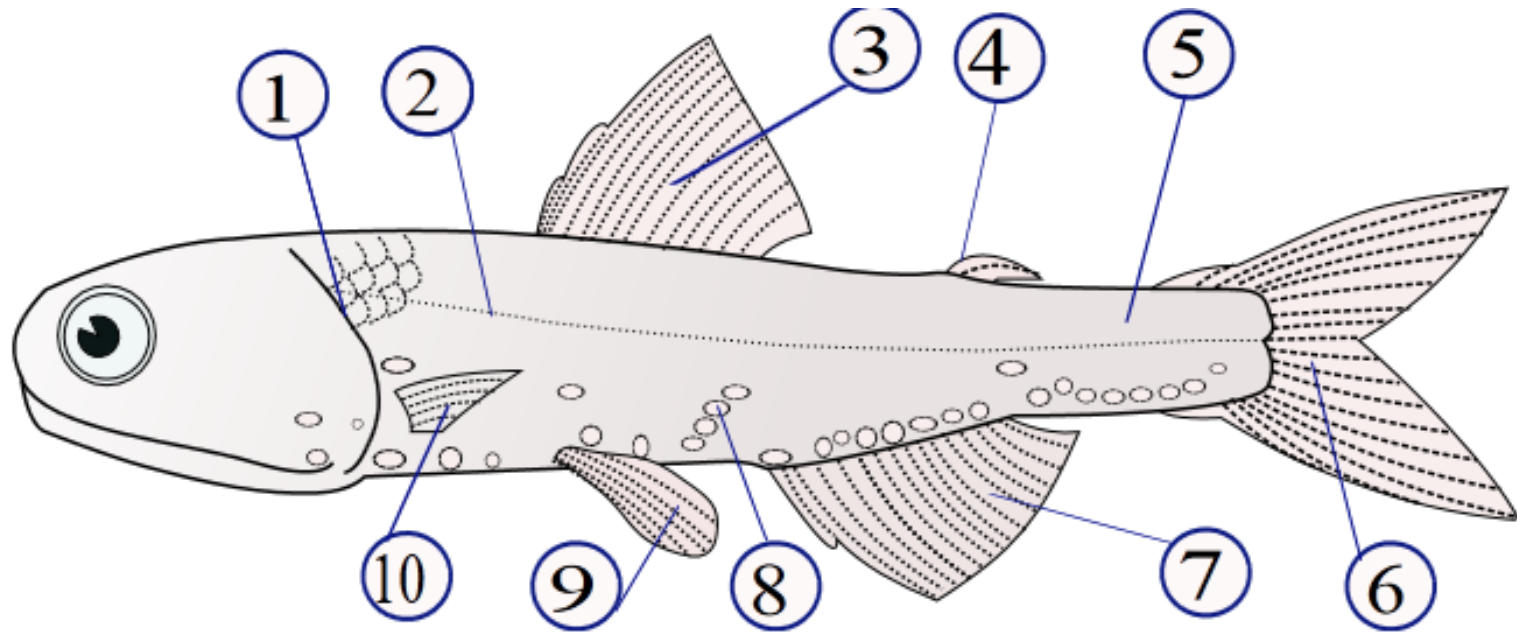
GENERAL ANATOMY - SHARK



Cartilaginous skelet
Strong jaw
Scales - placoid
5-7 gill openings
One or two dorsal fins
Heterocercal caudal fin

Pelvic and pectoral fins are paired
Reproduction organ of male
Developed senses

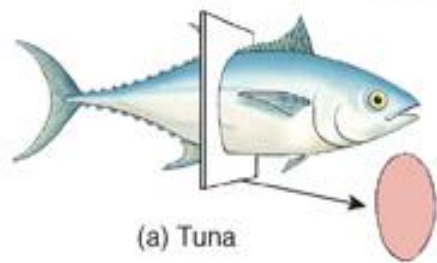
GENERAL ANATOMY – BONY FISH



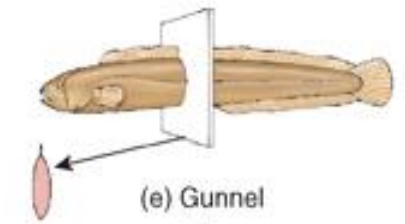
bony skeleton + fins supported by spines and rays, paired fins, scales

- (1) – operculum (one gill opening), (2) – lateral line, (3) – dorsal fin
- (4) – fat fin, (5) – caudal peduncle, (6) – caudal fin, (7) – anal fin
- (8) – photophores, (9) – pelvic fins (paired)
- (10) – pectoral fins (paired)

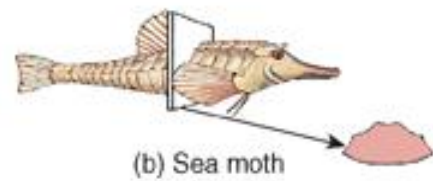
Fish form and function show a high degree of variation.



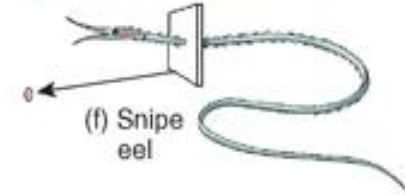
(a) Tuna



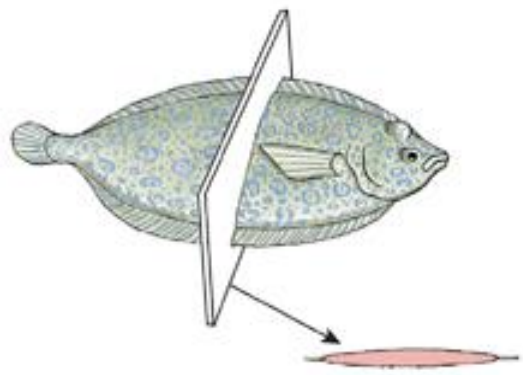
(e) Gunnel



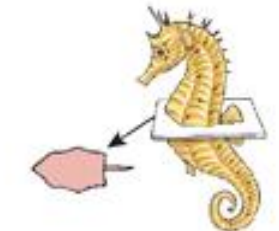
(b) Sea moth



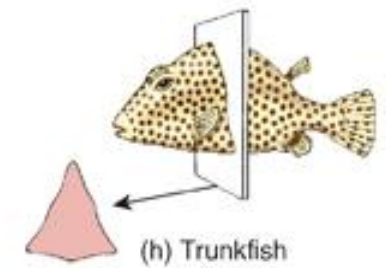
(f) Snipe eel



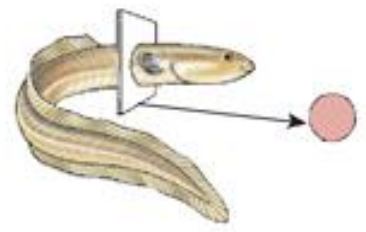
(c) Flatfish (flounder)



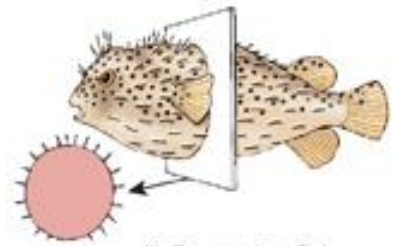
(g) Seahorse



(h) Trunkfish



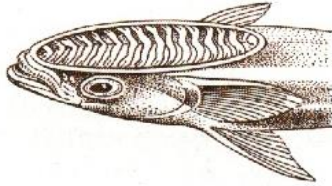
(d) Freshwater eel



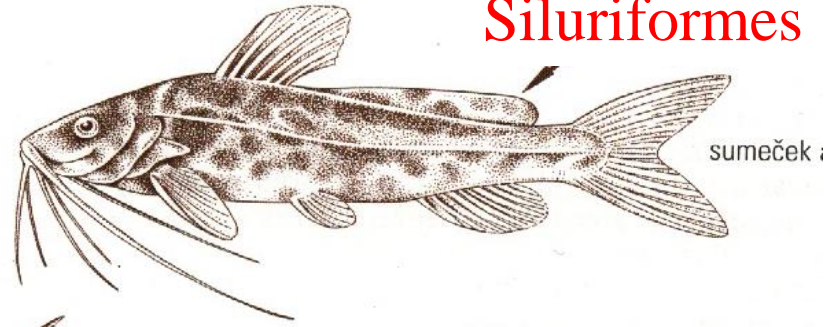
(i) Porcupine fish

ADAPTATION & MODIFICATION OF FINS

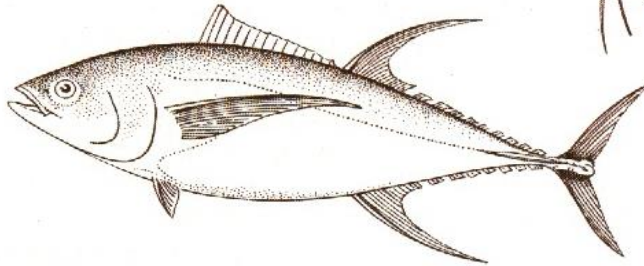
Perciformes
Remora



Siluriformes

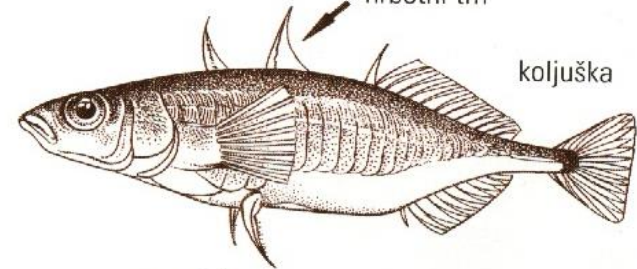


Perciformes
Tuna

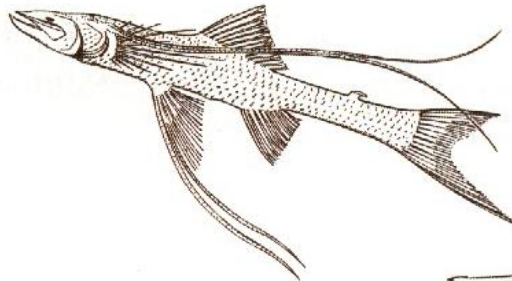


hřbetní trn

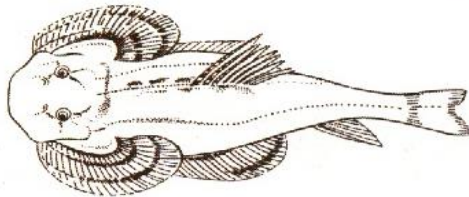
koljuška



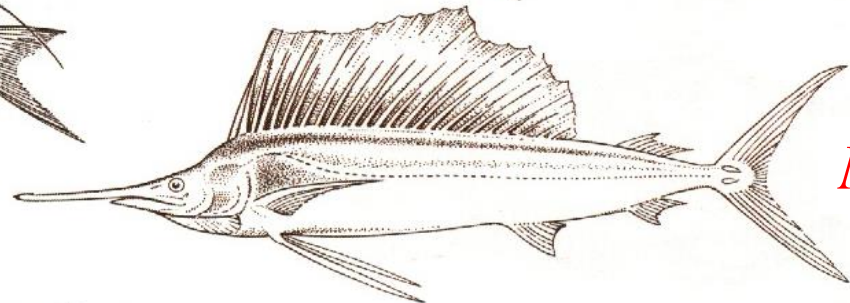
Aulopiformes
tripodfish



Loaches



Marlin



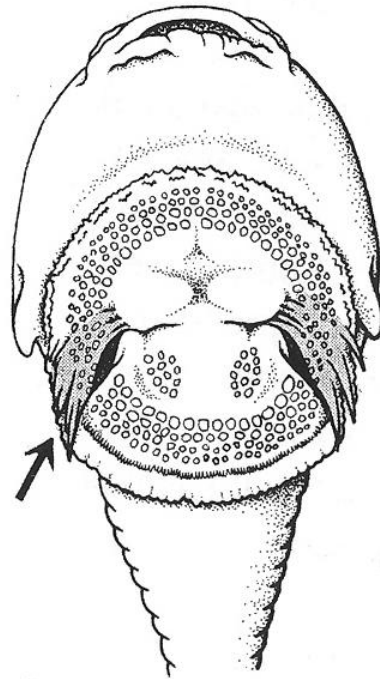
bichir



Bichir - Polypteriformes

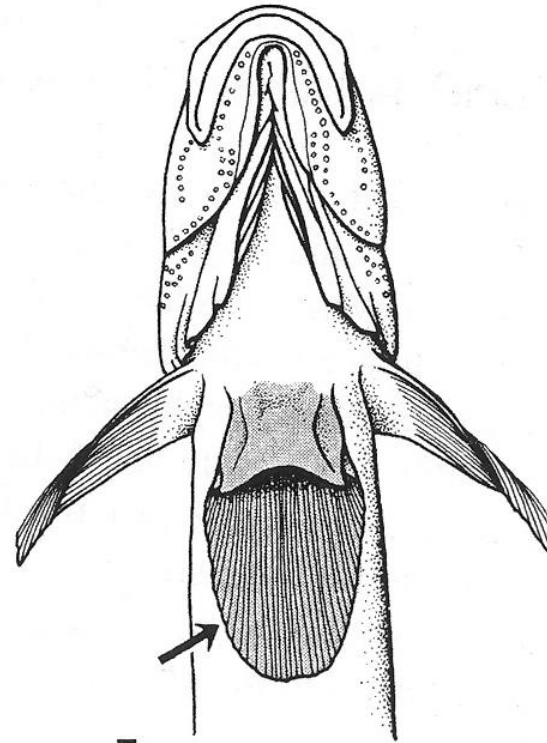
FIN MODIFICATIONS

„Sucking disc“ based on anatomical changes of fins



E

E – *Gobiesocidae*



F

F - *Gobiidae*

FIN MODIFICATIONS

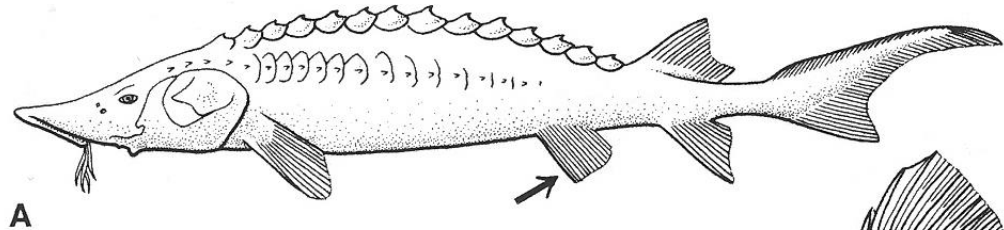
Modification allowing to fly...



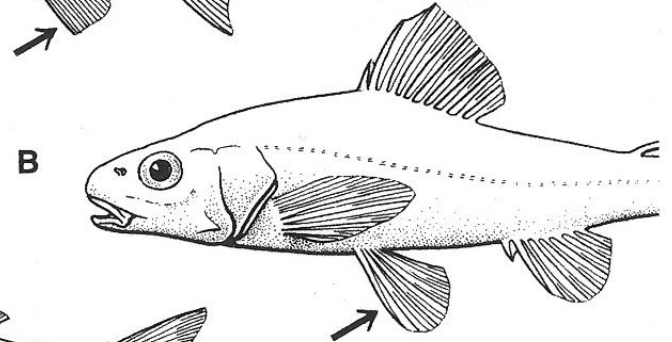
POSITION OF PELVIC FINS

Important taxonomical character

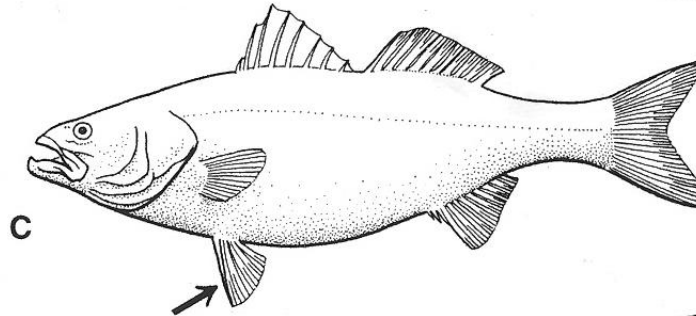
A – abdominal
sturgeon



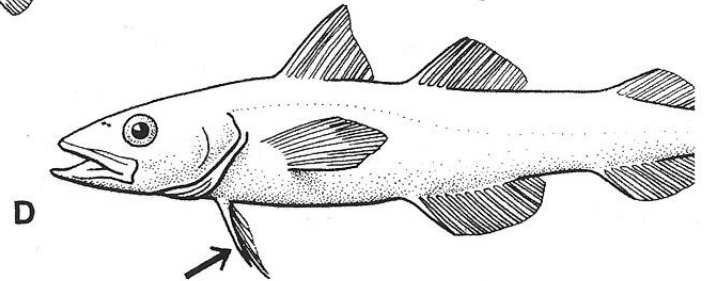
B – subabdominal



C - thoracic
perch or bass



D - jugular
cod

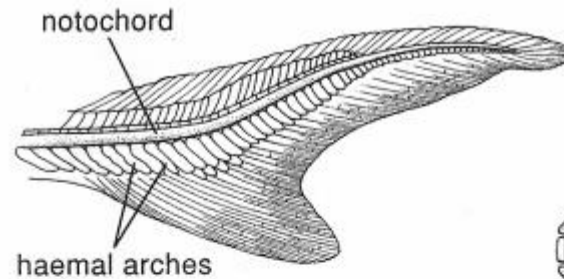


TYPES OF CAUDAL FIN

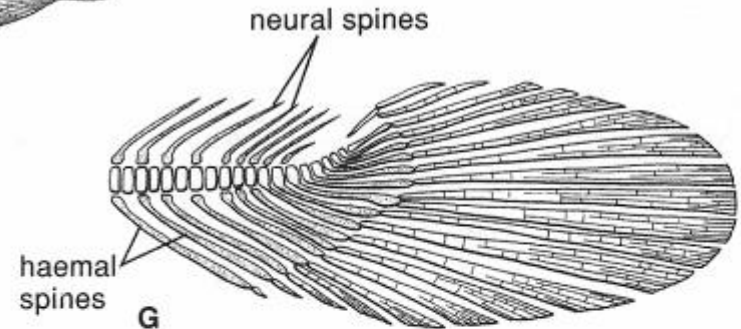
Based on a/symmetry

Primitive fishes

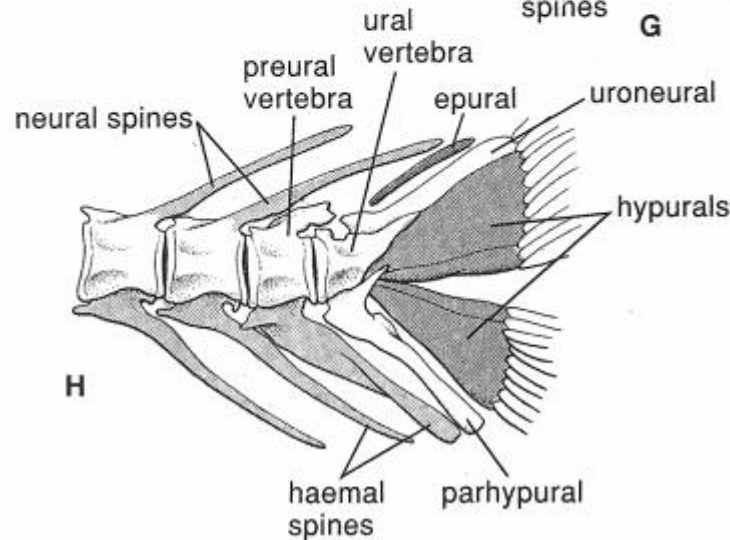
F - heterocercal
sturgeon



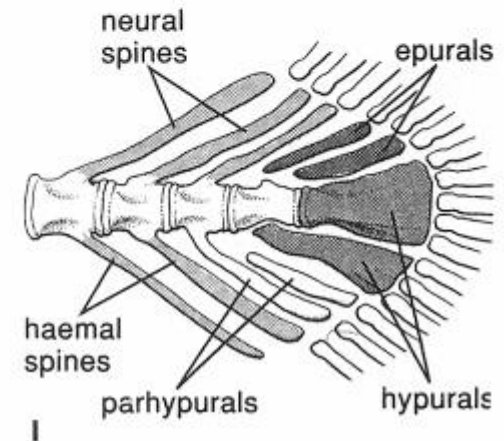
G - heterocercal
bowfin



H - homocercal
Sea bass

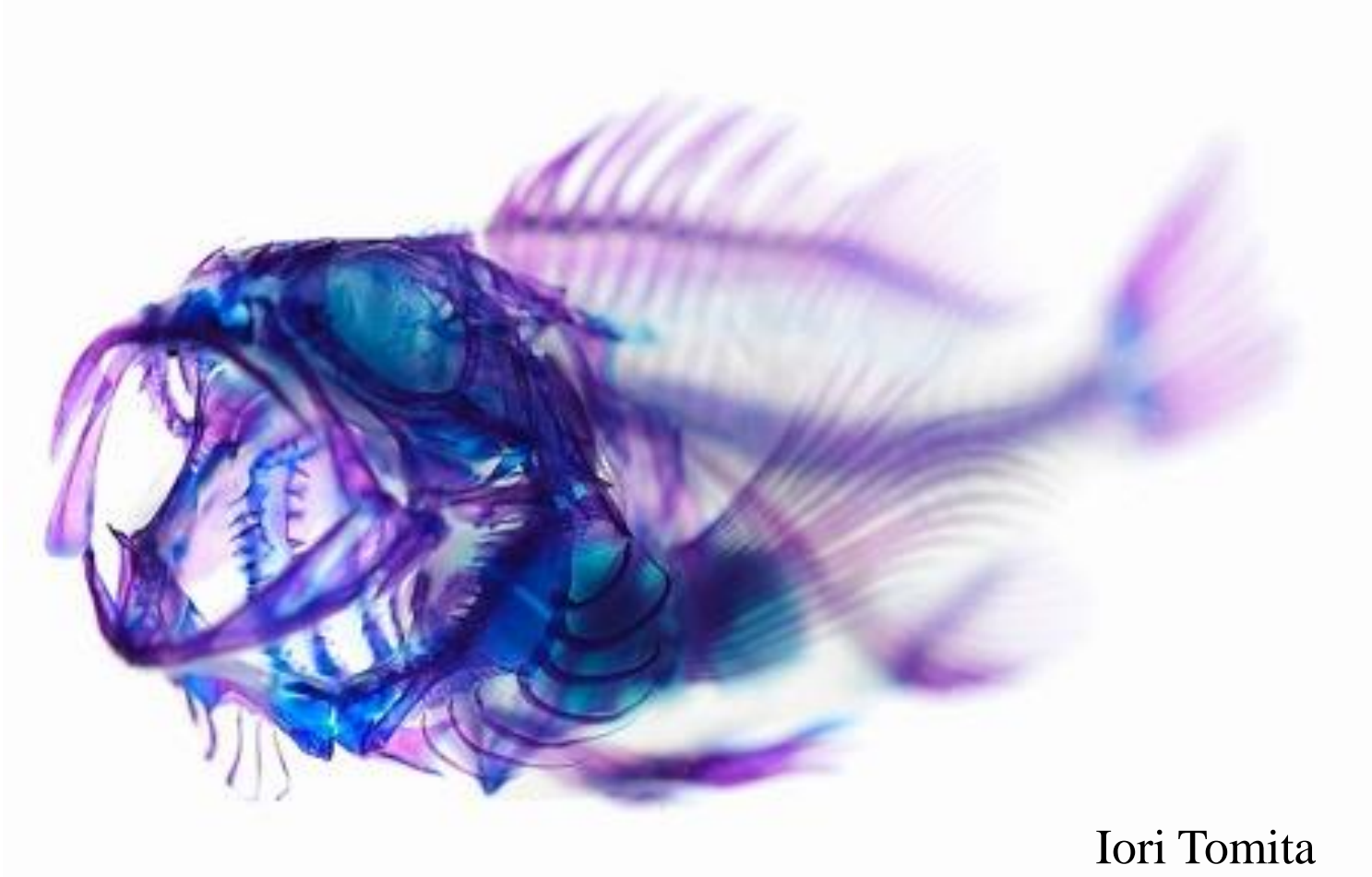


I - isocercal
Cod



Recent fishes

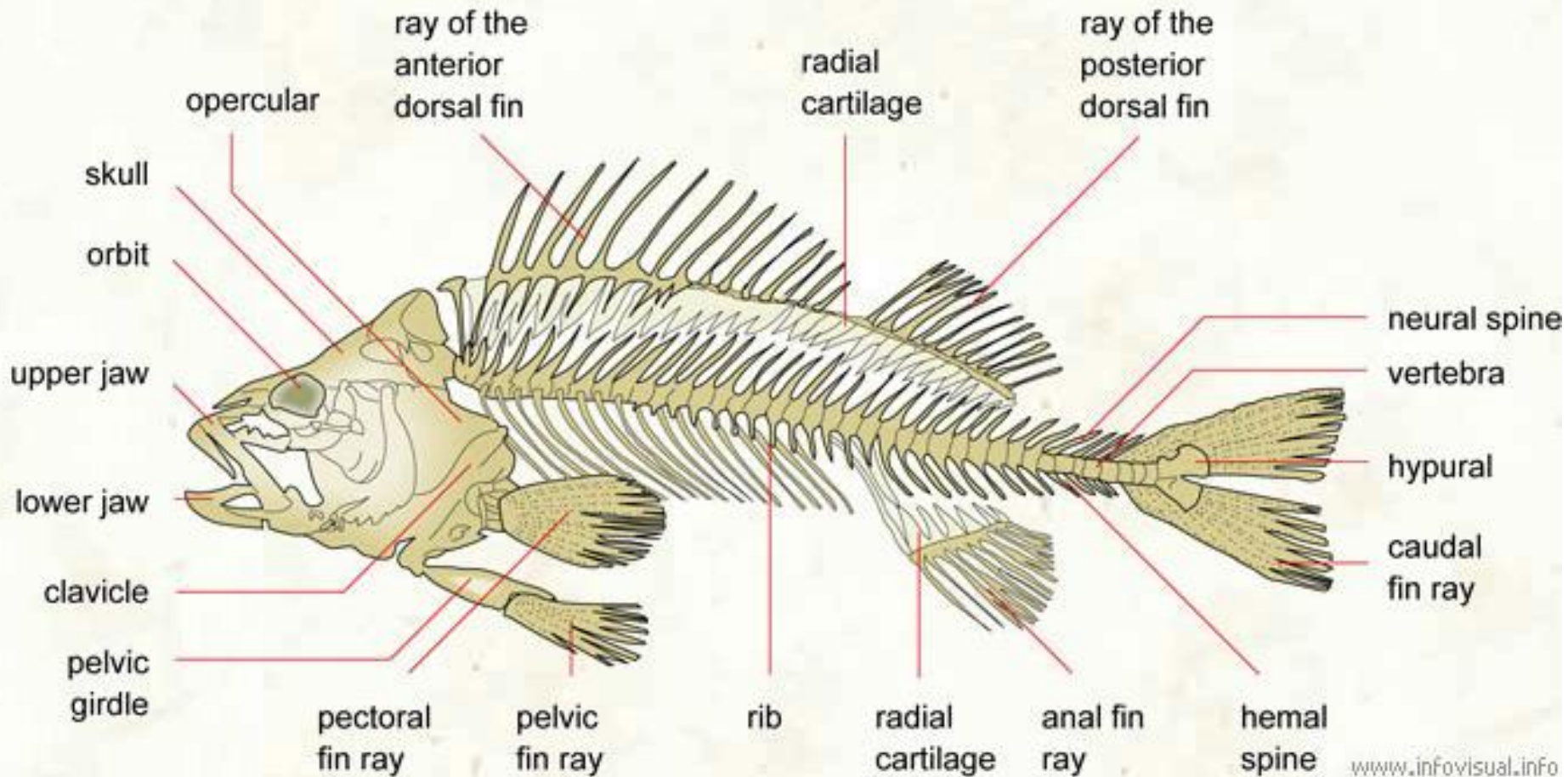
FISH SKELETON



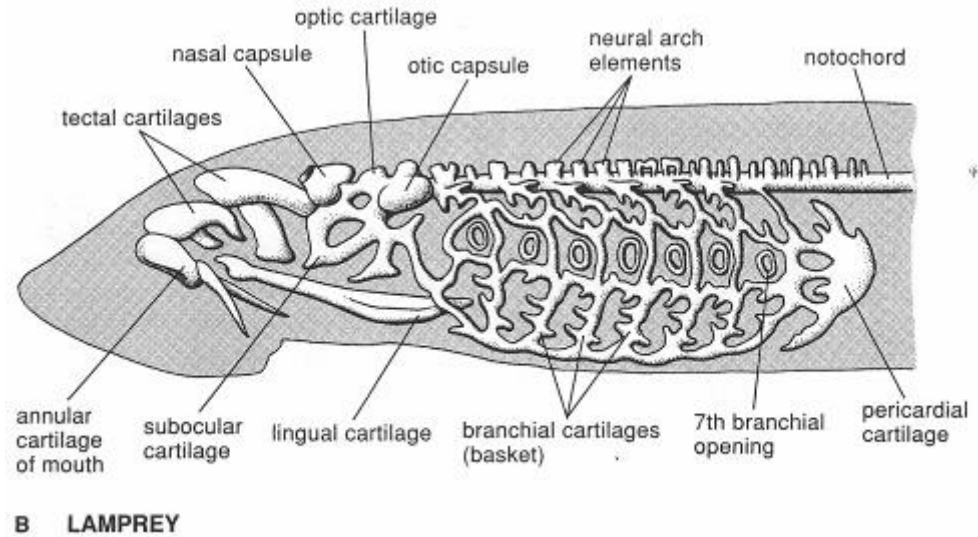
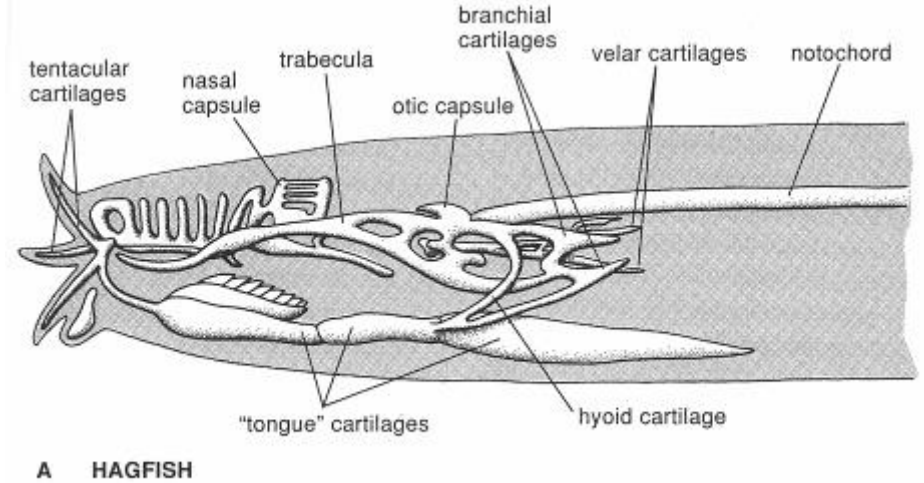
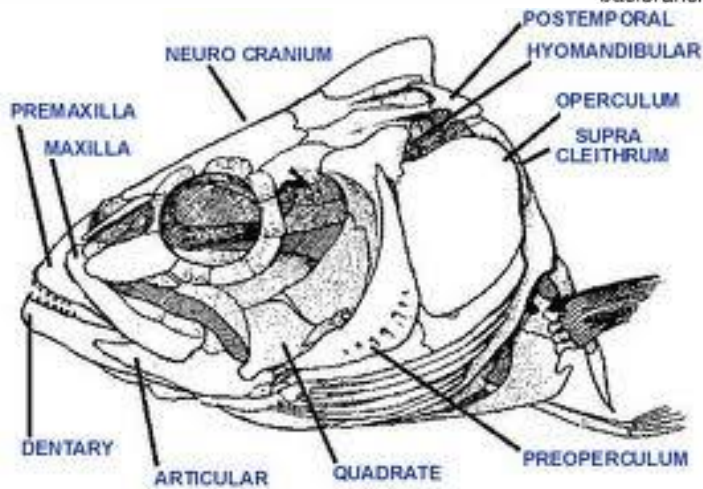
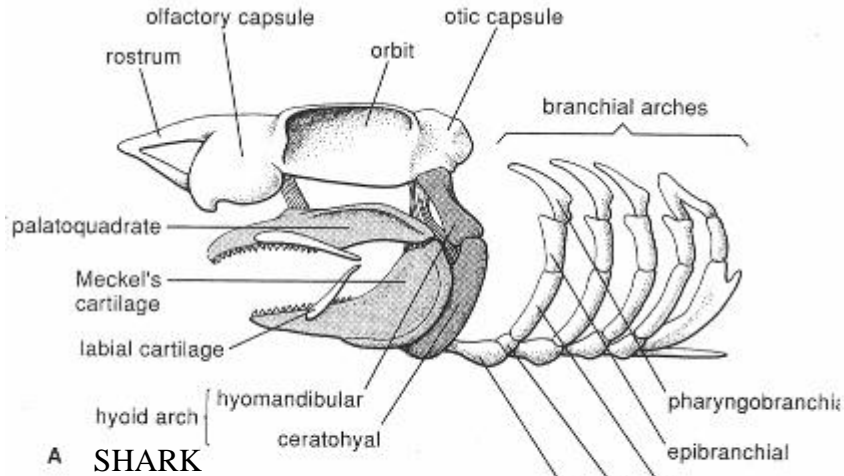
Iori Tomita

By proper preservation and staining of fish we can gain transparent fish body with all bones visible.

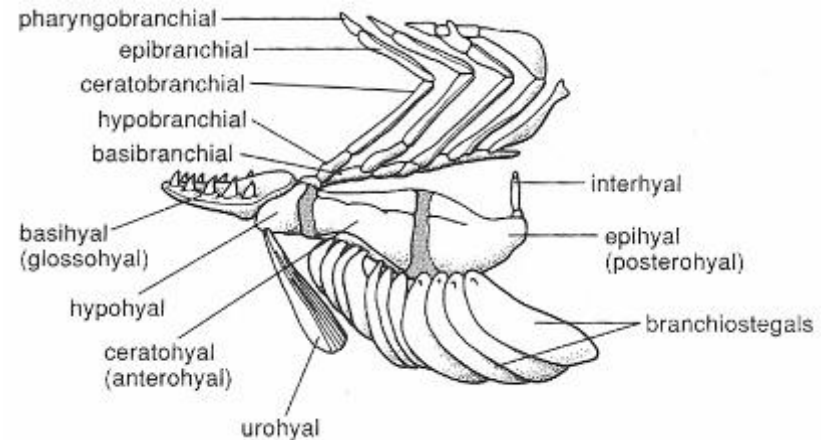
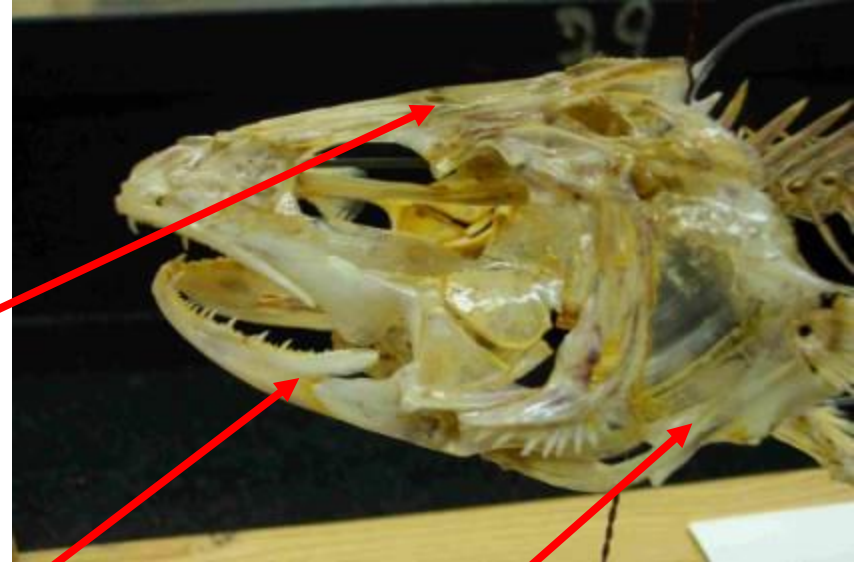
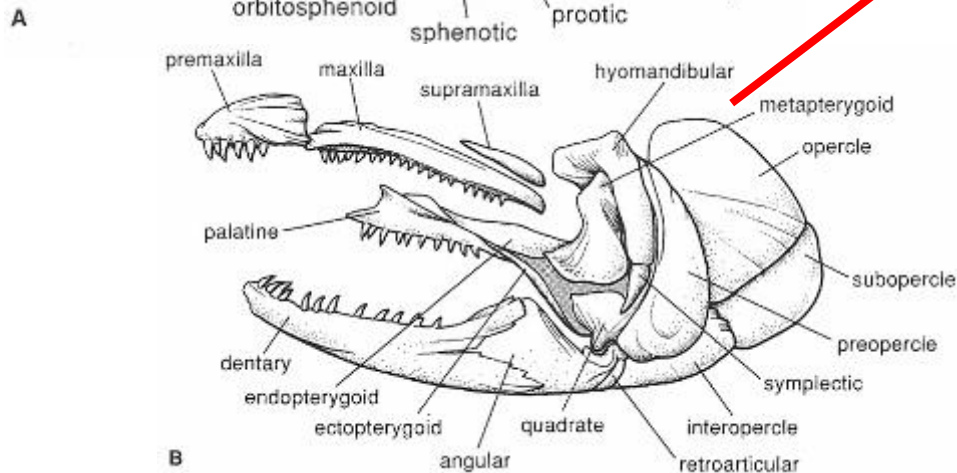
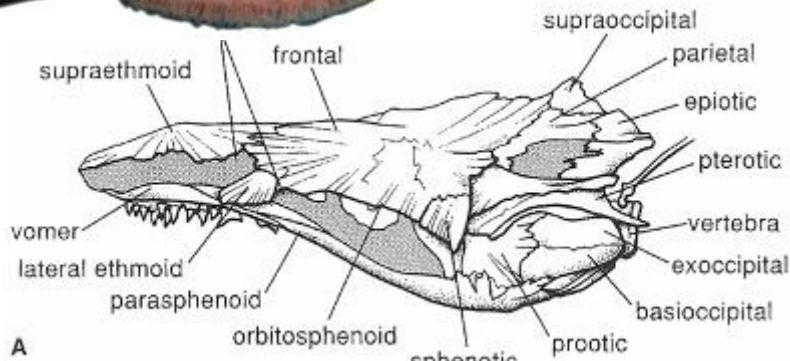
FISH SKELETON



„SKULL“

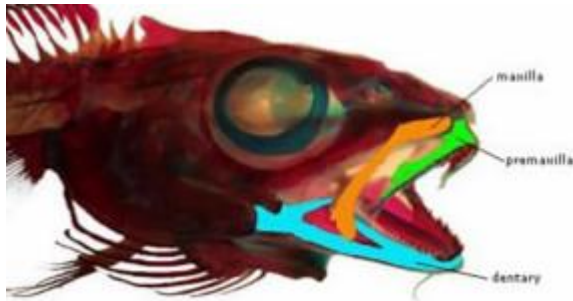


SKULL OF BONY FISH

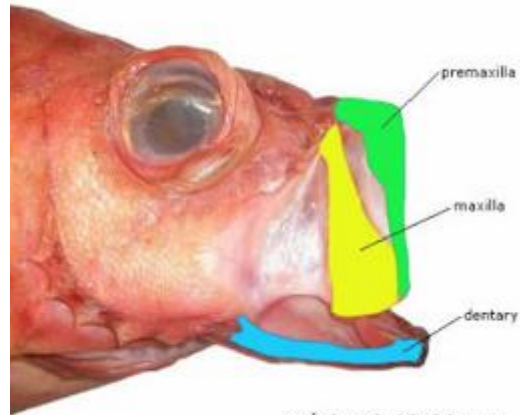


SKULL AND FEEDING

Important novelty of modern teleost – protrusion of mouth



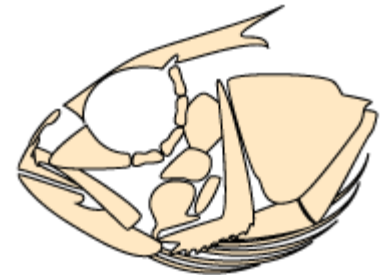
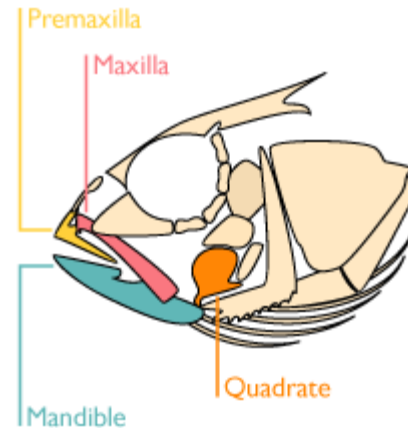
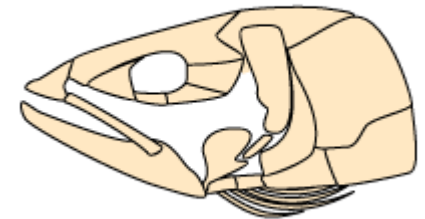
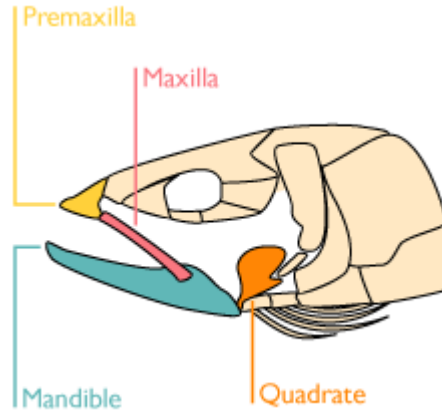
- Primitive fishes



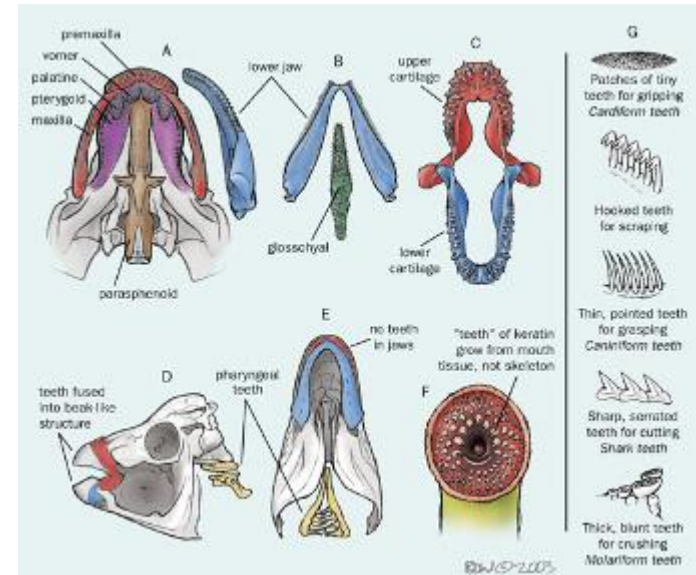
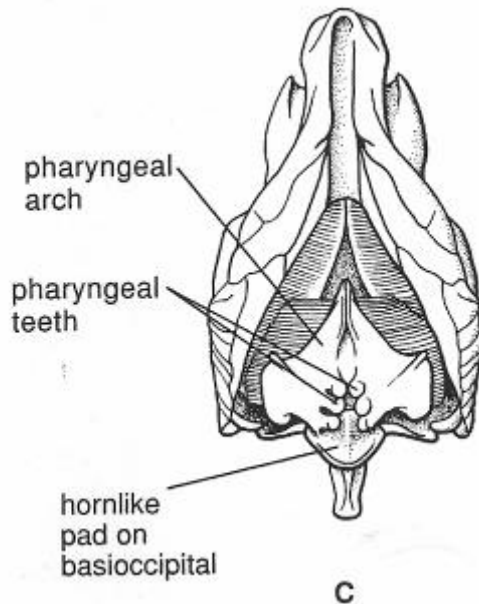
© Óskar Sindri Gíslason

- More recent fishes

[ANIMACE video](#)

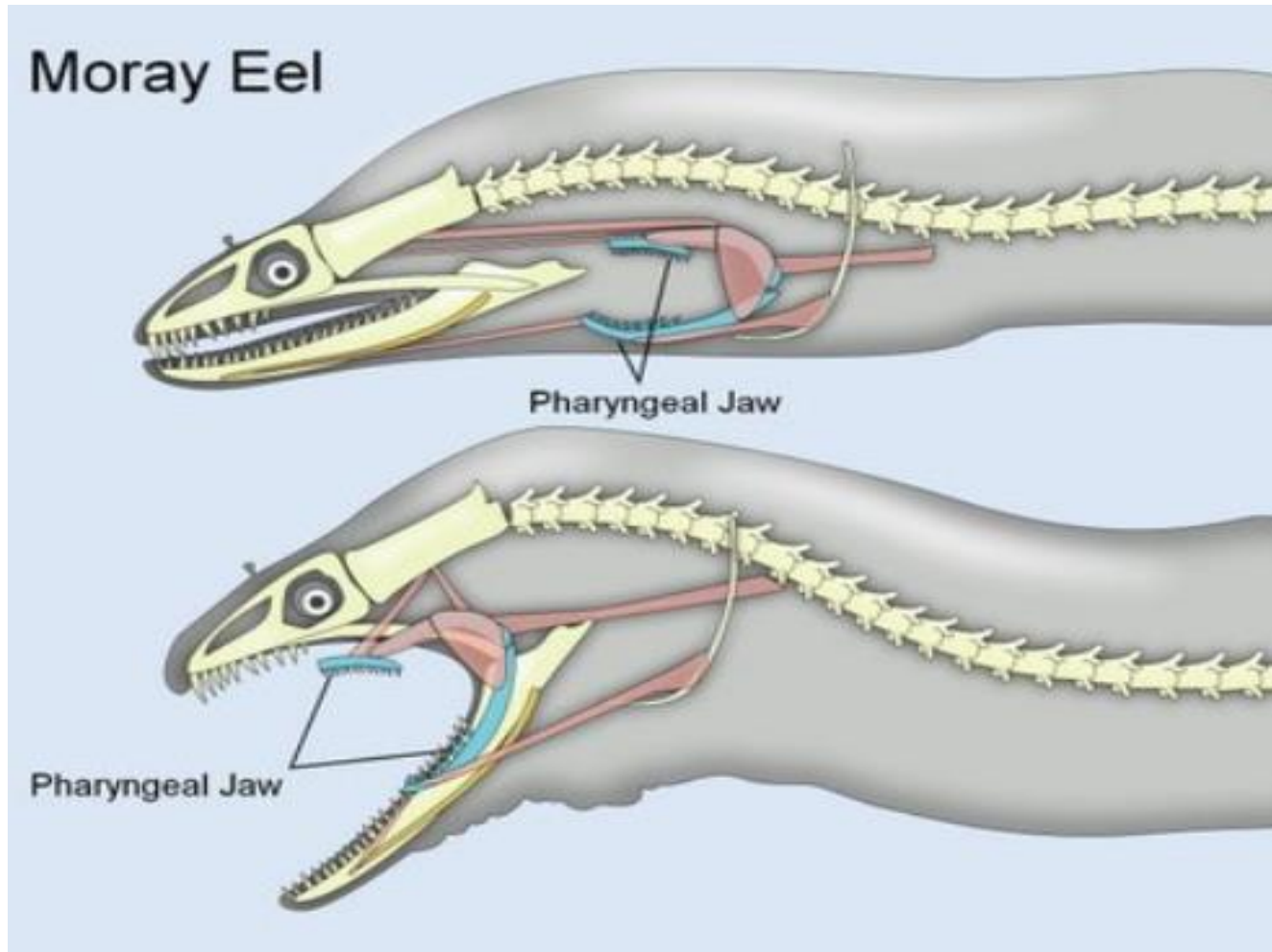


PHARYNGEAL TEETH



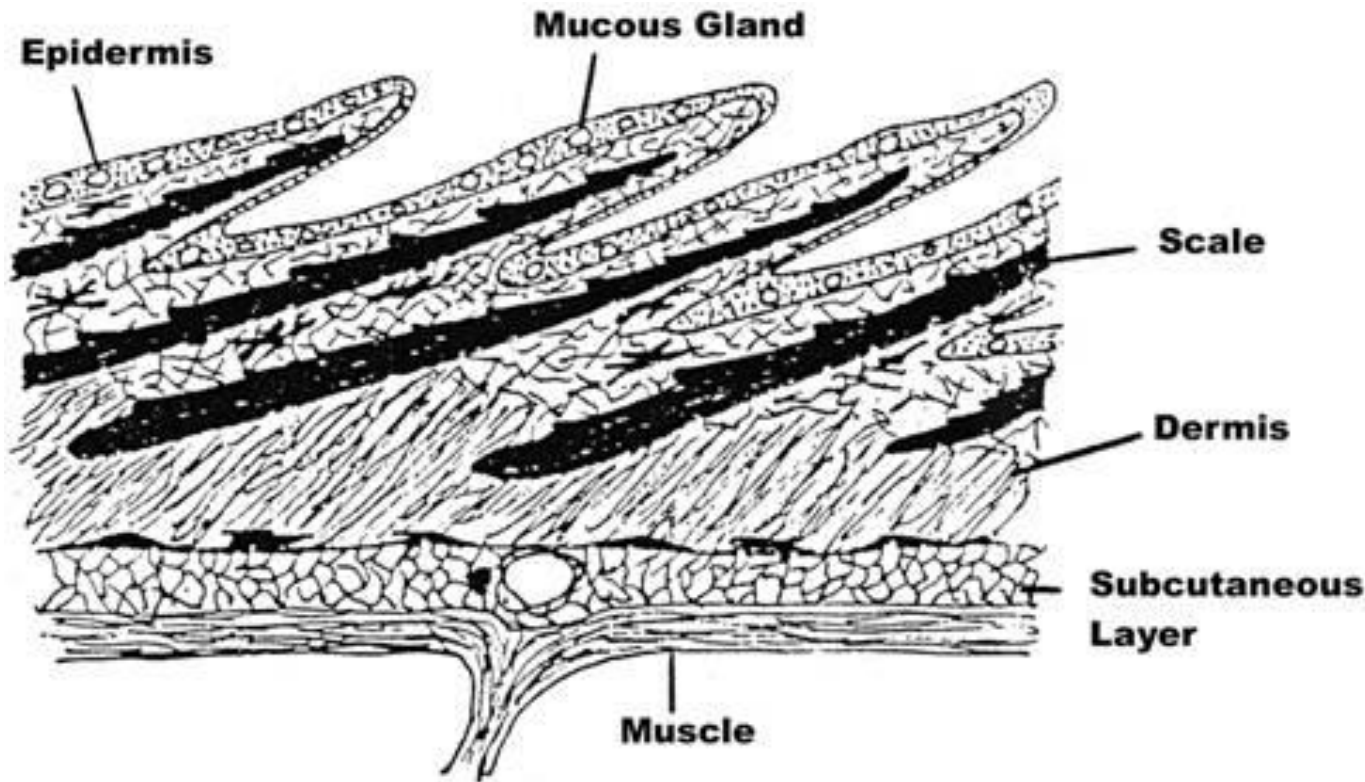
PHARYNGEAL TEETH

- Structure of the Moray's pharyngeal jaws



SKIN & COLORATION

- Body of fishes is mostly covered by scales
- Mucous glands on skin produces mucus as protection of the skin
- In epidermis are chromatophores – colour of the skin



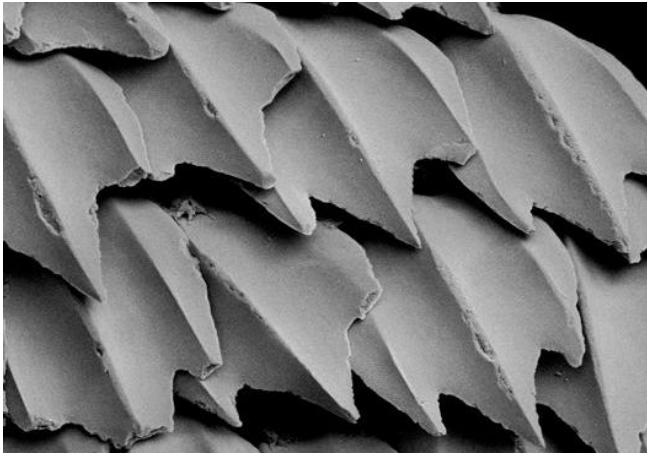
SKIN & COLORATION

- **Chromatophores** – pigment-containing cells
- **Melanophores** – black, dark brown
- **Xanthophores** – yellow and orange
- **Erythrophores** – red
- **Iridocyty** – guanin - silvery
- Xanthophore pigmentation – ornamental fish, golden fish
- Albinism - absence of pigments – light coloration



SCALES

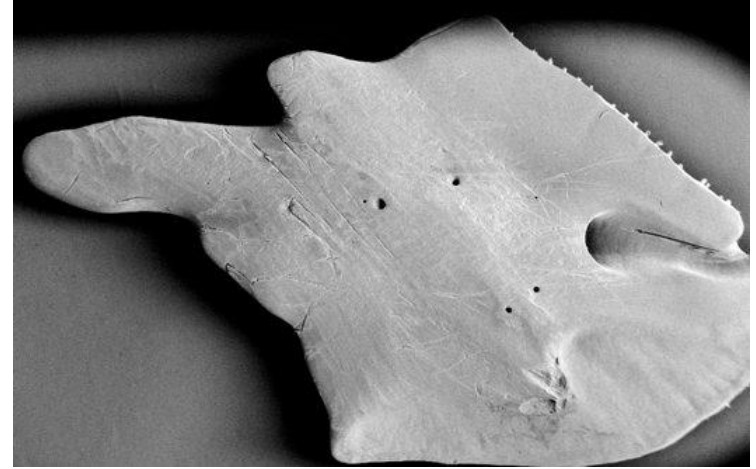
1. Placoid - sharks



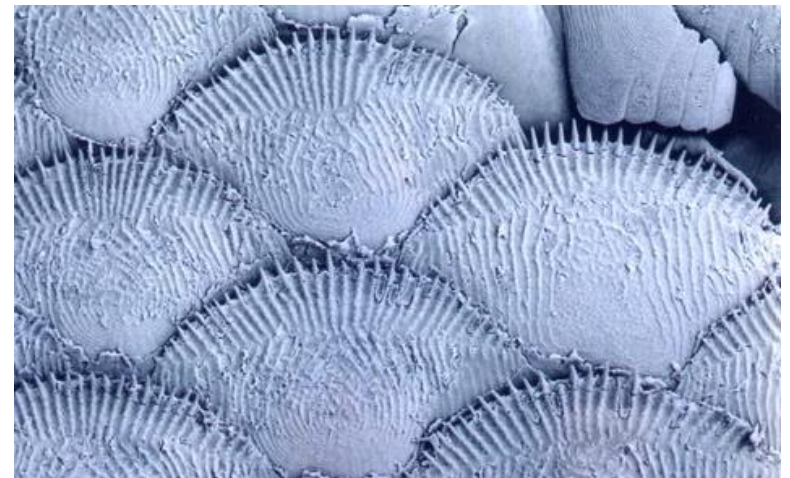
2. Cosmoid - lungfish

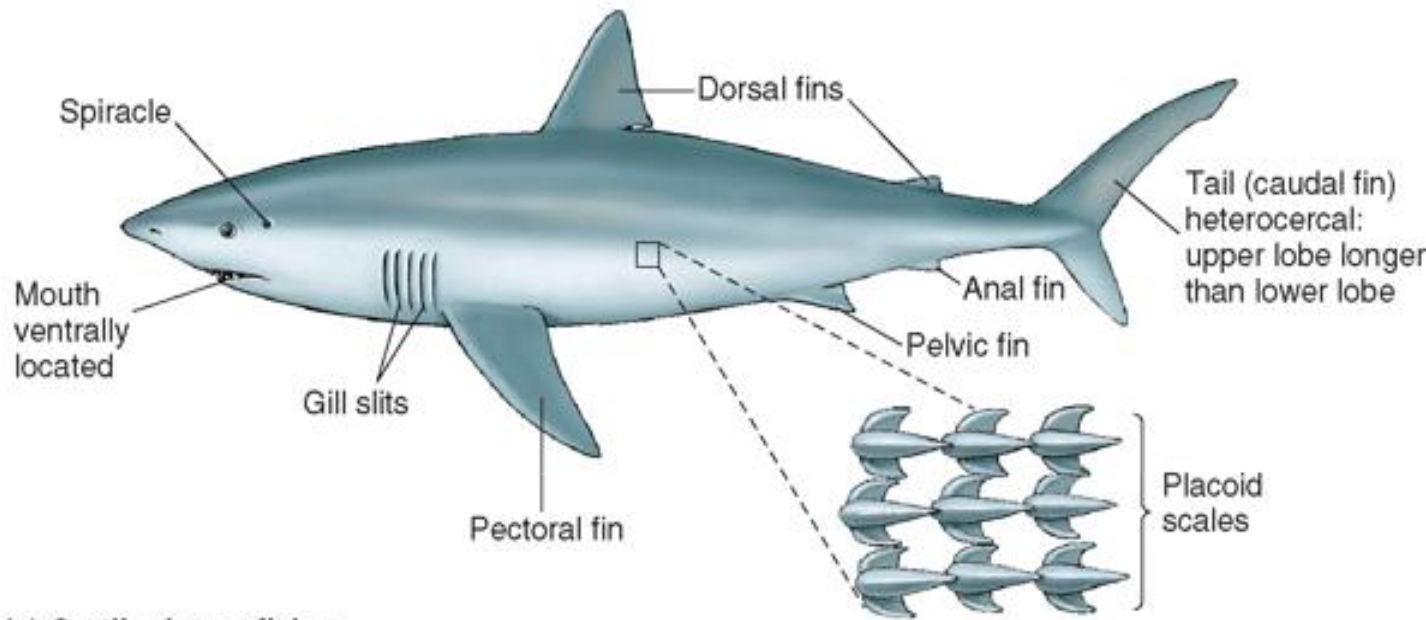


3. Ganoid - bichir, sturgeon

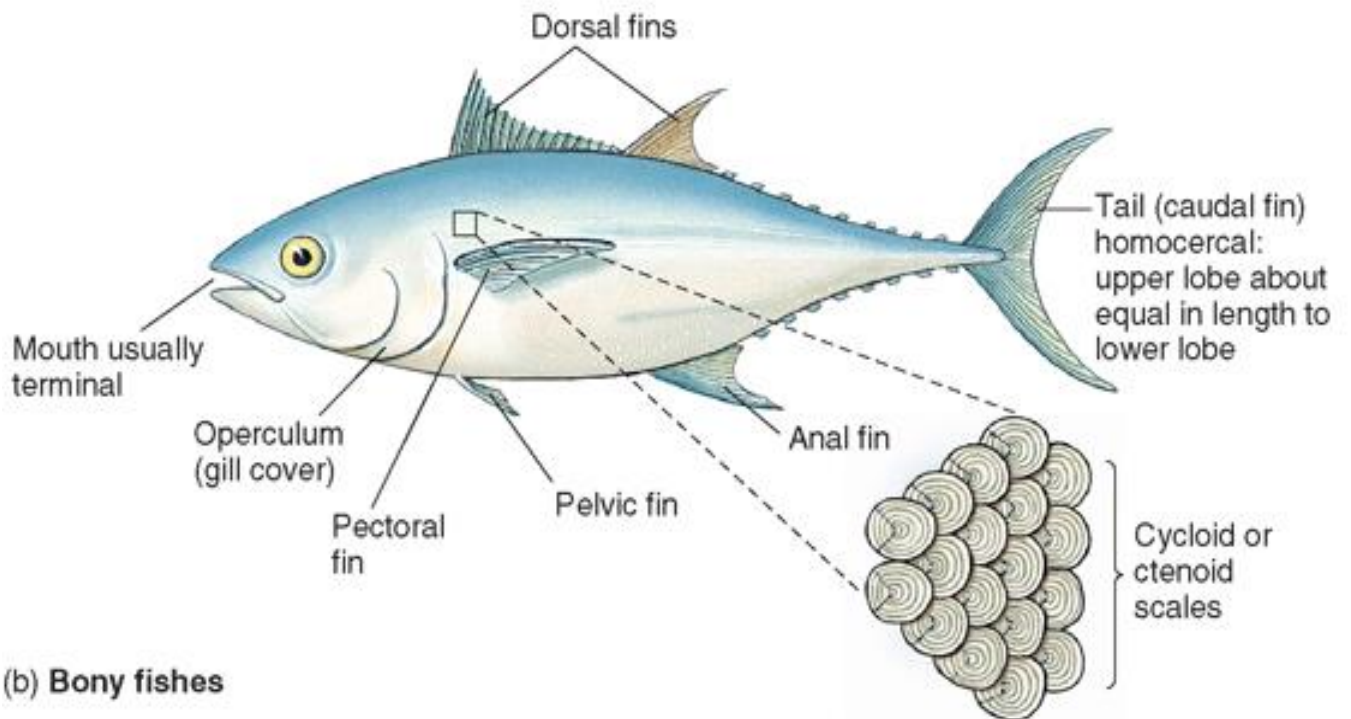


4. Cycloid + Ctenoid - teleostei



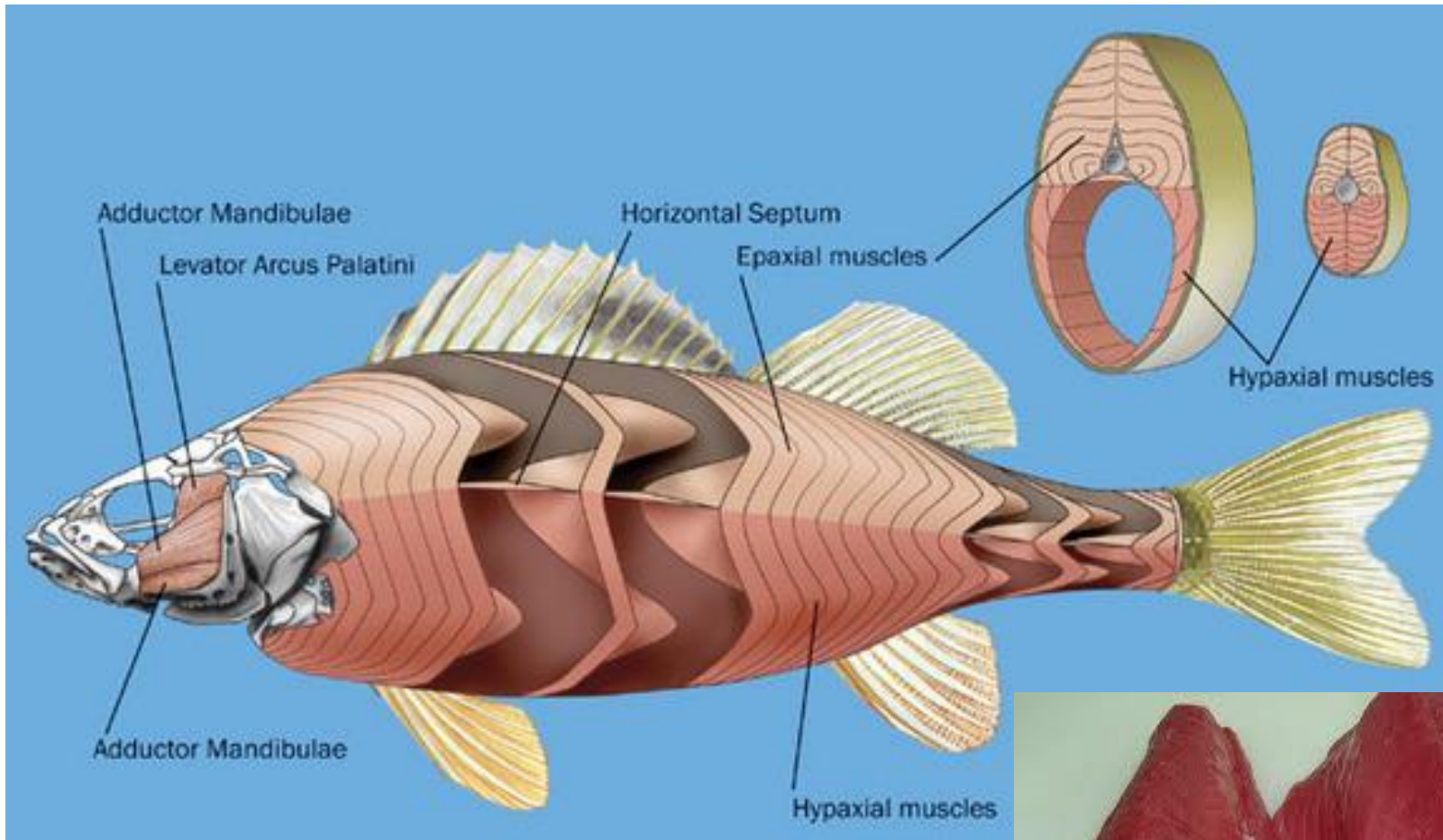


(a) Cartilaginous fishes



(b) Bony fishes

MUSCULAR SYSTEM

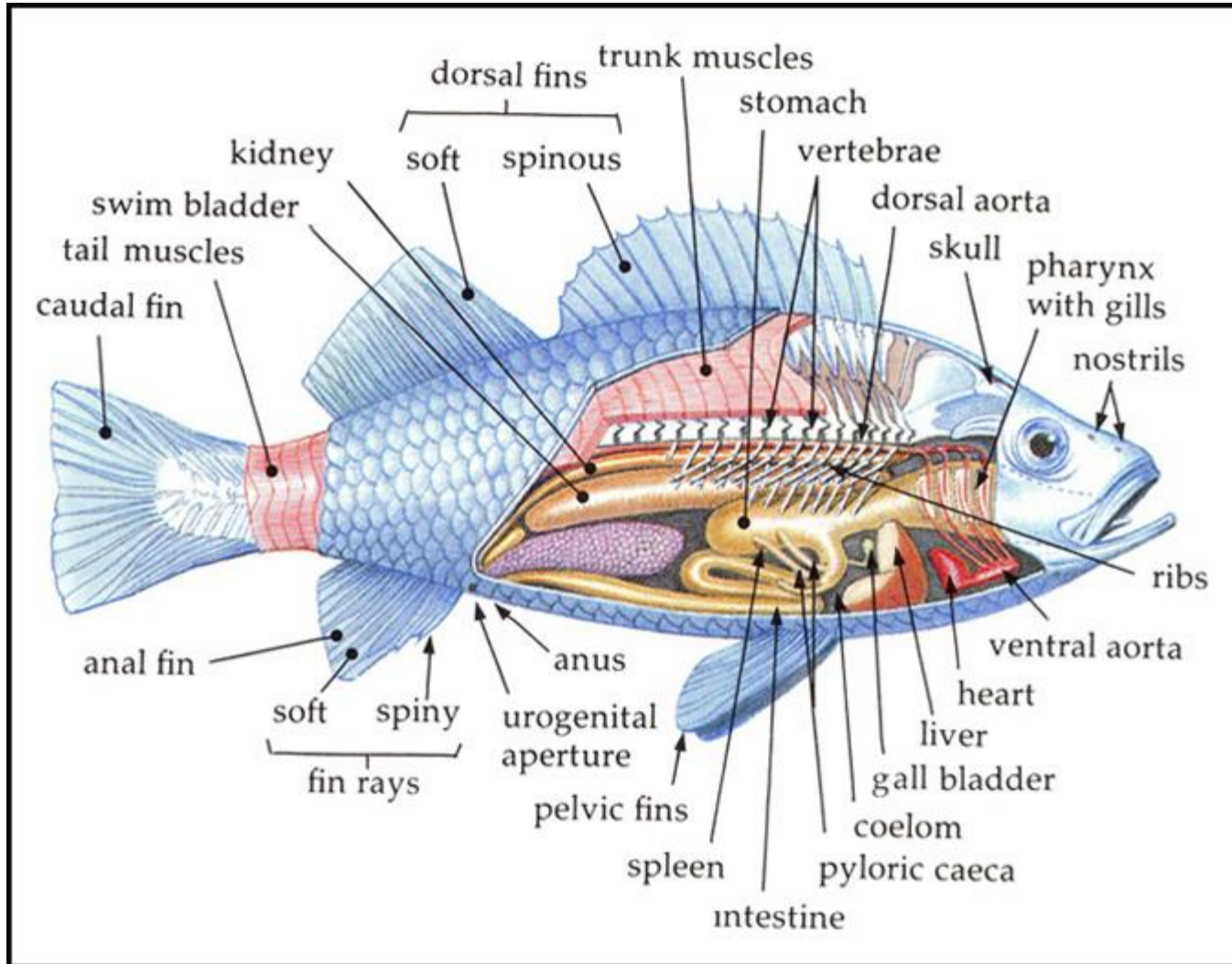


„quick“ white muscle (pike)

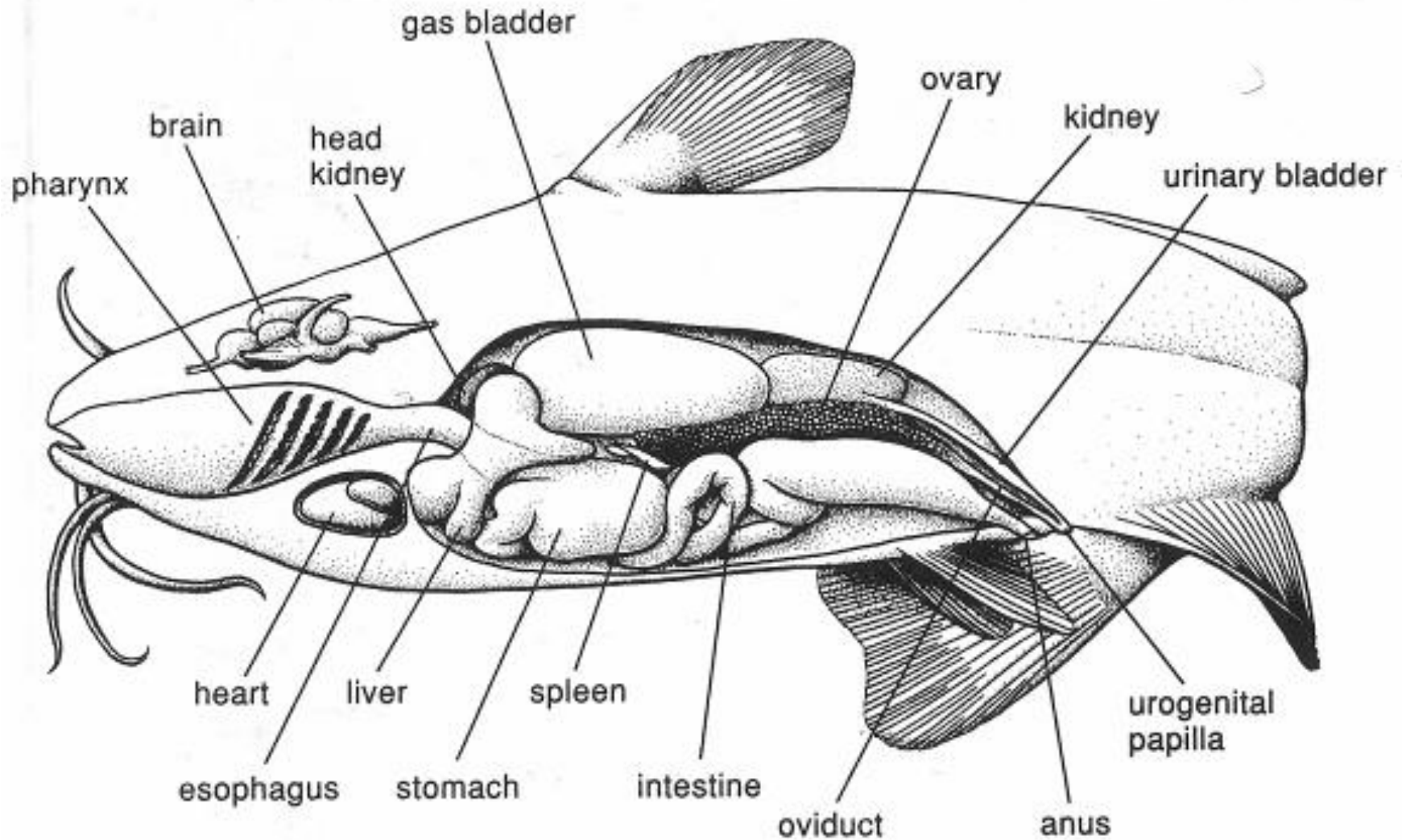
„slow“ red muscle (tuna)



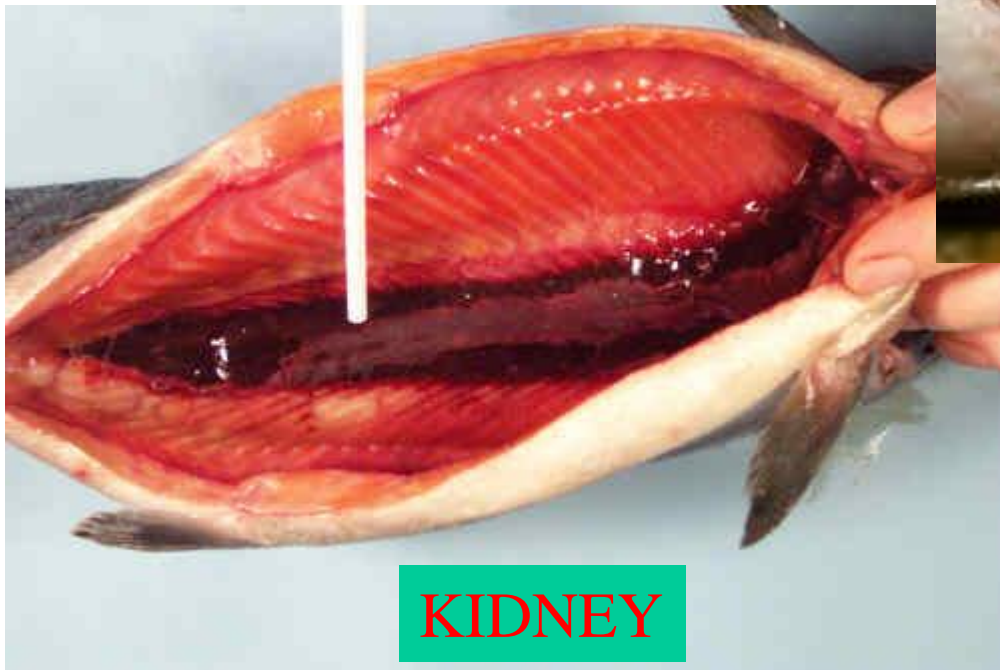
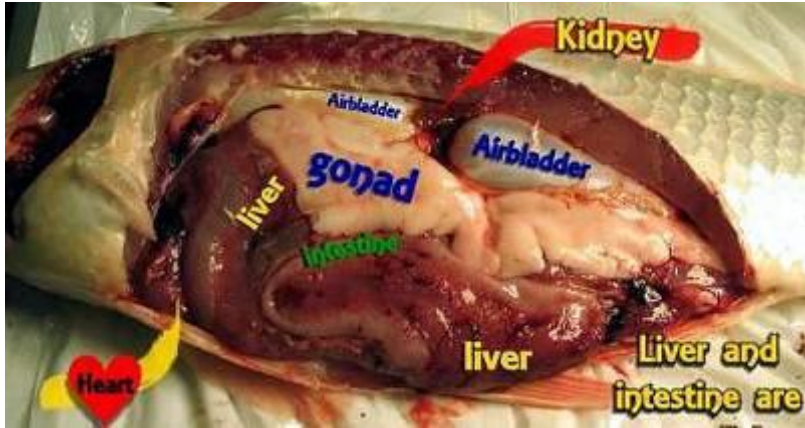
GENERAL ANATOMY - ORGANS



DIGESTIVE SYSTEM



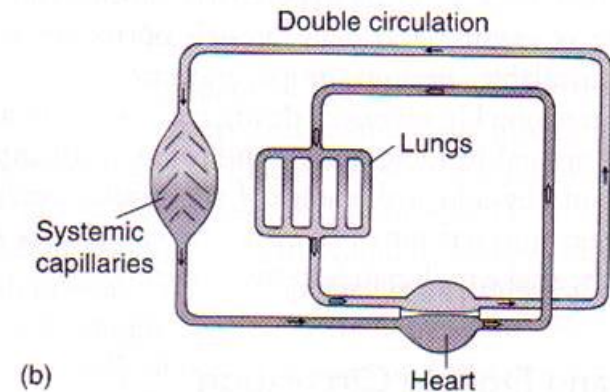
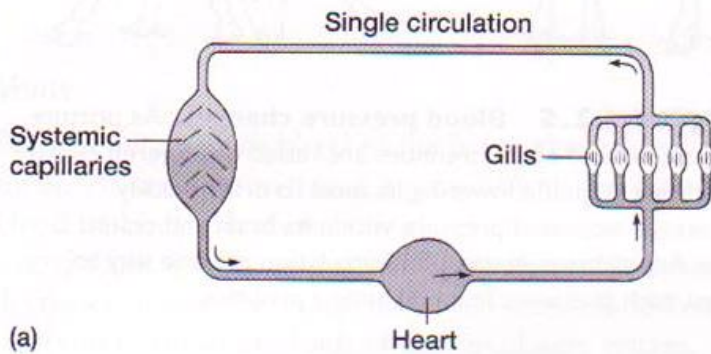
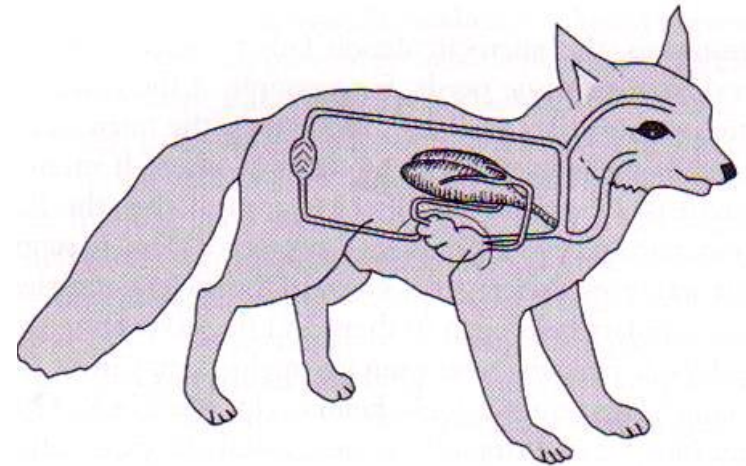
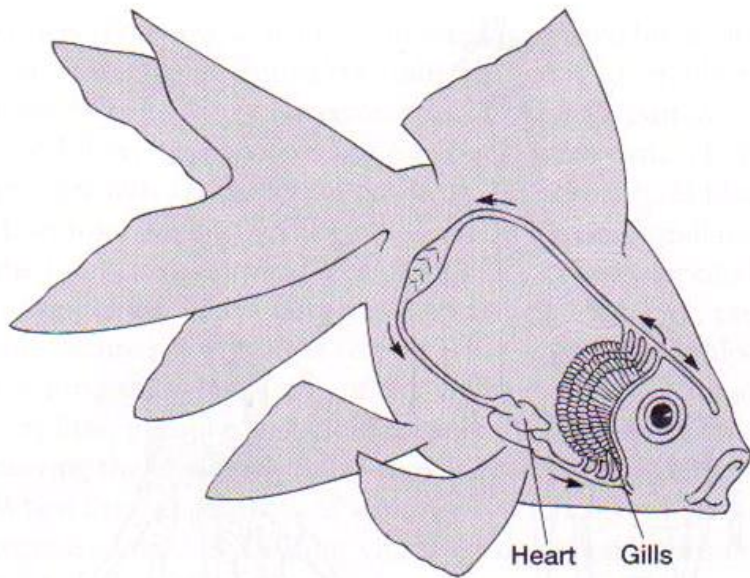
INTERANAL ORGANS



Part II - PHYSIOLOGY



CIRCULATORY SYSTEM

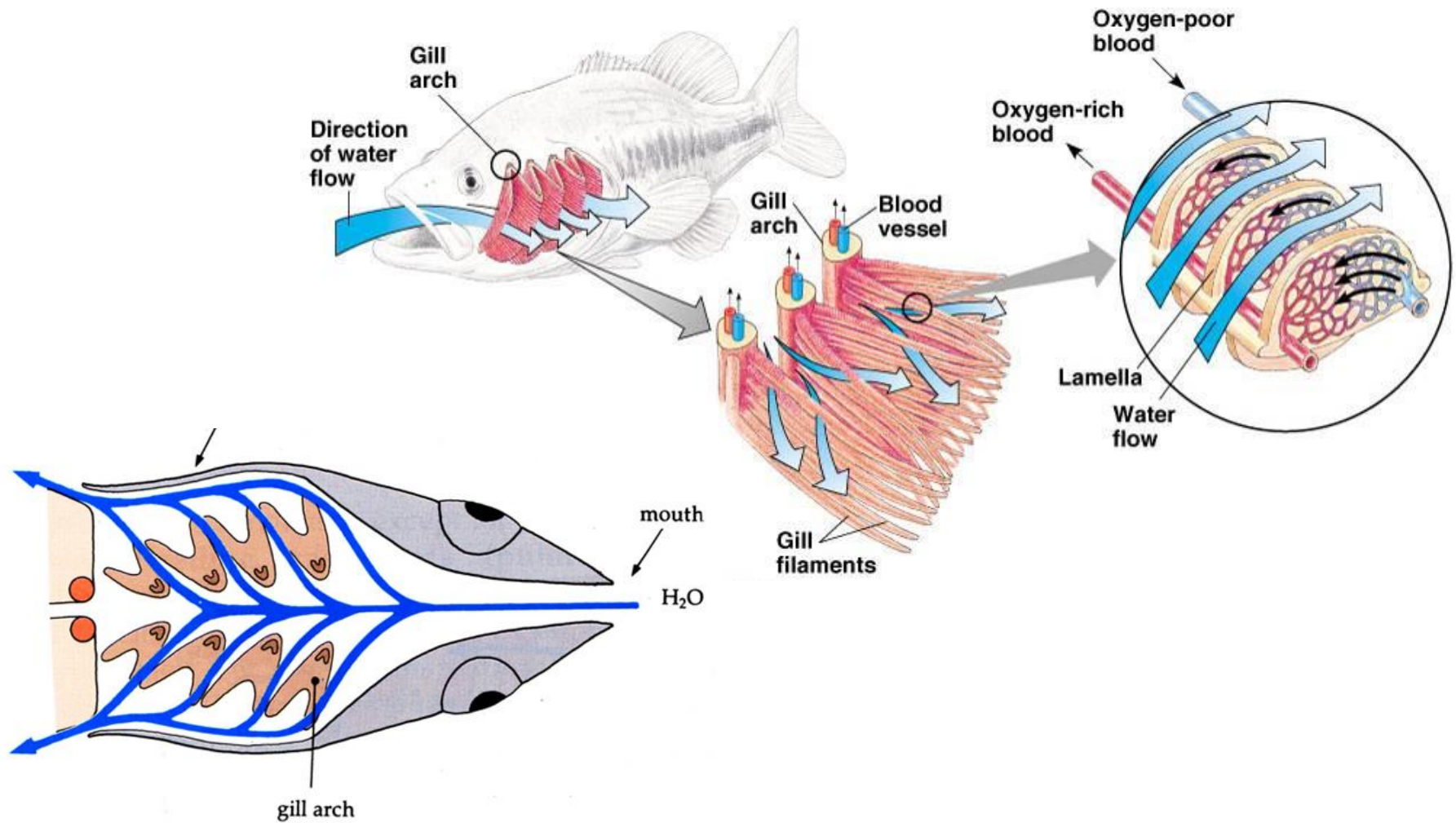


One circuit

Double circuit

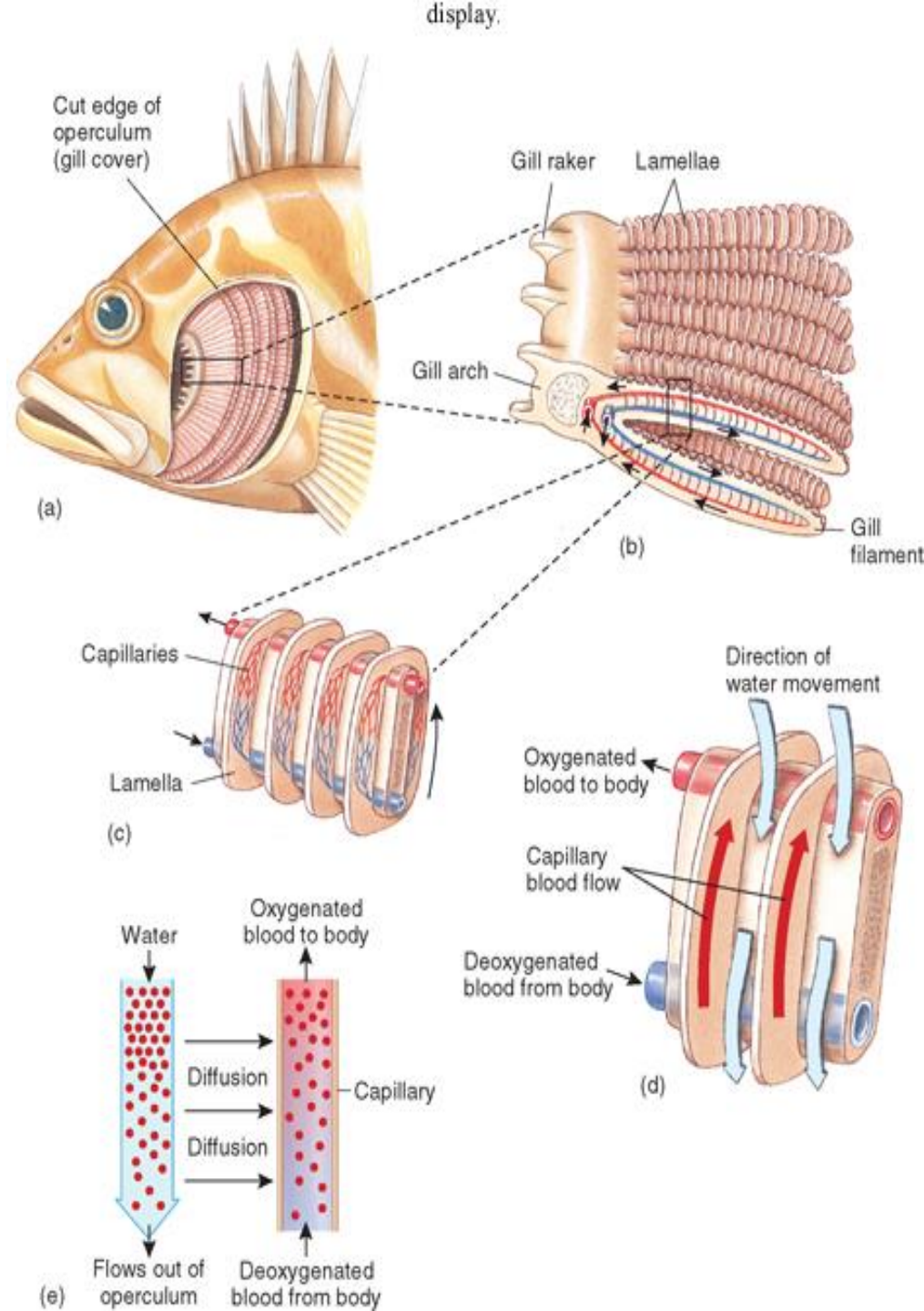
BREATHING - GILLS

Water - high density and viscosity, low oxygen content.



Gills: the best way to gain oxygen (O₂) from an environment where its concentration is already very low.

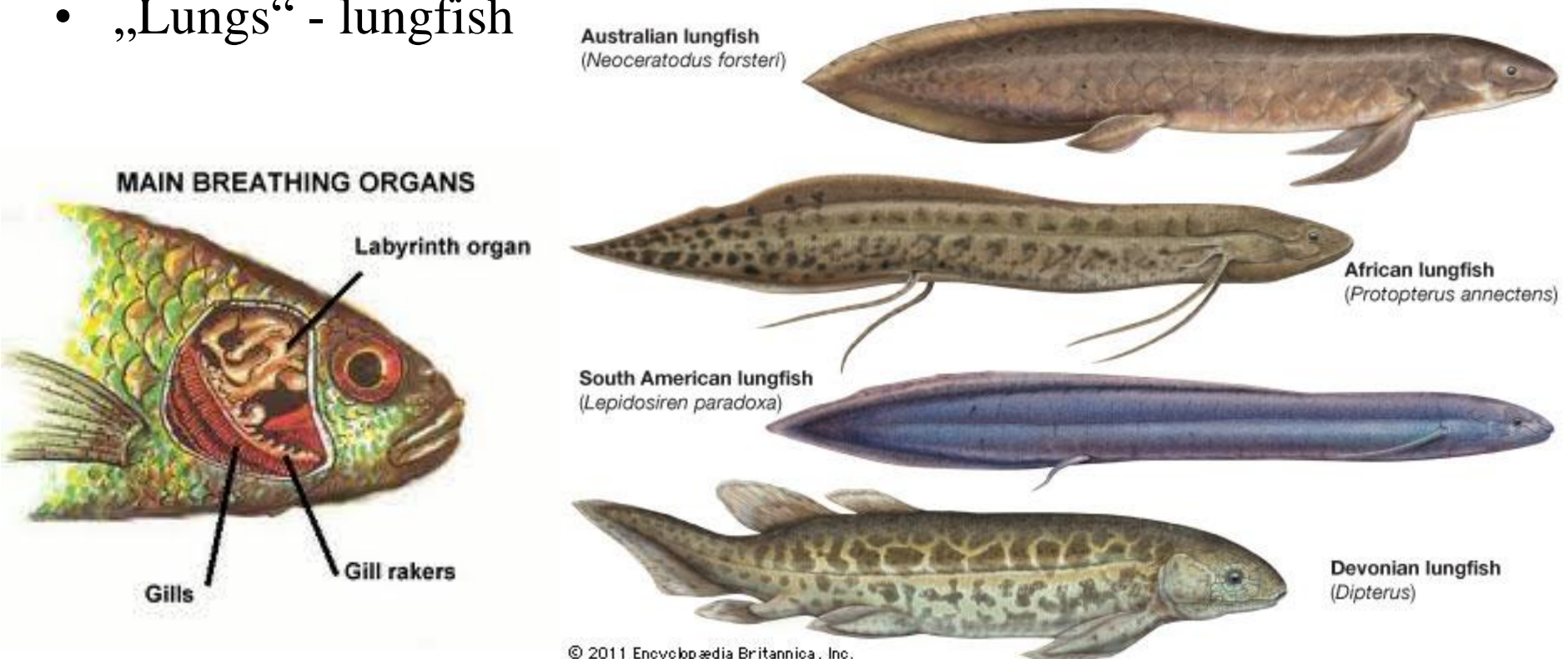
Counter-current circulation permits O₂ to diffuse from high to low concentration, even across venous tissue after most O₂ has been removed from the water by gills.



BREATHING OF ATMOSPHERICAL OXYGEN

ACCESSORY BREATHING ORGAN

- Skin – *Anguilla* (Eel)
- Intestiny – *cobitis*, *misgurnus* (loaches)
- Labyrinth – *clarias* (catfish), *beta* (labyrinth fish - Osphronemidae)
- „Lungs“ - lungfish

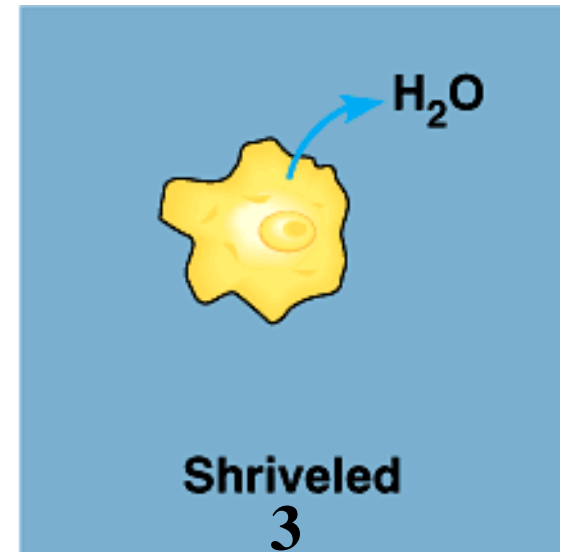
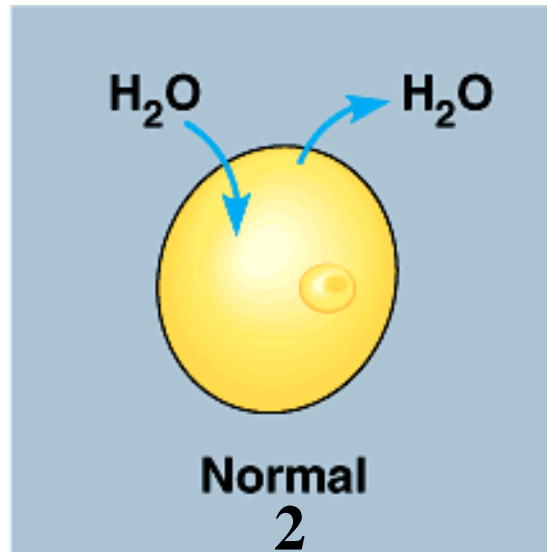
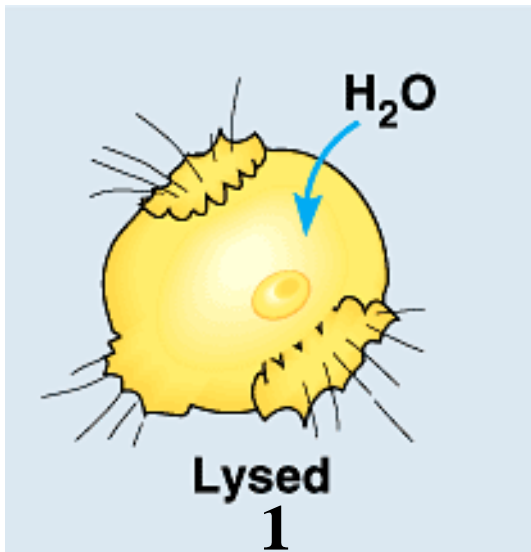


OSMOREGULATION

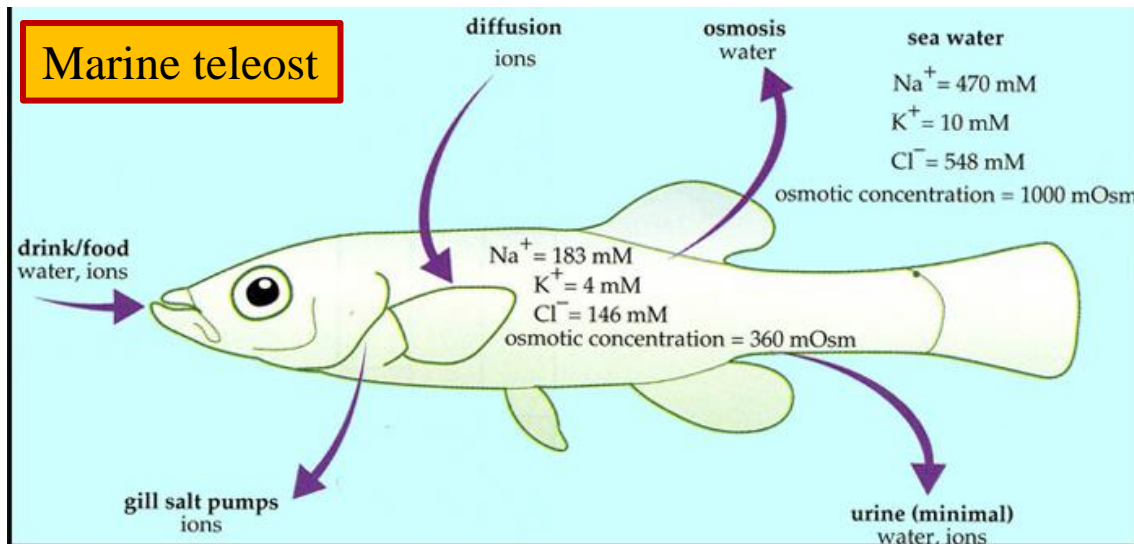
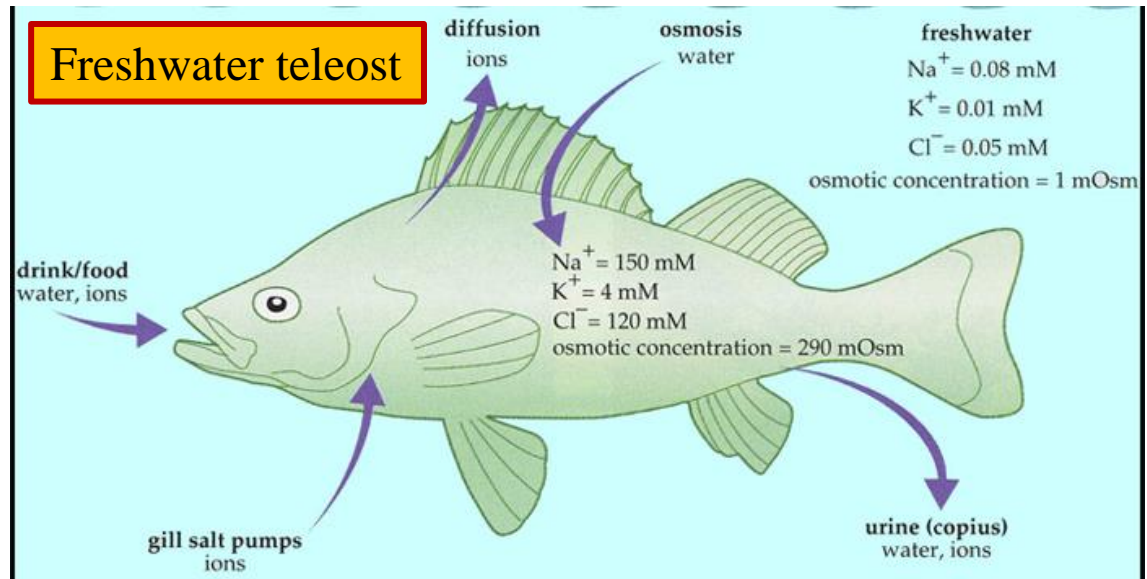
Osmosis: movement of water through a membrane from an area of high concentration to area of low concentration.

Osmolarity: total moles of solute per liter of water.

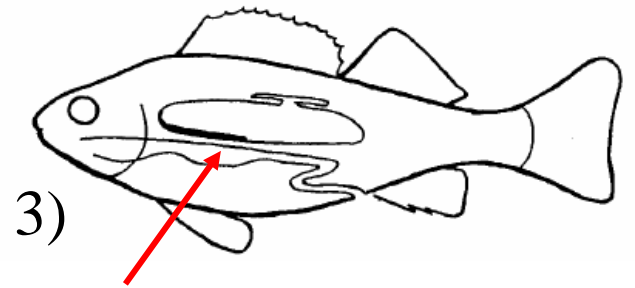
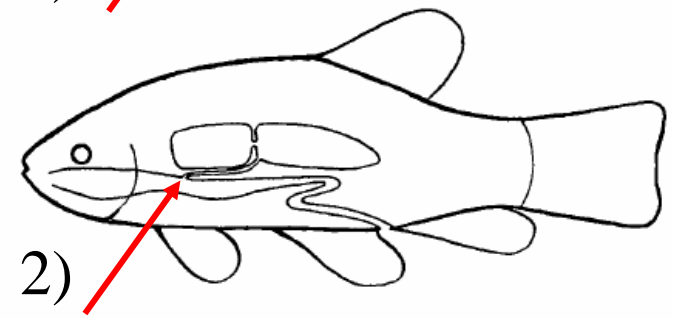
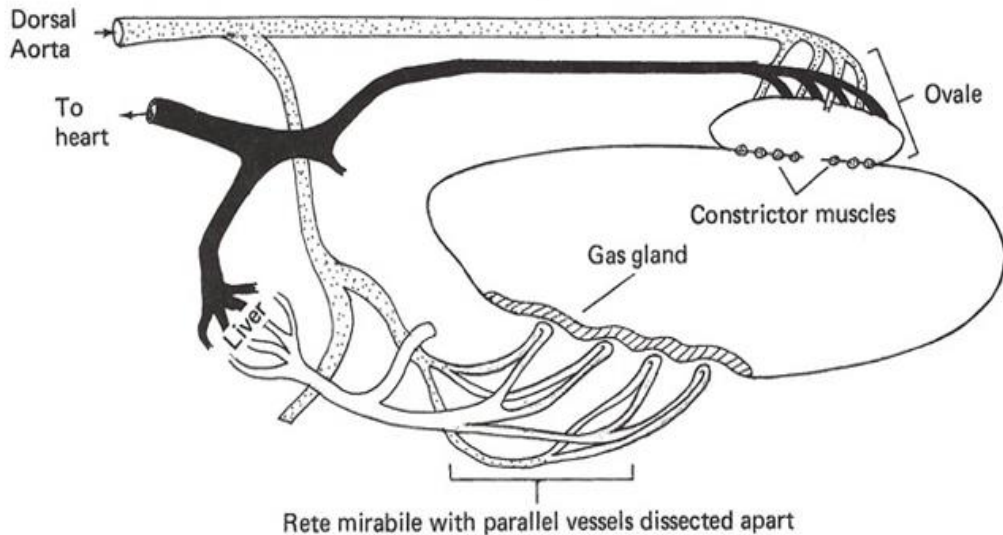
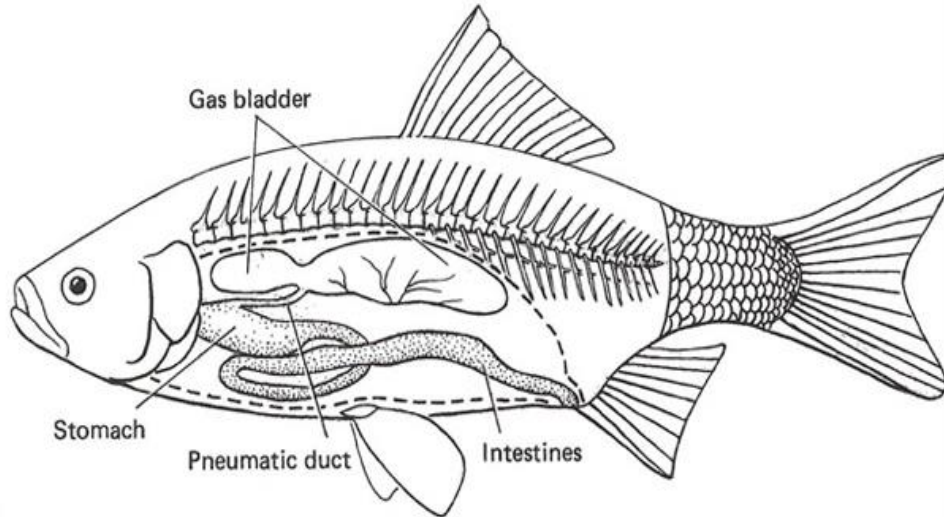
1. **Isoosmotic:** 2 solutions have same osmolarity.
2. **Hypoosmotic:** solution with higher H_2O concentration.
3. **Hyperosmotic:** solution with lower H_2O concentration.



ARE THEY DRINKING WATER?



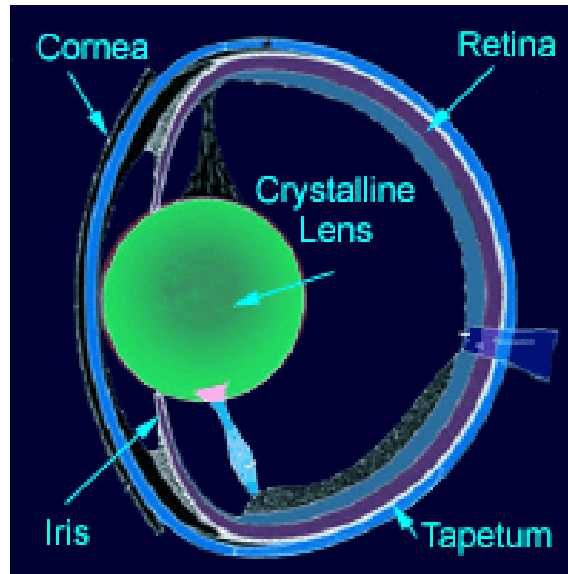
BUOYANCY



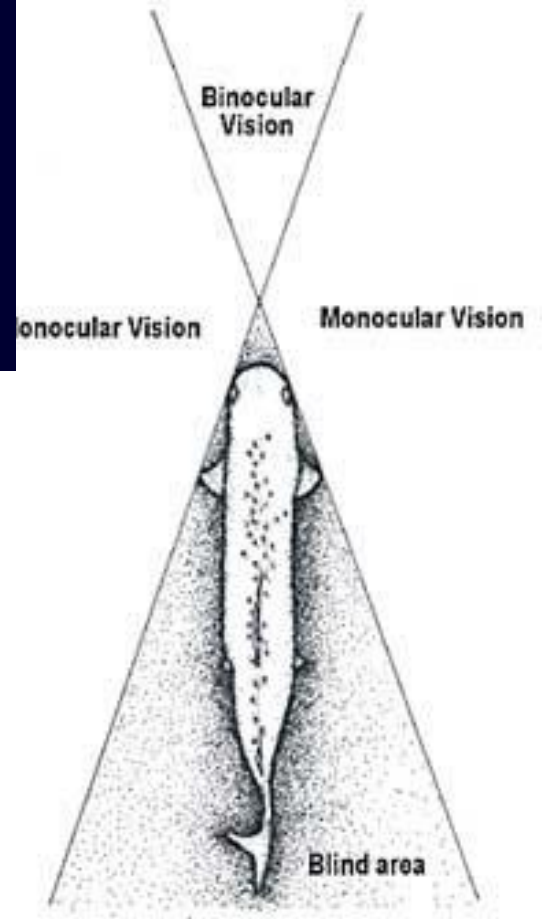
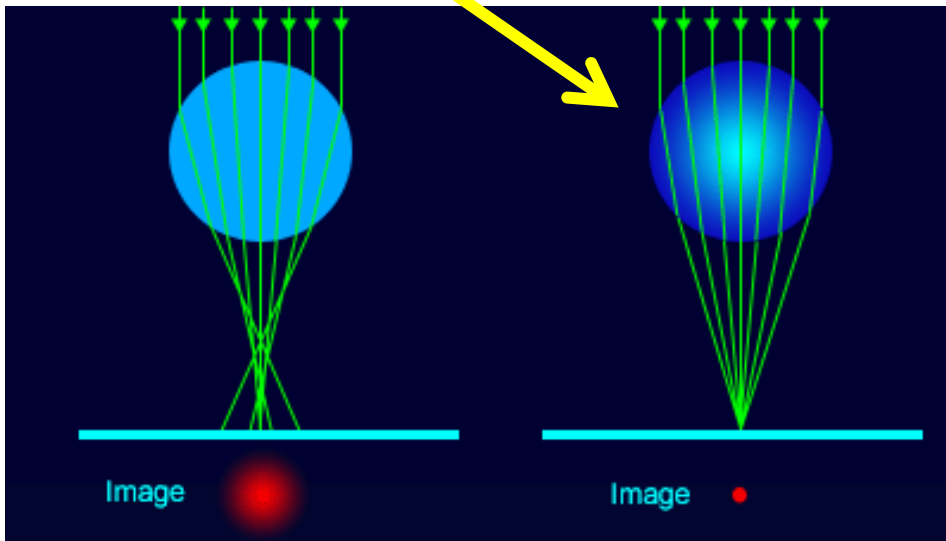
- 1) Esocidae (physostomous)
- 2) Cyprinidae (physostomous)
- 3) Percidae (physoclistous)

SENSES - SIGHT

Lens of fish is spherical

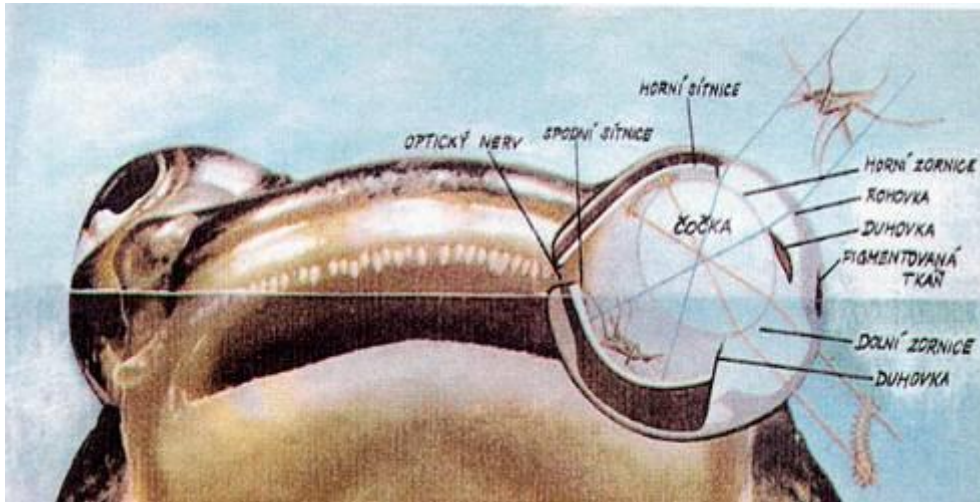


Lens has variable optical density



SENSES - SIGHT

- Anableps anableps



SENSES - SIGHT

- Deep sea adaption of *Macropinna microstoma*, transparent head

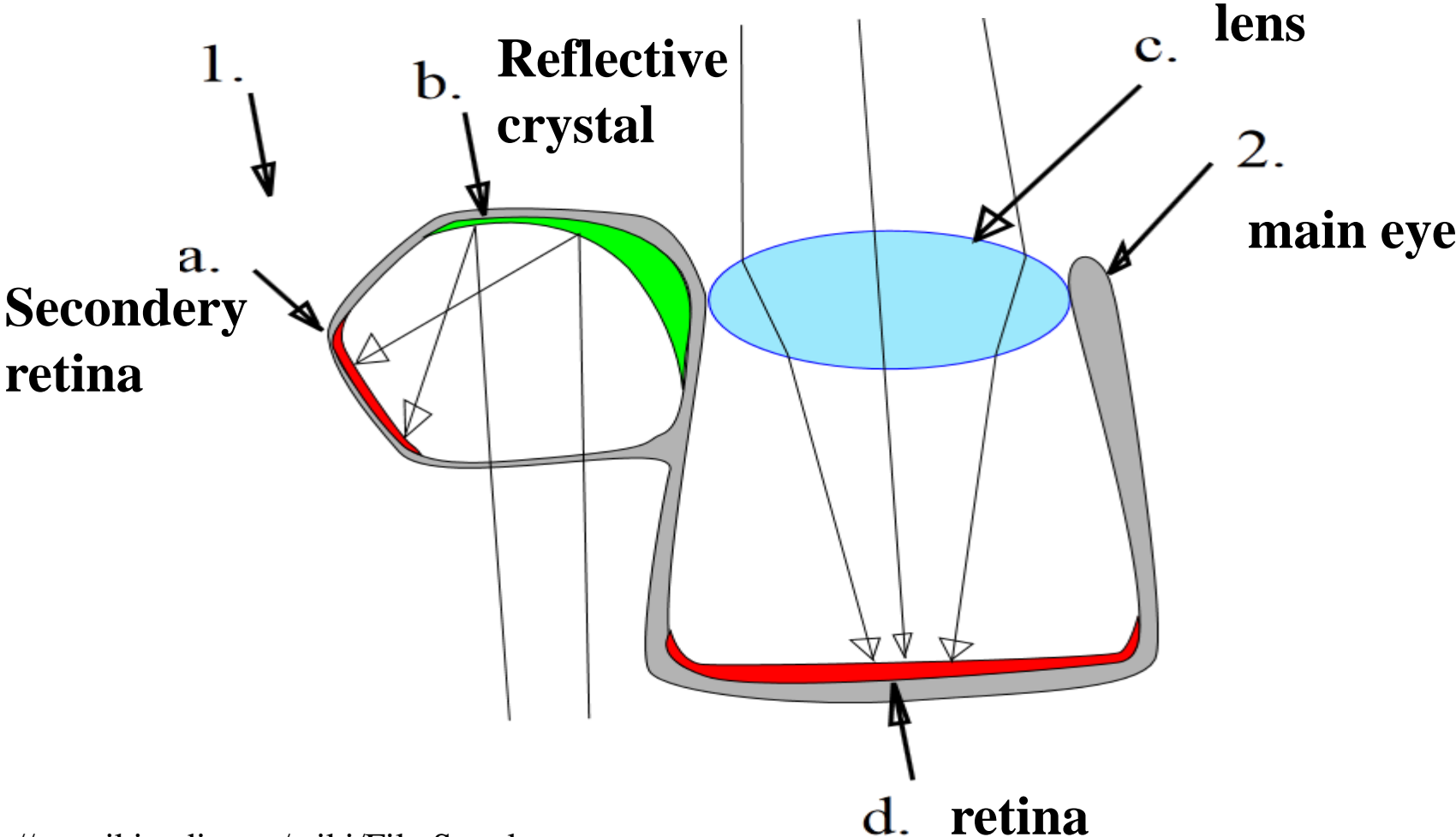


SENSES - SIGHT

- Deep sea adaption of *Dolichopteryx longipes* – mirror organ.



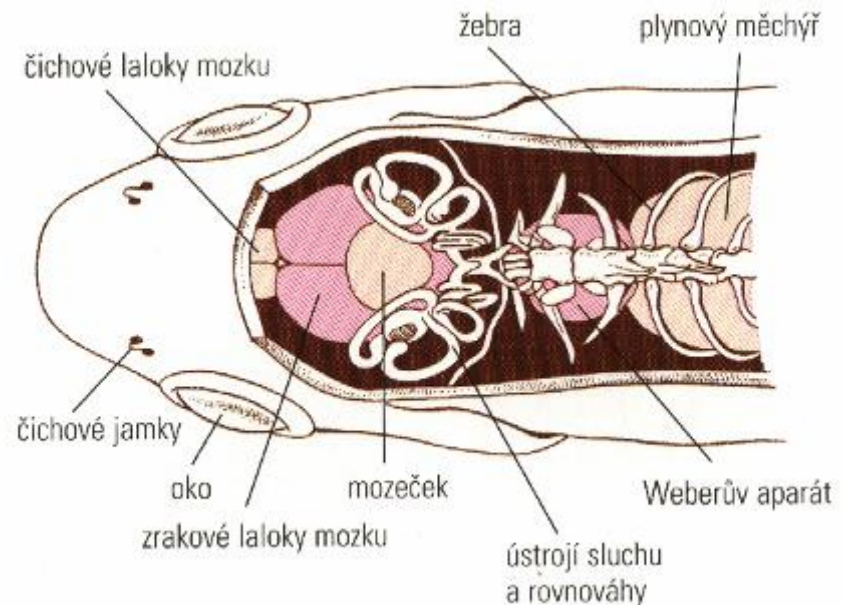
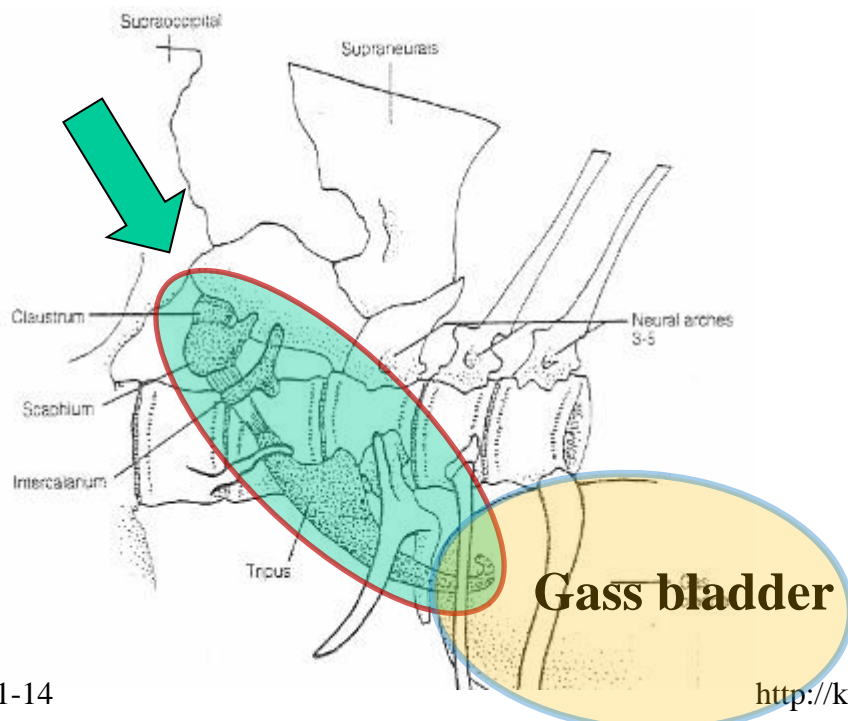
MIRROR ORGAN -



<http://en.wikipedia.org/wiki/File:Spokeye.svg>

SENSES - HEARING

- Weber's organ – connected with gass bladder
- It is an anatomical structure that connects the swim bladder to the auditory system - transmitting auditory signals (ossicles) straight from the gas bladder
- It is typical character of Ostariophysi - the second-largest superorder of fish

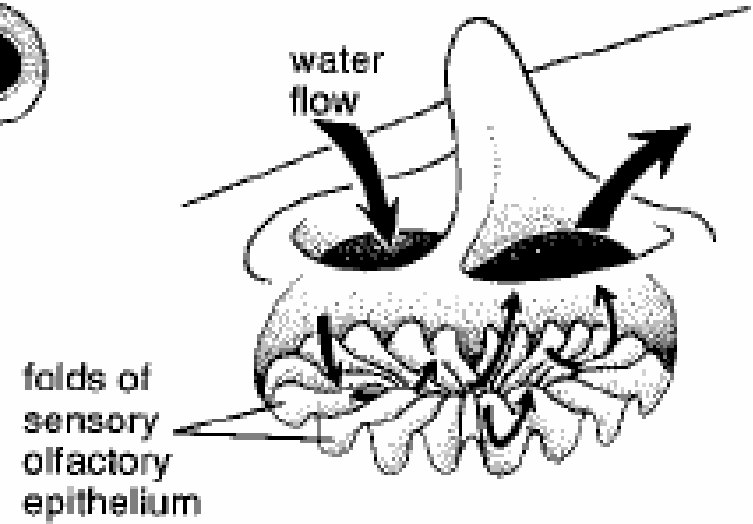
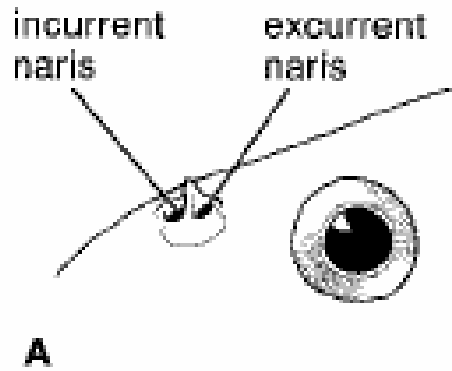


SENSES - TASTE

- Sensors in the mouth, pharynx, on the operculum, barbels

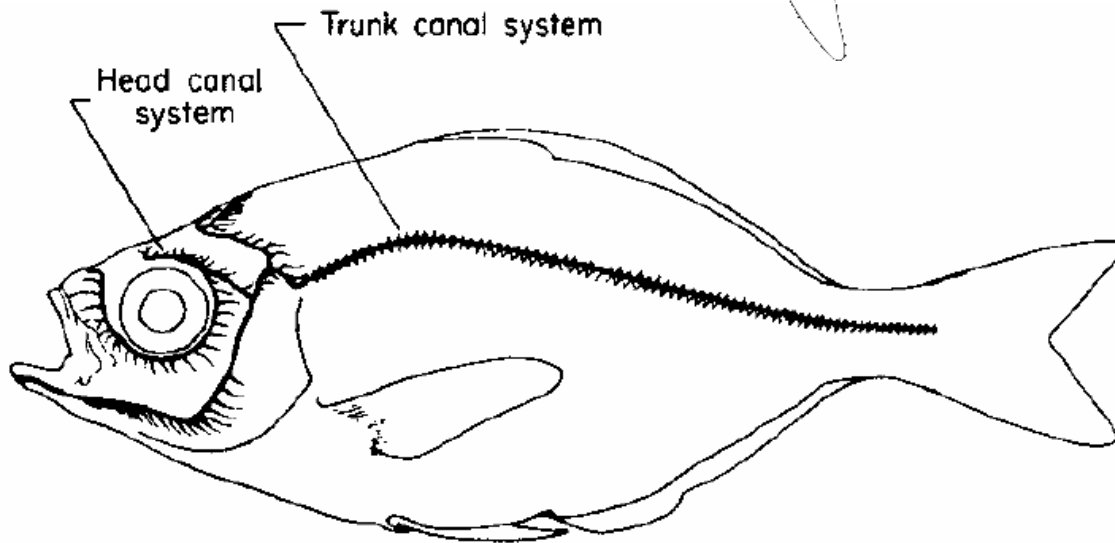
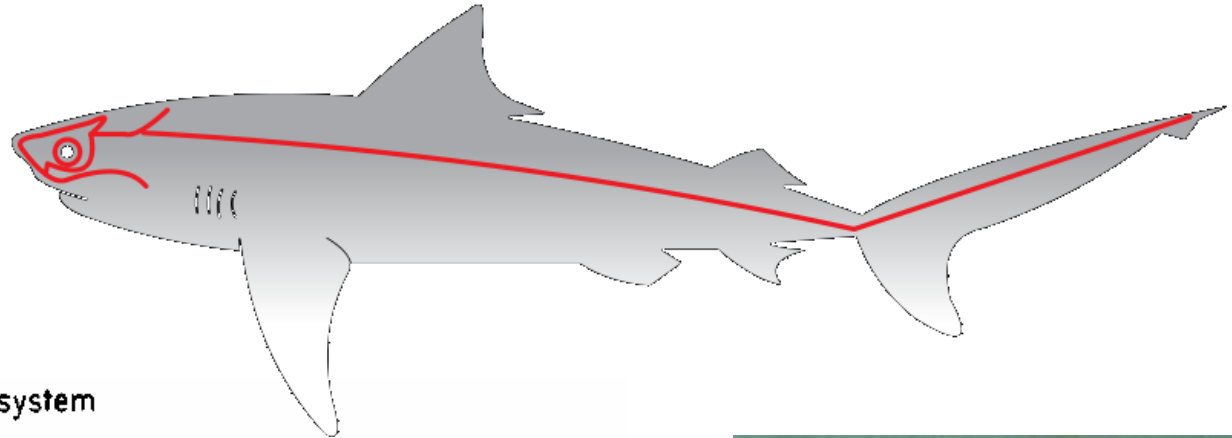


SENSES - SMELL

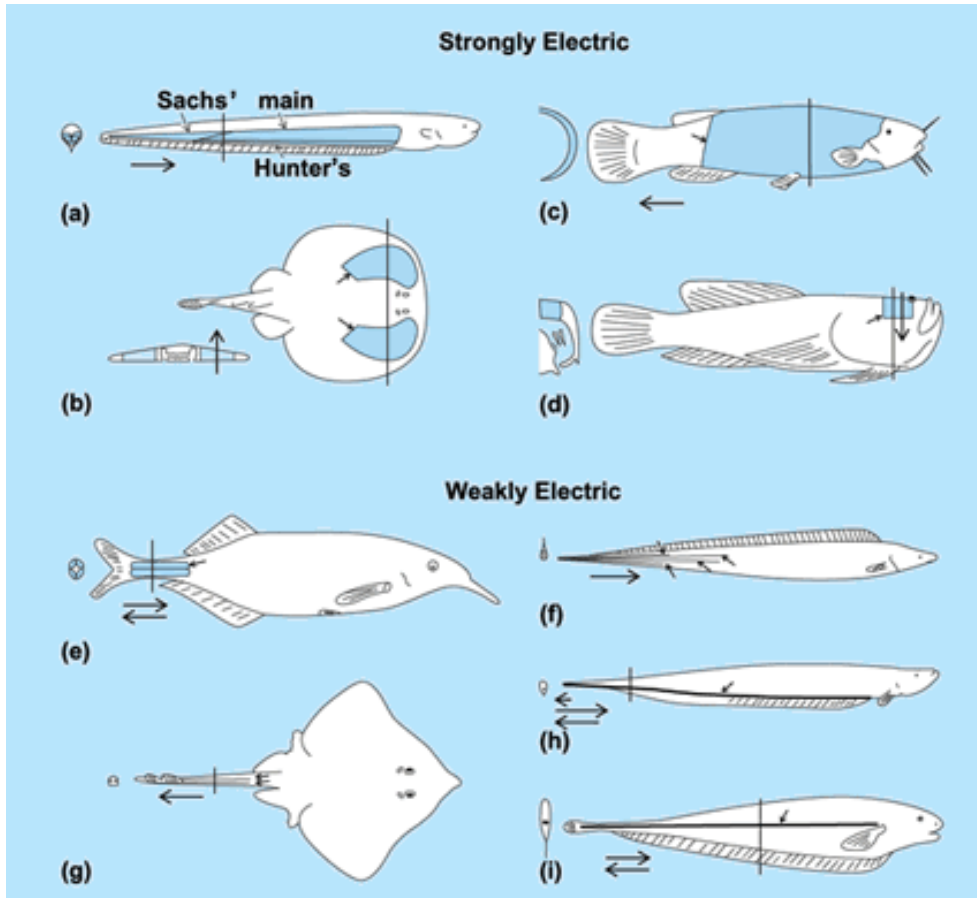


SENSES - TOUCH

- Neuromasts on the body – head, lateral line



SENSES – ELETRIC FIELD



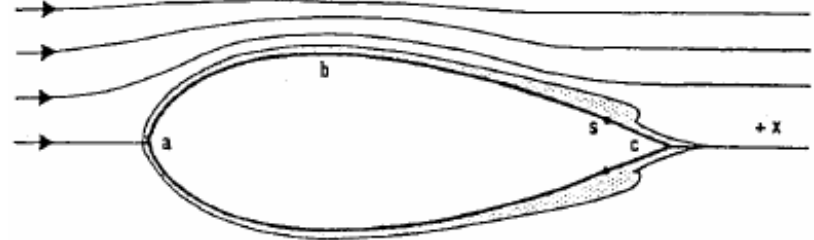
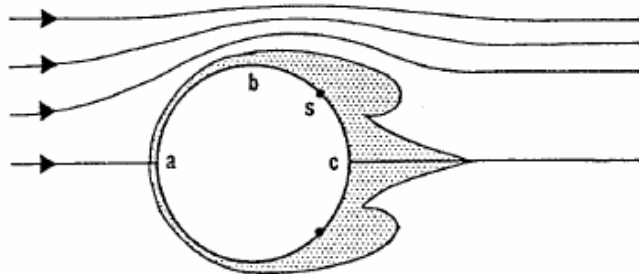
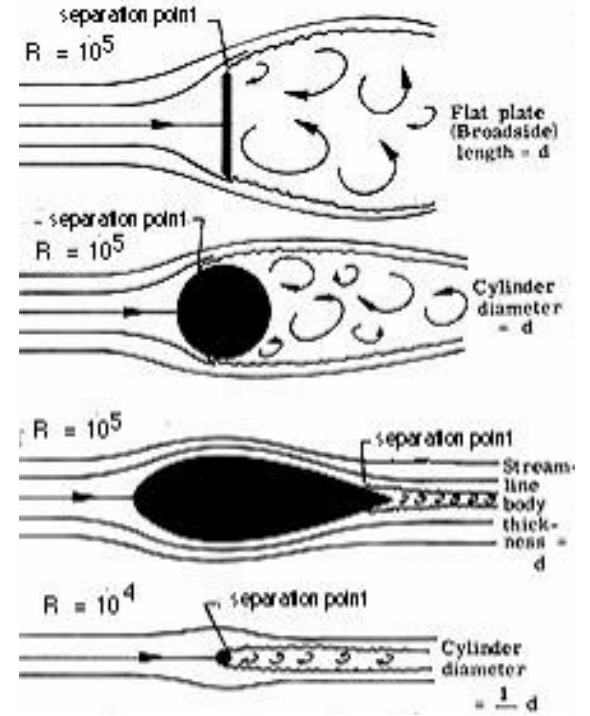
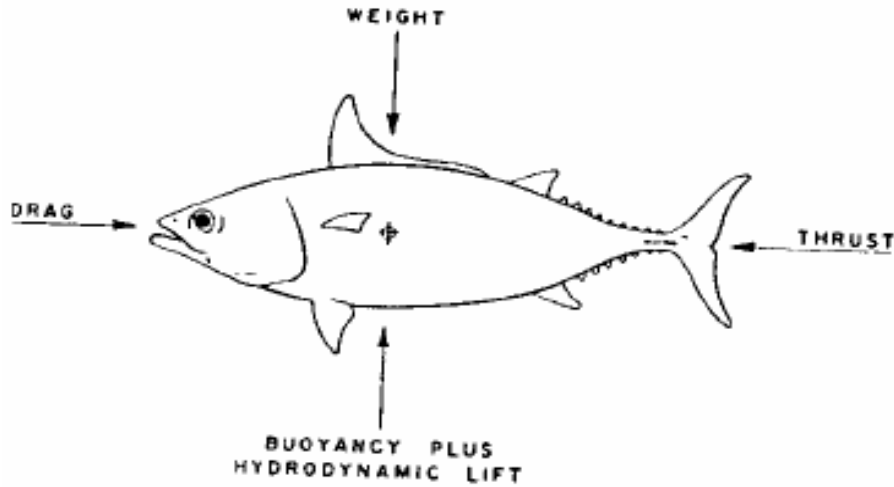
Catfish

Torpedo

Elephant fish (mormyridae)

Eels

BODY SHAPE



MOTION

- Swimming of individual



- Swimming in shoal

Part III - ONTOGENY - ECOLOGY



SEXUAL DIMORPHISM

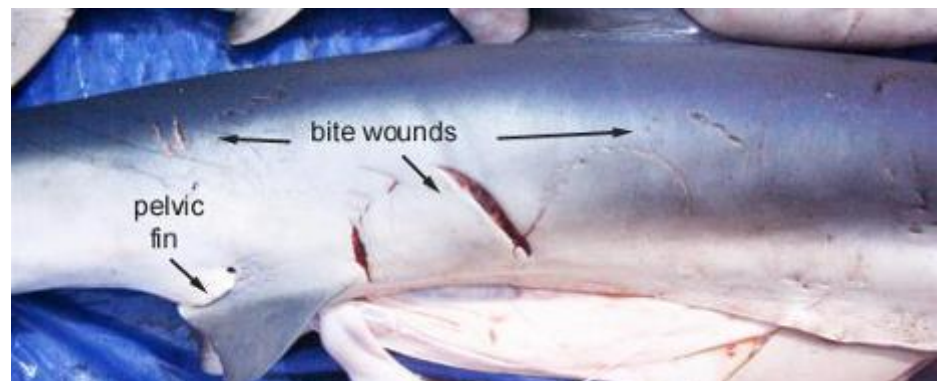
Different coloration



Different size of male and female - cavity for the eggs



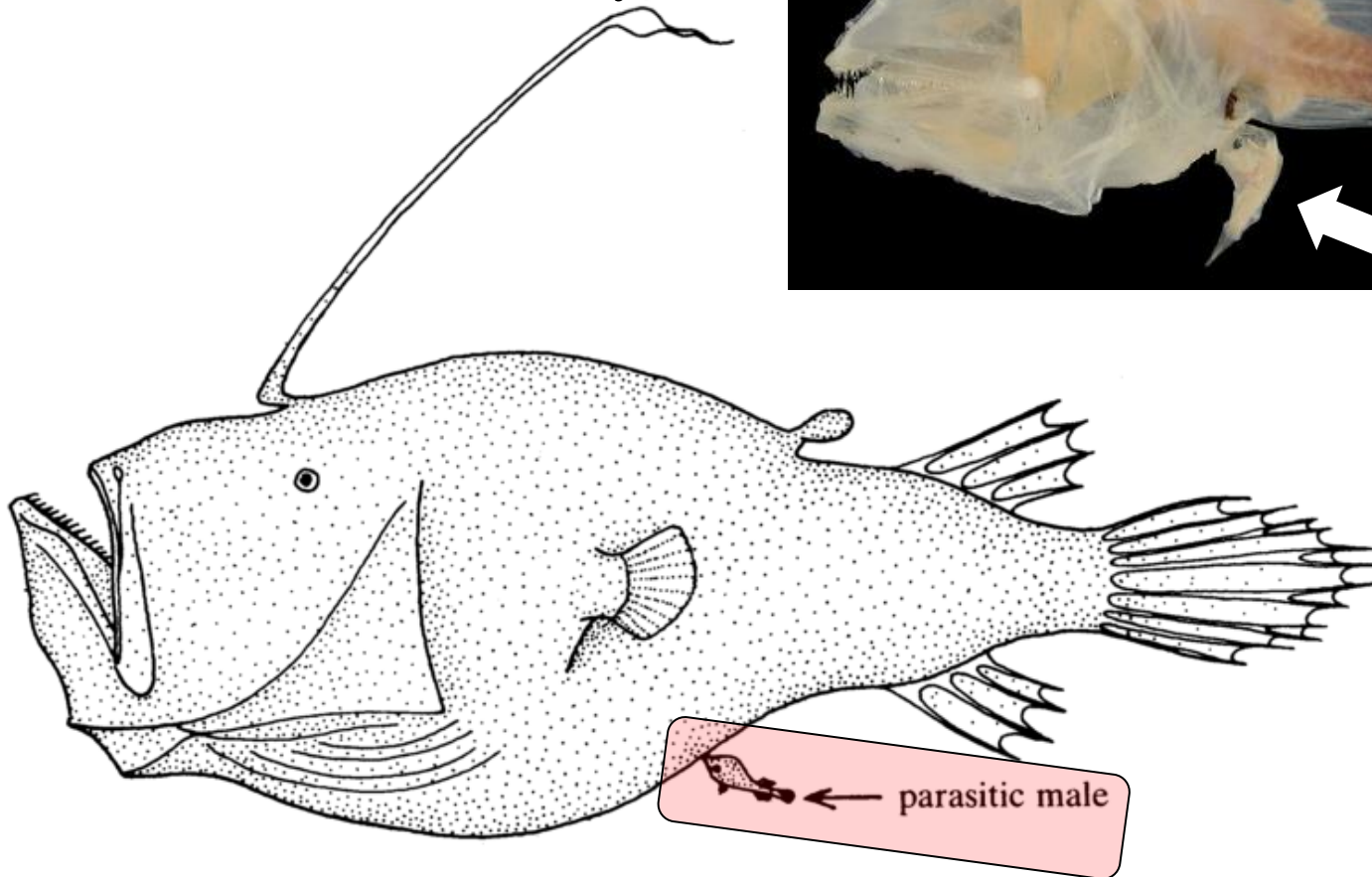
Different thickness of the skin in sharks – male bites female



SEXUAL DIMORPHISM

Extrem in deep sea fishes:

Tini miniaturezid males,
attached to female body



REPRODUCTION

Cartilaginous fish (chimaera, shark)

Internal fertilization

A few eggs or vivipary

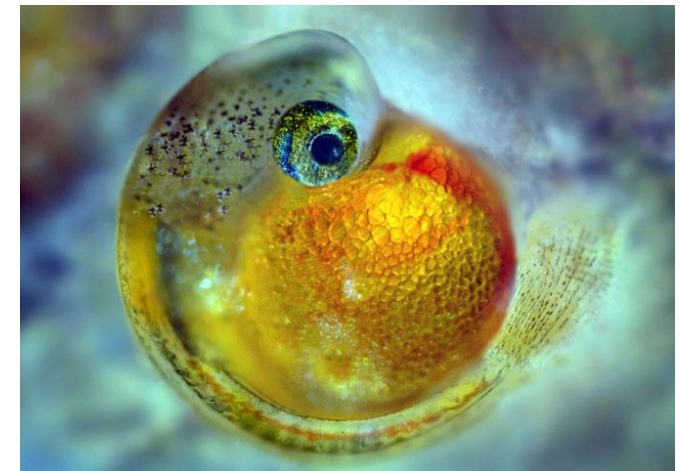


Bony fish (gold fish, tuna,...)

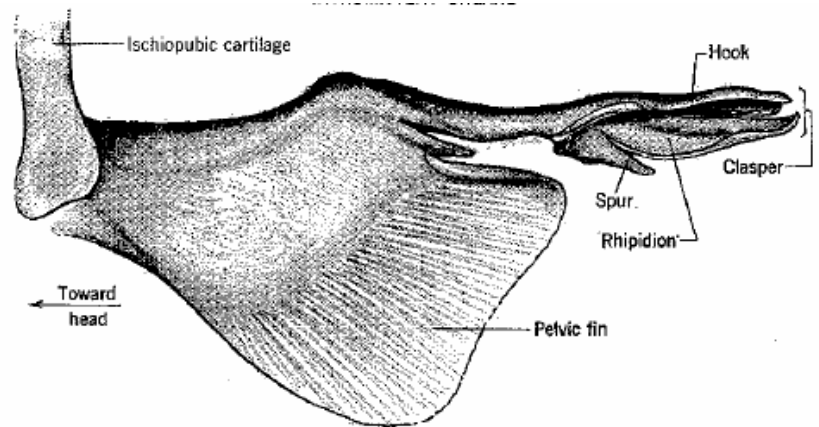
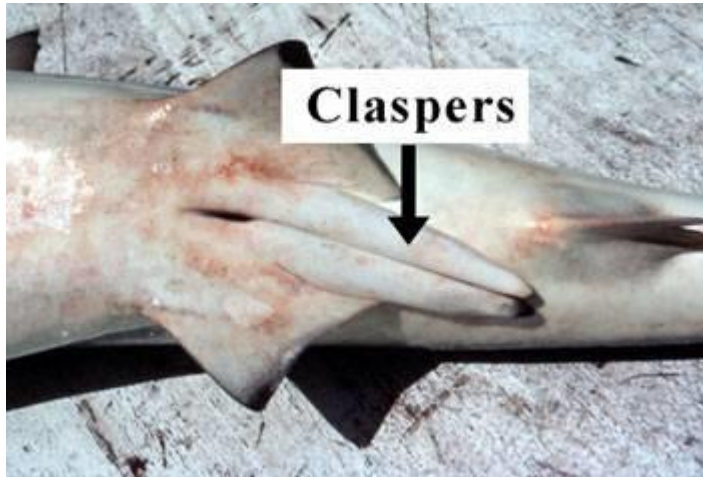
- External fertilization
- Many eggs – roe (caviar)



X

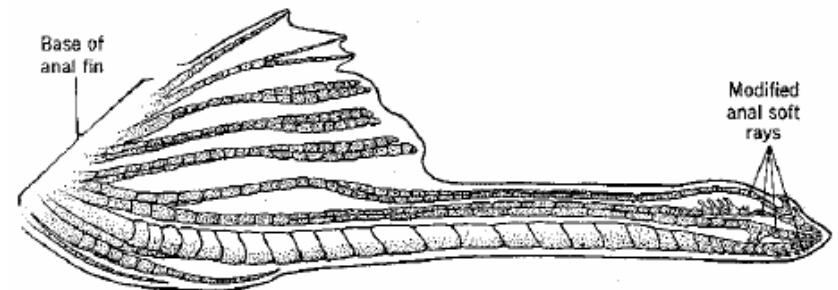
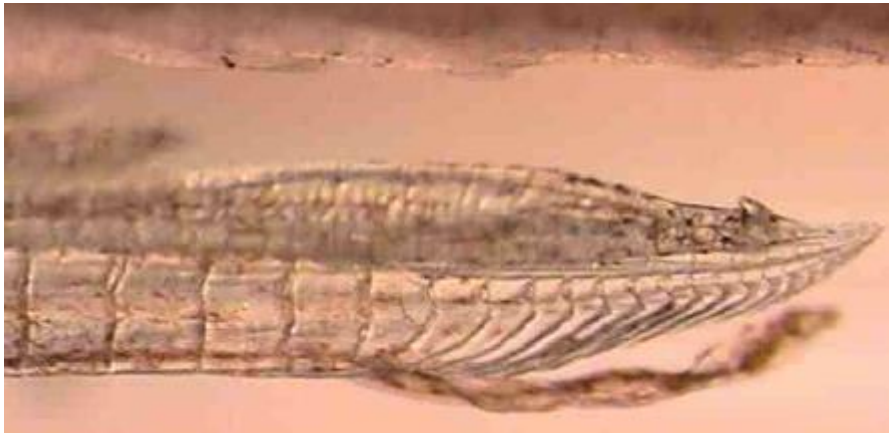


REPRODUCTION



(a) Shark clasper (myxoptergium)

- Chondrichthyes



(b) *Gambusia* gonopodium

- Bony fish

Reproductive traits and life-history patterns

Mating systems:

- Promiscuous - both sexes with multiple partners - mostly
- Polygynous - males with multiple mates (cichlids)
- Polyandry - females with multiple mates – few (Anglerfish, males “parasitize” females, clownfish)
- Monogamy - mating pair remains together over time, long gestation of young (some cichlids, seahorses, pipefish)

Various types of parental care:

- Cichlids
- Catfishes
- Seahorse - Syngnathidae



LIFE CYCLE

Egg: Trout eggs have black eyes and a central line that show healthy development. Egg hatching depends on the water temperature in an aquarium or in a natural habitat.

Alevin: Once hatched, the trout have a large yolk sac used as a food source. Each alevin slowly begins to develop adult trout

Characteristics.

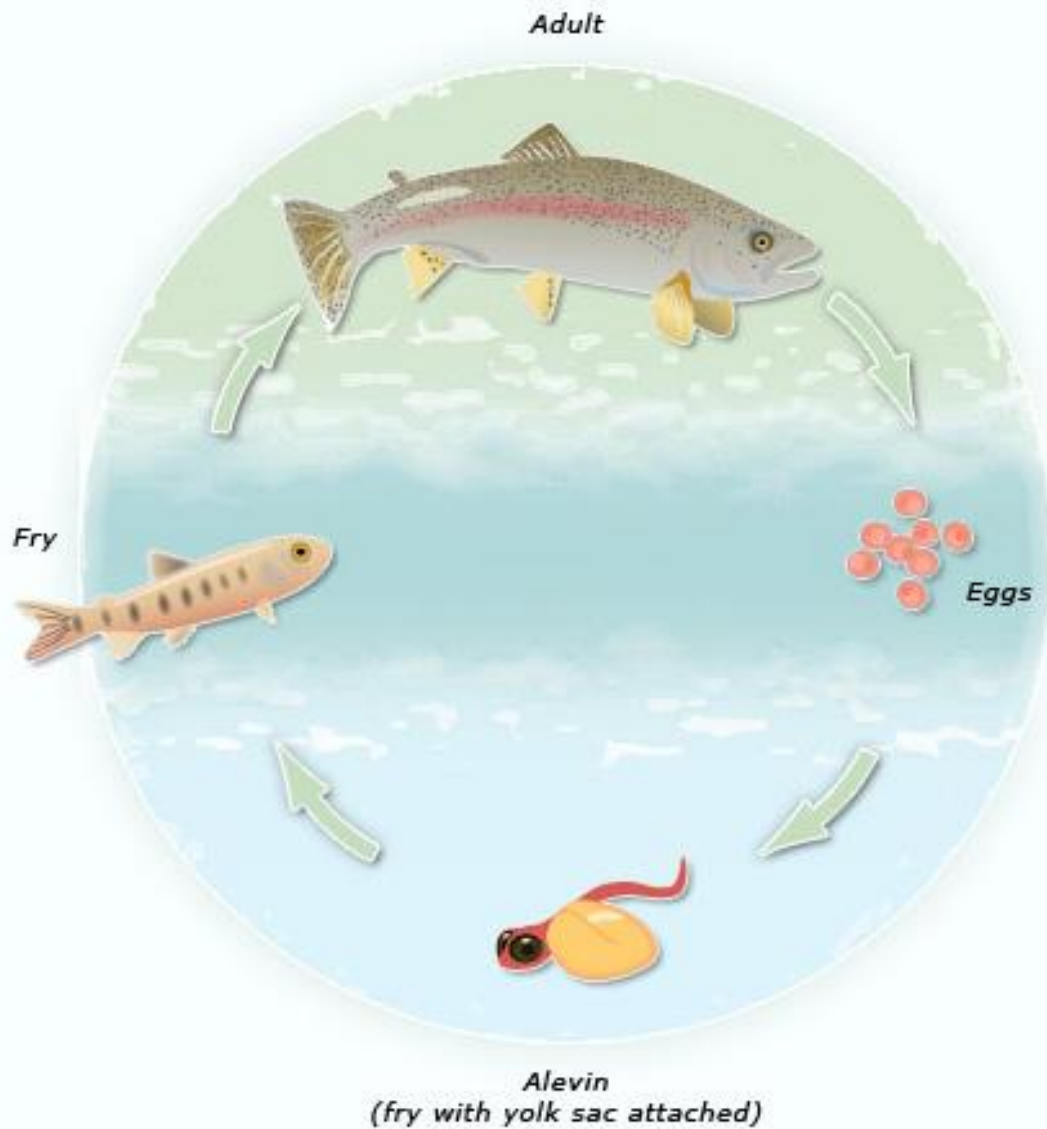
Fry: Buttoning-up occurs when alevin absorb the yolk sac and begin to feed on aquatic insects.

Fingerling and Parr: When a fry grows to 2-5 inches, it becomes a fingerling. When it develops large dark markings, it then becomes a parr.

Juvenile: In the natural habitat, a trout avoids predators, including wading birds and larger fish, by hiding in underwater roots and brush.

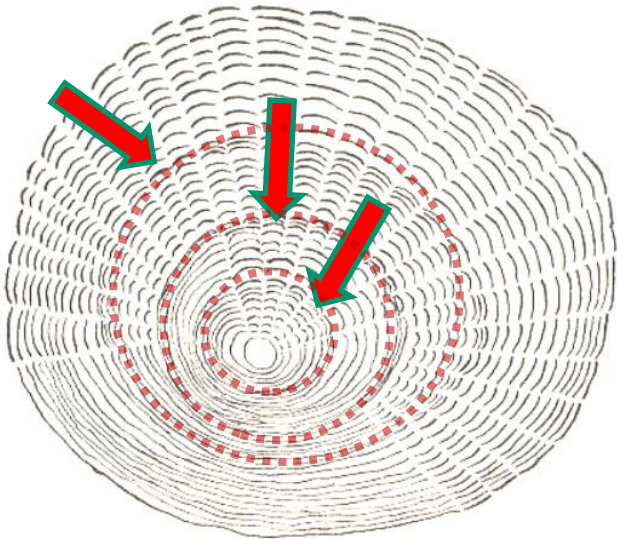
Adult: In the adult stage, female and male Tasmanian Rainbow Trout spawn in autumn. Trout turn vibrant in color during spawning and then lay eggs in fish nests, or redds, in the gravel.

LIFE CYCLE



SCALES & AGE

We can count annual rings on hard structures such as scales, otoliths, vertebra...

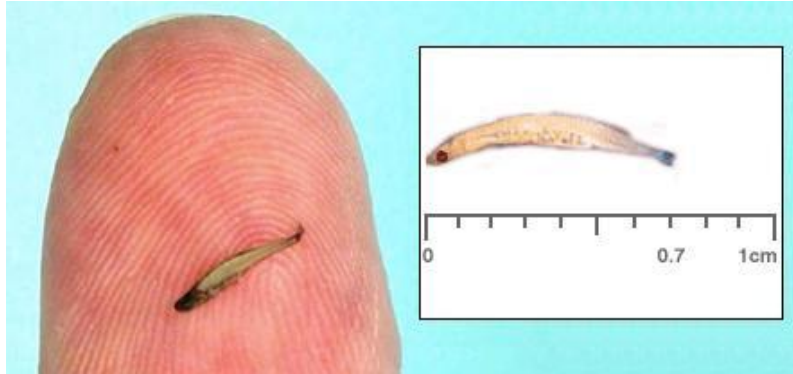


Many of fishes grow continuously, many of fishes can live for decades
And reach up to a few meters in size...

...biggest are around 18 m (*Rhyncodon typus*)

SIZES OF FISHES

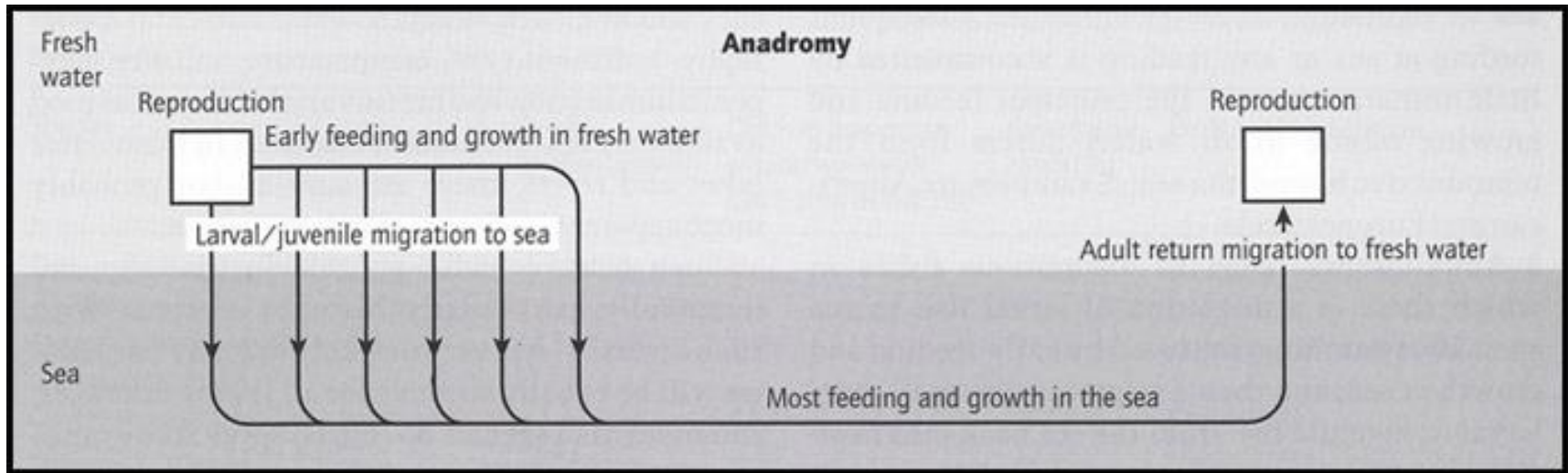
Schindleria brevipinguis 7 – 8 mm, 1 mg



Rhincodon typus
12 – 18m, 20 - 30t



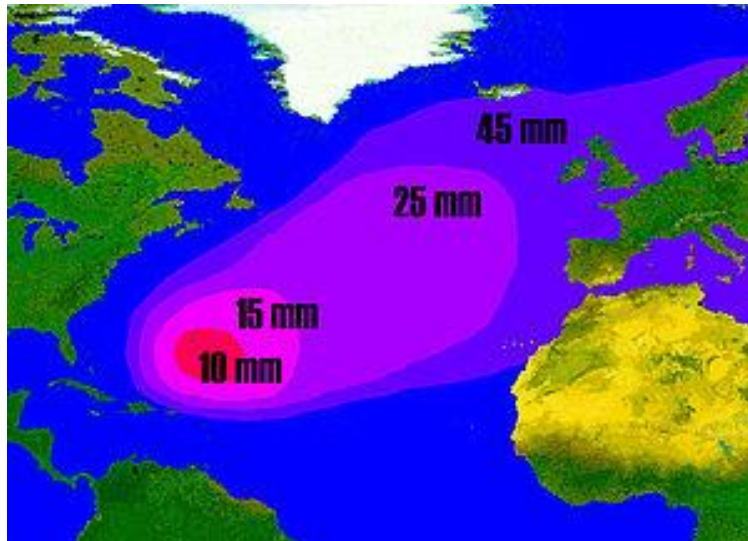
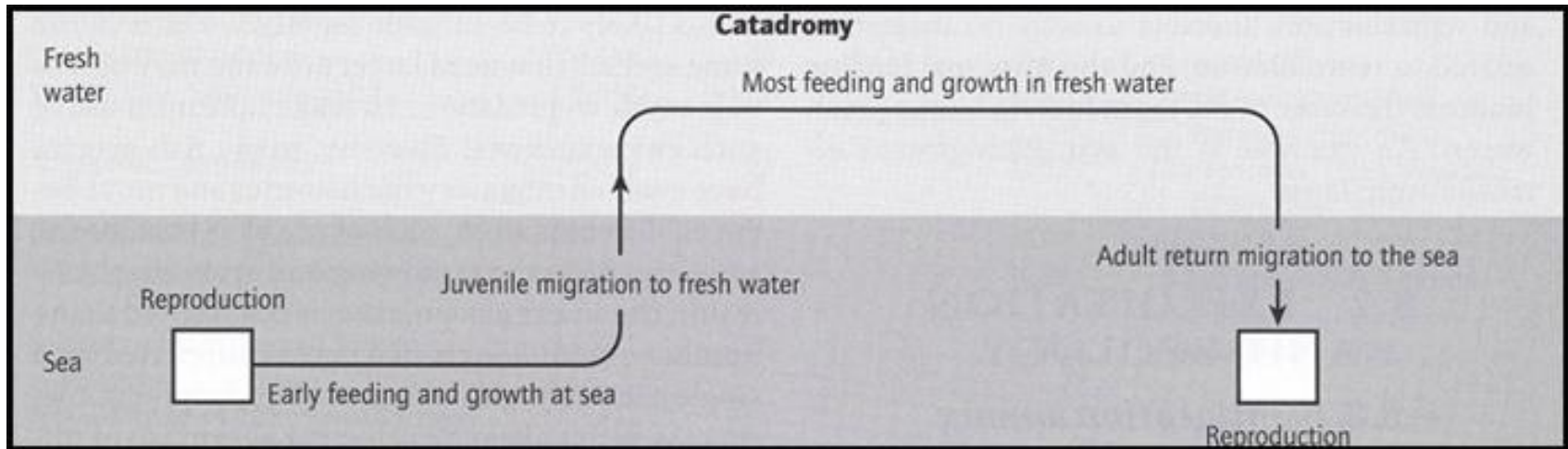
MIGRATION - ANADROMOUS



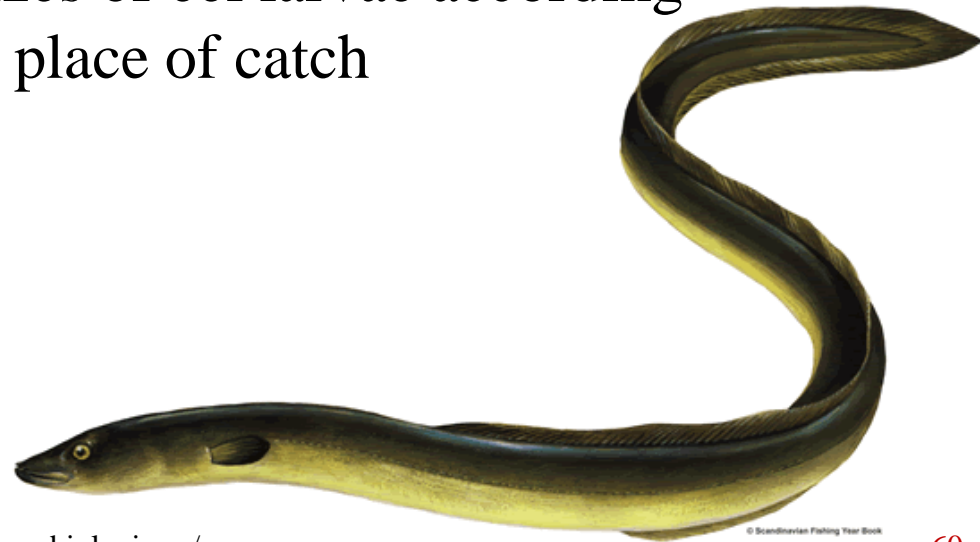
- Salmonids (trout, salmon,..)



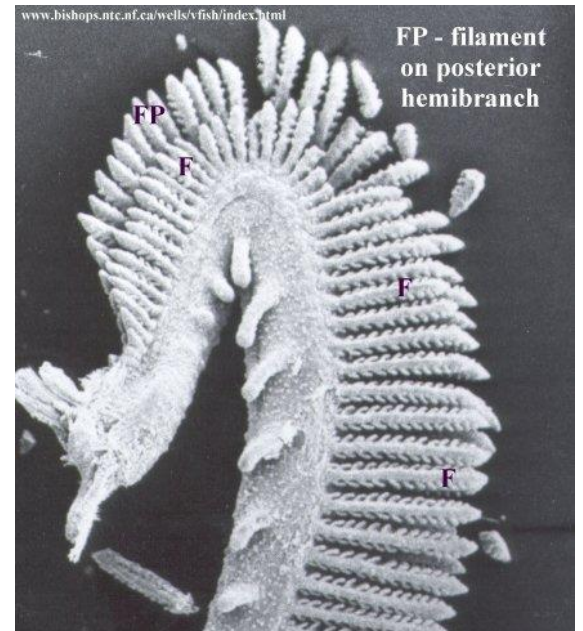
MIGRATION - CATADROMOUS



Sizes of eel larvae according to place of catch



FOOD AND FEEDING



FISH FEEDING - FUNCTION

- Herbivores
 - < 5% of all bony fishes, no cartilaginous fishes
 - browsers - selective - eat only the plant
 - grazers - less selective - include sediments
- Detritivores
 - 5 - 10% of all species
 - feed on decomposing organic matter



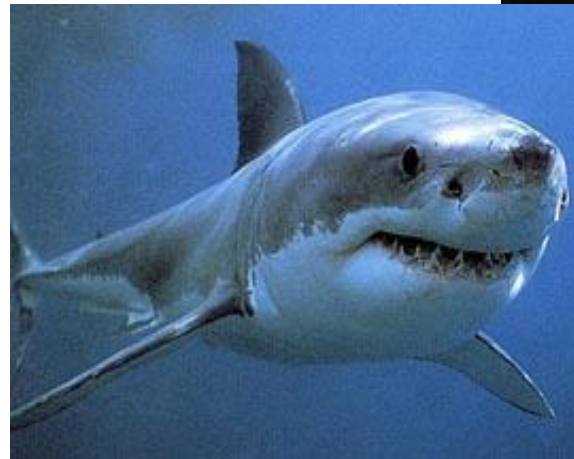
FISH FEEDING - FUNCTION

- Carnivores
 - zooplanktivores
 - benthic invertebrate feeders

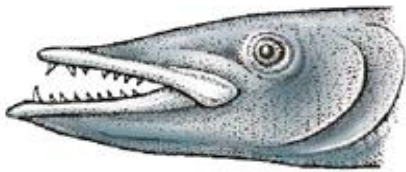


FISH FEEDING

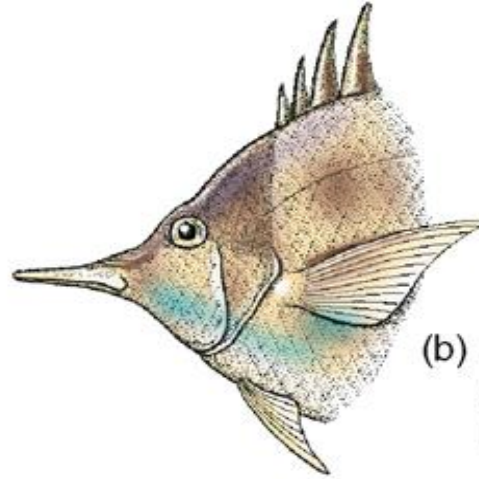
- Carnivores, *cont.*
 - fish feeders
 - active pursuit
 - stalking
 - ambushing
 - luring



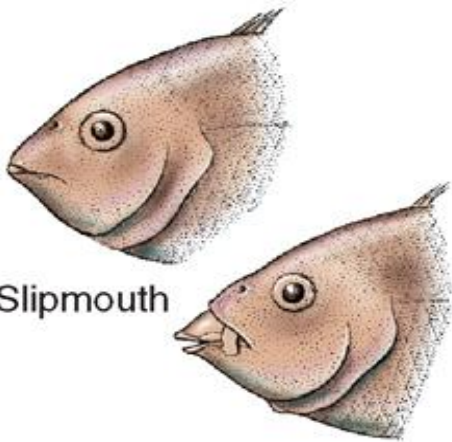
Similar to Darwin's finches, different shaped mouths permit specialization on many prey items.



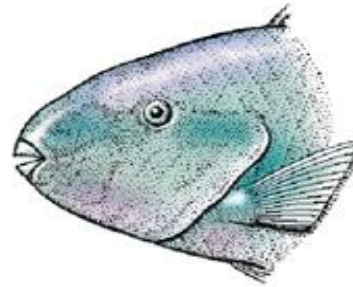
(a) Barracuda



(b) Long-billed,
six-spined
butterflyfish



(c) Slipmouth



(d) Parrotfish



(e) Herring

DIFFERENT FEEDING

- *Epibulus insidiator* – extreme protrusion



- [video](#)

THANK YOU FOR YOUR ATTENTION