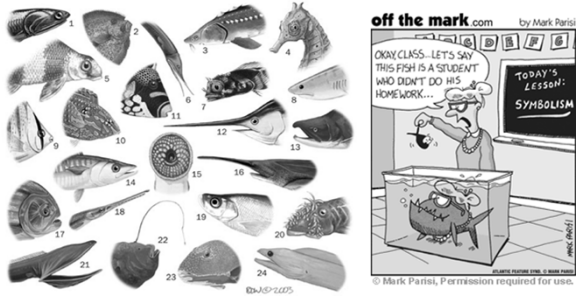


# ANATOMY, PHYSIOLOGY & ECOLOGY OF FISHES



Miloslav Petřtýl - [petrtyl@af.czu.cz](mailto:petrtyl@af.czu.cz) - 2012

## What is „FISH“

### JAWLESSS

*Cartilaginous*



### JAWED

*Cartilaginous*



*Bony*



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## Part I - ANATOMY

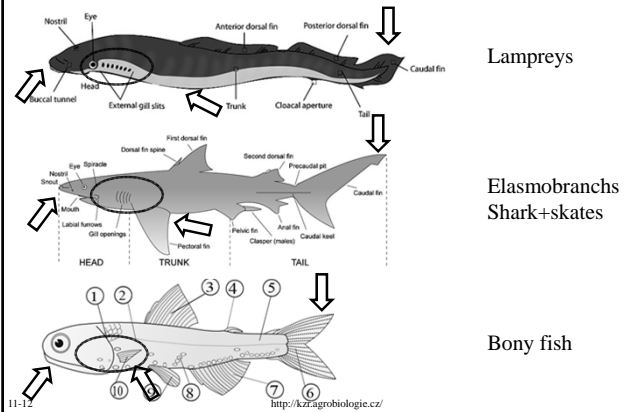


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## GENERAL ANATOMY OF FISHES

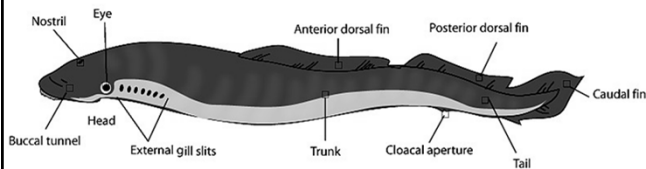


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## GENERAL ANATOMY - LAMPREY

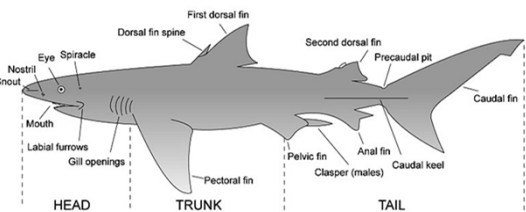


- No jaws – oral disk - suck
- No real bones
- No scales
- No paired fins
- No paired nostrils
- 7 external gill slits



source: Wikipedia

## GENERAL ANATOMY - SHARK

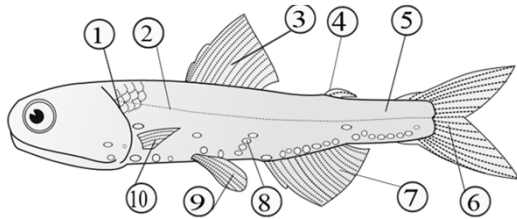


- Cartilaginous skeleton
- Strong jaw
- Scales - placoid
- 5-7 gill openings
- One or two dorsal fins
- Heterocercal caudal fin

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

source: Wikipedia

### GENERAL ANATOMY – BONY FISH

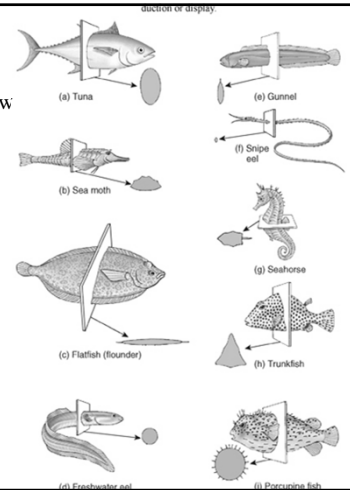


bony skeleton + fins supported by spines and rays, paired fins, scales

- (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)

source: Wikipedia

Fish form and function show a high degree of variation.



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### ADAPTATION & MODIFICATION OF FINS

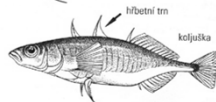
Perciformes  
*Remora*



Siluriformes



Perciformes  
*Tuna*



Aulopiformes  
tripodfish



*Marlin*

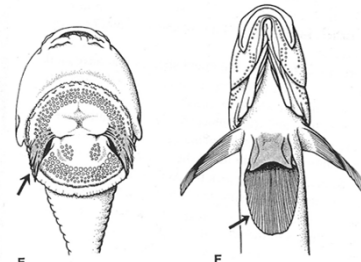
Loaches



Bichir - Polypteriformes

### FIN MODIFICATIONS

„Sucking disc“ based on anatomical changes of fins



E – *Gobiesocidae*

F – *Gobiidae*

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### FIN MODIFICATIONS

Modification allowing to fly...



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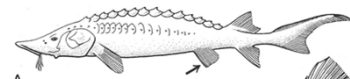
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### POSITION OF PELVIC FINS

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**

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### FISH SKELETON

Iori Tomita

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

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### FISH SKELETON

Labels include: opercular, ray of the anterior dorsal fin, radial cartilage, ray of the posterior dorsal fin, skull, orbit, upper jaw, lower jaw, clavicle, pelvic girdle, pectoral fin ray, pelvic fin ray, rib, anal fin ray, hemal spine, neural spine, vertebra, hypural, and caudal fin ray.

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### „SKULL“

**A SHARK**

**A HAGFISH**

**BONY FISH**

**B LAMPREY**

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### SKULL OF BONY FISH

Labels include: supraethmoid, frontal, parietal, epiotic, pterotic, vomer, lateral ethmoid, parasphenoid, orbitosphenoid, basioccipital, prootic, sphenotic, premaxilla, supra-maxilla, hyomandibular, metapterygoid, opercle, palatine, dentary, endopterygoid, ectopterygoid, angular, subopercle, proopercle, symplectic, entosplenial, retroarticular, pharyngobranchial, epibranchial, ceratobranchial, hypobranchial, basibranchial, basihyal (glossohyal), hypohyal, ceratohyal (arteriohyal), interhyal, epigial (posterohyal), branchiostegalis, and urohyal.

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### SKULL AND FEEDING

Important novelty of modern teleost – protrusion of mouth

- Primitive fishes
- More recent fishes

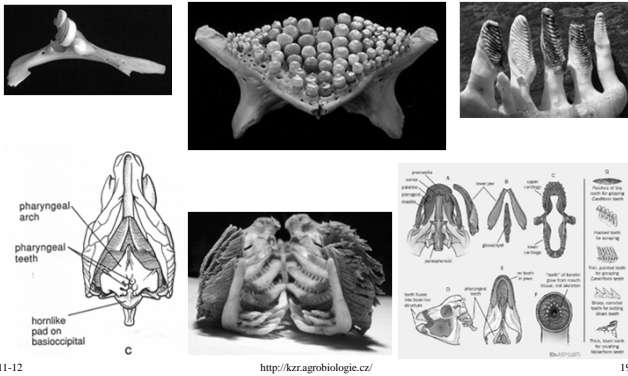
Labels include: Premaxilla, Maxilla, Mandible, and Quadrate.

© Ørskar Sindre Gløkken

[ANIMACE video](#)

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## PHARYNGEAL TEETH



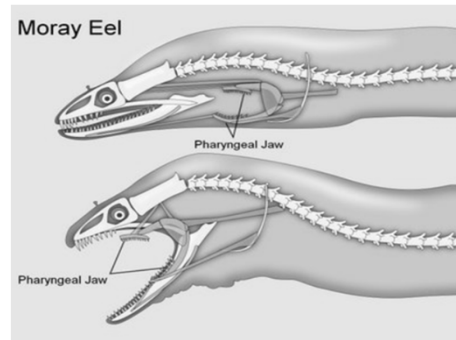
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## PHARYNGEAL TEETH

- Structure of the Moray's pharyngeal jaws



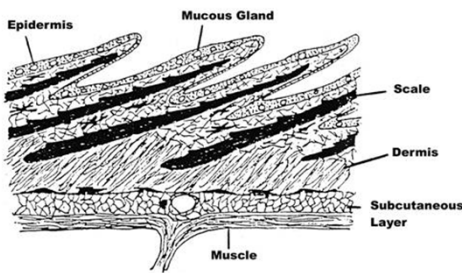
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## SKIN & COLORATION

- 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



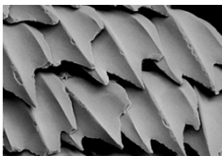
## SKIN & COLORATION

- **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

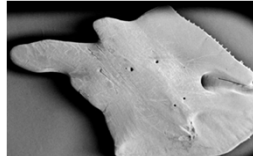


## SCALES

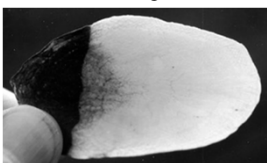
### 1. Placoid - sharks



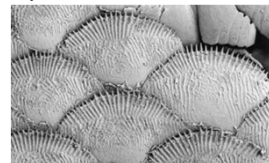
### 3. Ganoid - bichir, sturgeon



### 2. Cosmoid - lungfish



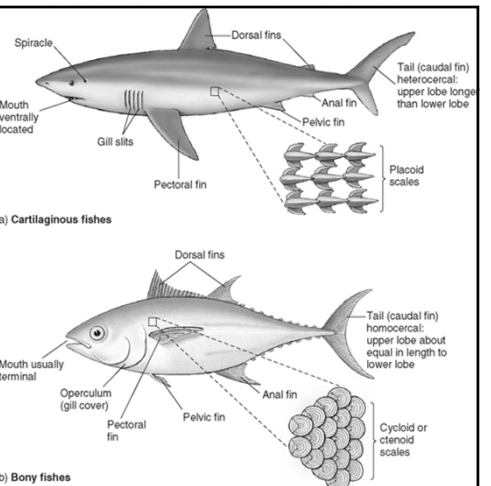
### 4. Cycloid + Ctenoid - teleostei



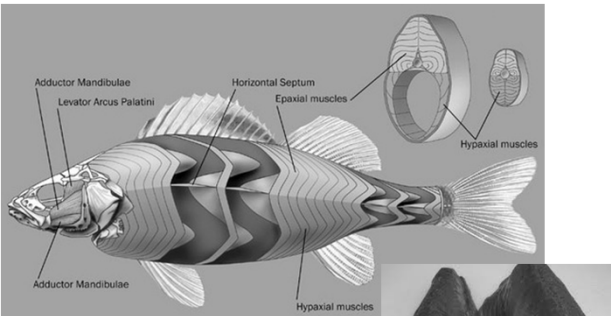
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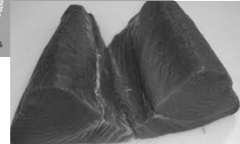
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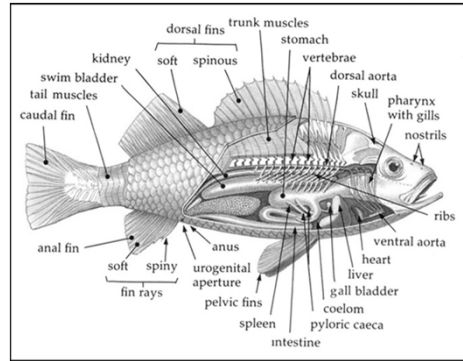
## MUSCULAR SYSTEM



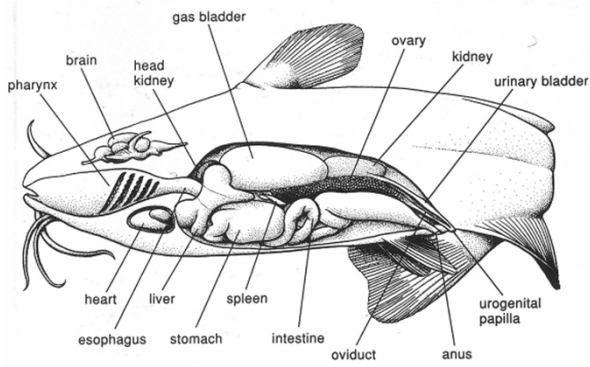
„quick“ white muscle (pike)  
 „slow“ red muscle (tuna)



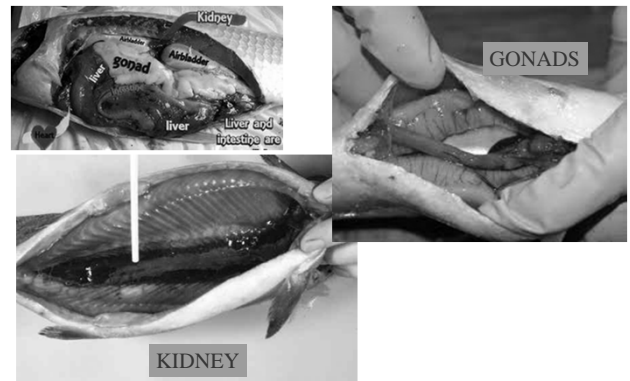
## GENERAL ANATOMY - ORGANS



## DIGESTIVE SYSTEM



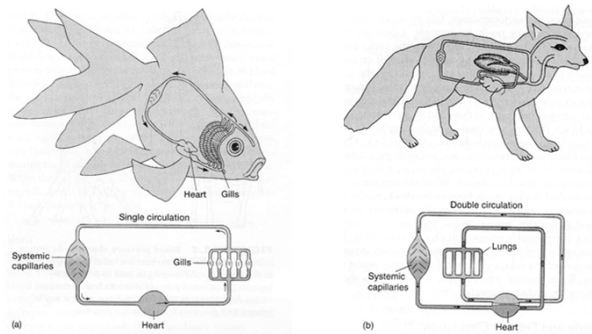
## INTERANAL ORGANS



## Part II - PHYSIOLOGY



## CIRCULATORY SYSTEM

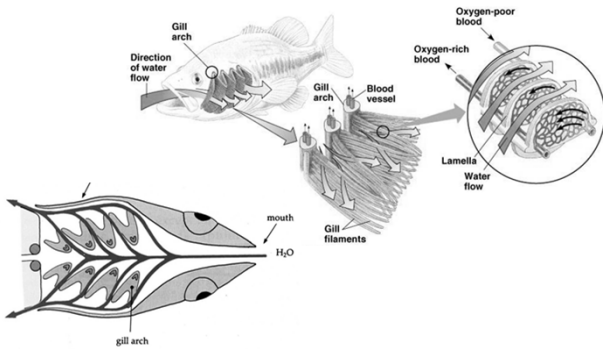


One circuit

Double circuit

## BREATHING - GILLS

Water - high density and viscosity, low oxygen content.



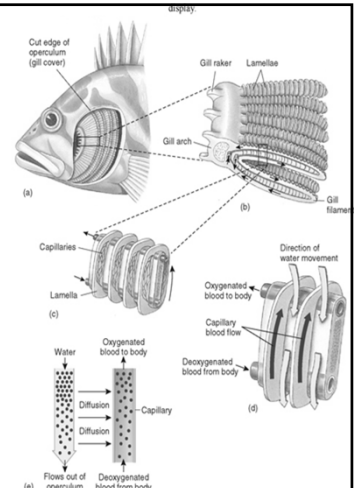
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Gills: the best way to gain oxygen (O<sub>2</sub>) from an environment where its concentration is already very low.

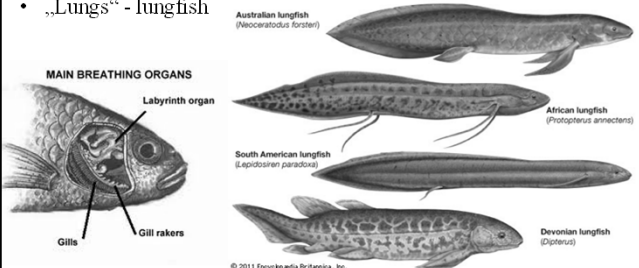
Counter-current circulation permits O<sub>2</sub> to diffuse from high to low concentration, even across venous tissue after most O<sub>2</sub> has been removed from the water by gills.



## BREATHING OF ATMOSPHERICAL OXYGEN

ACCESSORY BREATHING ORGAN

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



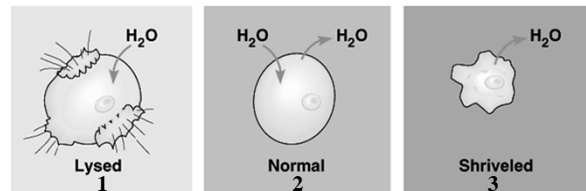
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## OSMOREGULATION

**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. **Isosmotic:** 2 solutions have same osmolarity.
2. **Hypoosmotic:** solution with higher H<sub>2</sub>O concentration.
3. **Hyperosmotic:** solution with lower H<sub>2</sub>O concentration.

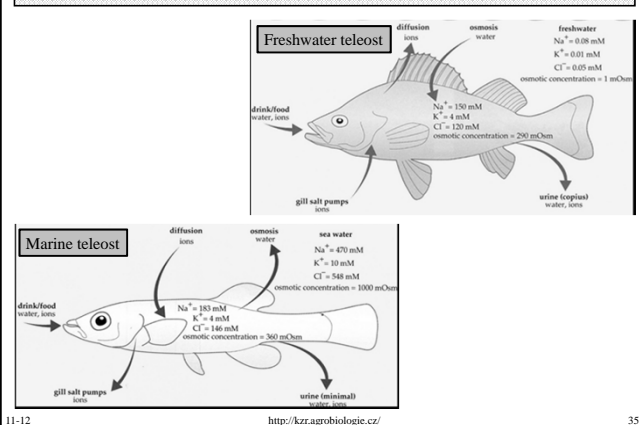


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## ARE THEY DRINKING WATER?

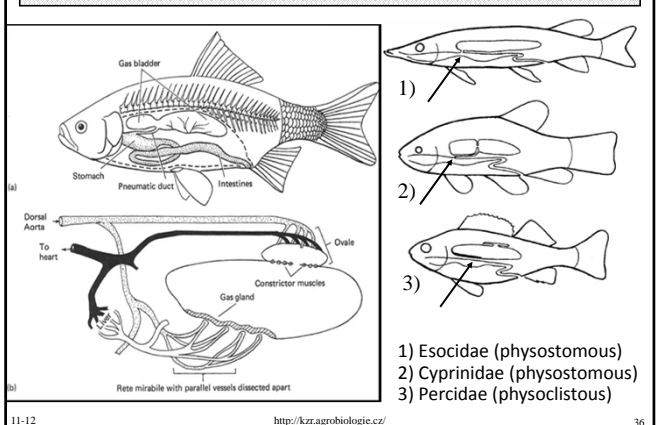


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## BUOYANCY



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

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### SENSES - SIGHT

Lens of fish is spherical

Lens has variable optical density

Labels in diagram: Cornea, Retina, Crystalline Lens, Iris, Tapetum, Binocular Vision, Monocular Vision, Blind area.

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### SENSES - SIGHT

- Anableps anableps

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### SENSES - SIGHT

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

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### SENSES - SIGHT

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

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### MIRROR ORGAN -

Labels: a. Secondary retina, b. Reflective crystal, c. lens, d. retina, 1., 2. main eye.

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

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### SENSES - HEARING

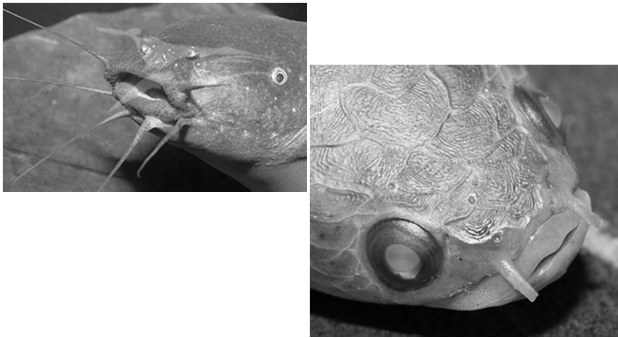
- Weber's organ – connected with gass bladder
- It is an anatomical structure that connects the swim bladder to the auditory system - transmitting auditory signals (ossicles) straight from the gas bladder
- It is typical character of Ostariophysi - the second-largest superorder of fish

Labels: Čichové laloky mozku, Jeztra, plynový měchýř, Čichové jamky, oko, mozček, Weberův aparát, zrakové laloky mozku, ústrojí sluchu a rovnováhy, Gass bladder.

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## SENSES - TASTE

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

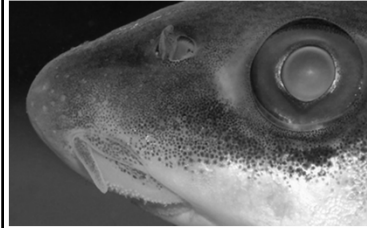
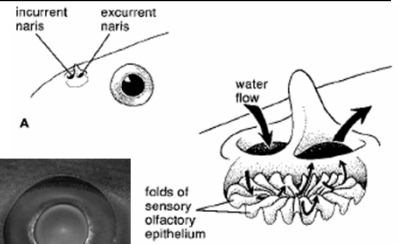


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## SENSES - SMELL



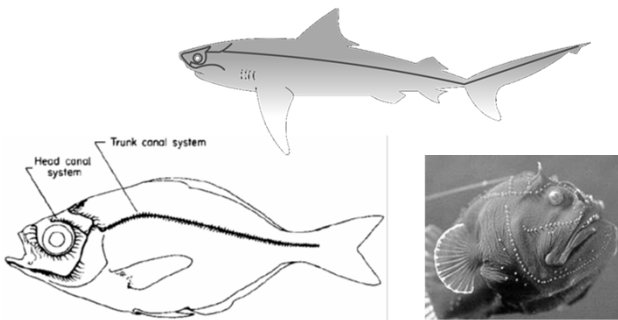
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## SENSES - TOUCH

- Neuromasts on the body – head, lateral line

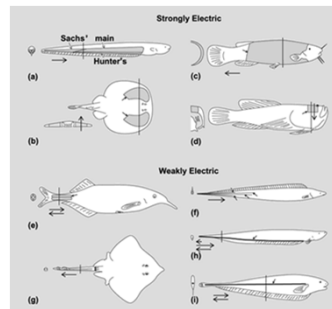


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## SENSES - ELECTRIC FIELD



Catfish

Torpedo

Elephant fish (mormyridae)

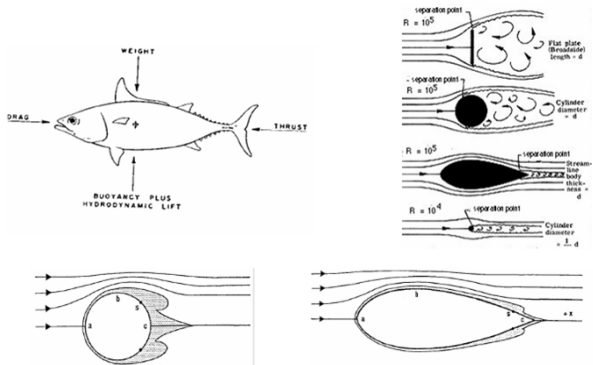
Eels

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## BODY SHAPE



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## MOTION

- Swimming of individual



- Swimming in school

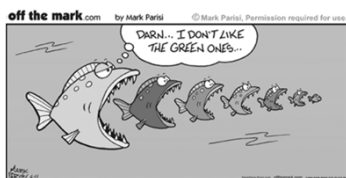
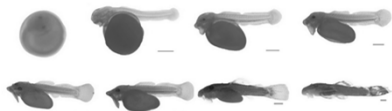
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## Part III - ONTOGENY - ECOLOGY



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## SEXUAL DIMORPHISM

Different coloration



Different size of male and female - cavity for the eggs



Different thickness of the skin in sharks - male bites female



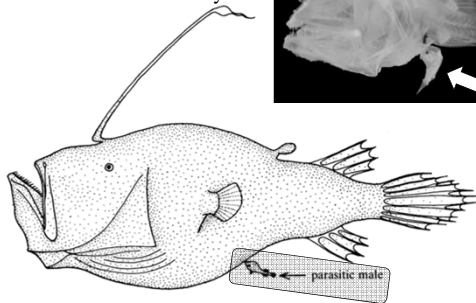
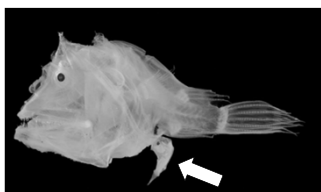
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## SEXUAL DIMORPHISM

Extrem in deep sea fishes:  
Tini miniaturezid males,  
attached to female body



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## REPRODUCTION

**Cartilaginous fish (chimaera, shark)**

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

Internal fertilization

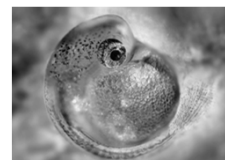
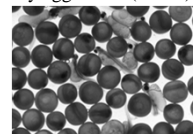
• External fertilization

A few eggs or vivipary

• Many eggs - roe (caviar)



X

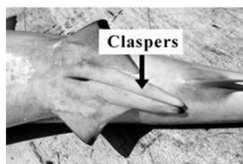


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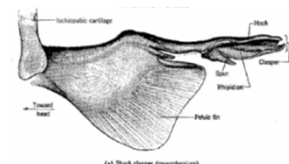
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## REPRODUCTION



Claspers

• Chondrichthyes



(a) Shark clasper (protophyll)



• Bony fish



(b) *Gasterosteus aculeatus*

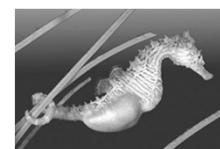
## Reproductive traits and life-history patterns

### 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.

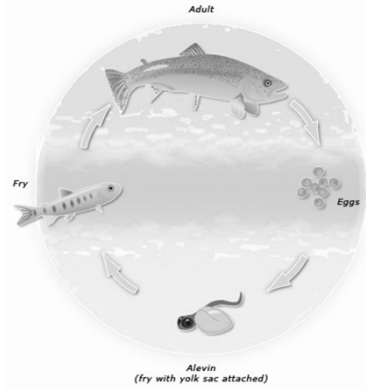
**Adult:** In the adult stage, female and male Tasmanian Rainbow Trout spawn in autumn. Trout turn vibrant in color during spawning and then lay eggs in fish nests, or redds, in the gravel.

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## LIFE CYCLE



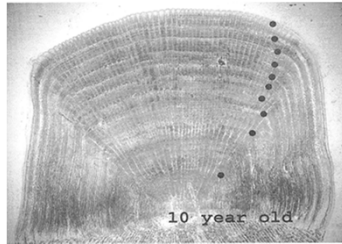
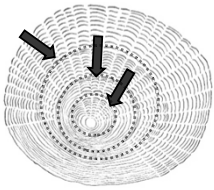
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## SCALES & AGE

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 (*Rhincodon typus*)

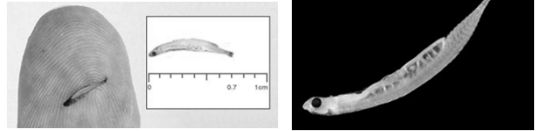
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## SIZES OF FISHES

*Schindleria brevipinguis* 7 – 8 mm, 1 mg



*Rhincodon typus*  
12 – 18m, 20 - 30t

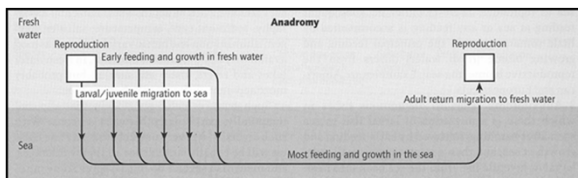


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## MIGRATION - ANADROMOUS



- Salmonids (trout, salmon,..)

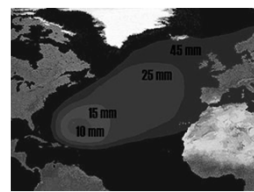
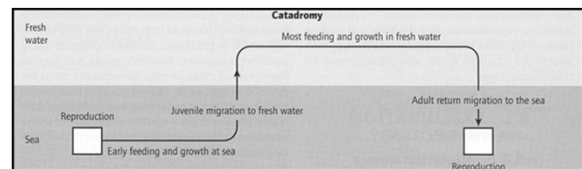


11-12

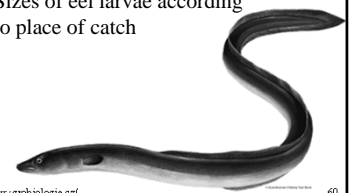
<http://kzr.agrobiologie.cz/>

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## MIGRATION - CATADROMOUS



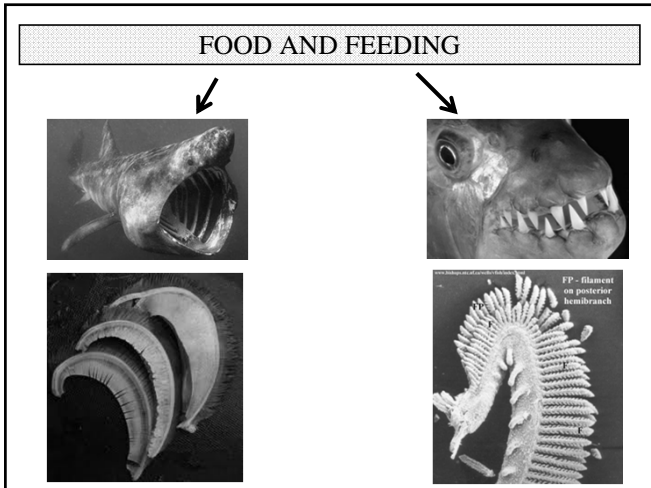
Sizes of eel larvae according to place of catch



11-12


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**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



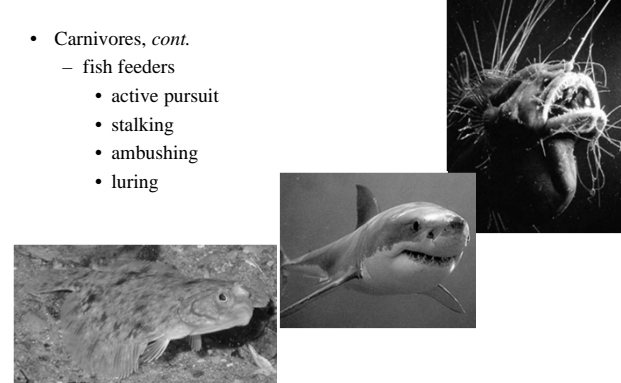
**FISH FEEDING - FUNCTION**

- **Carnivores**
  - zooplanktivores
  - benthic invertebrate feeders

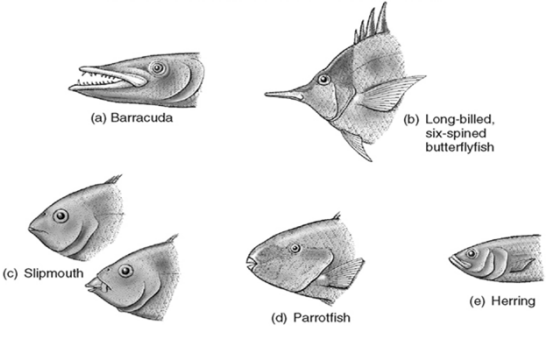


**FISH FEEDING**

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



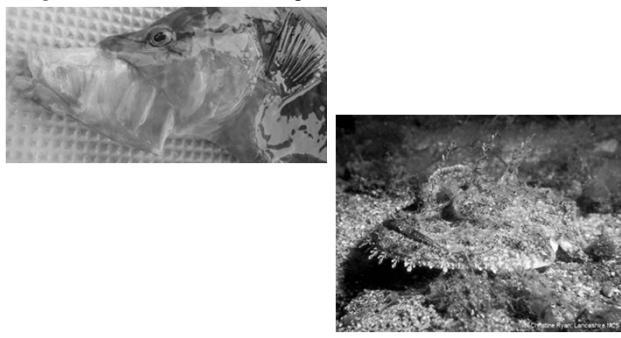
Similar to Darwin's finches, different shaped mouths permit specialization on many prey items.



(a) Barracuda      (b) Long-billed, six-spined butterflyfish  
(c) Slipmouth      (d) Parrotfish      (e) Herring

**DIFFERENT FEEDING**

- *Epibulus insidiator* – extreme protrusion



- [video](#)

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**THANK YOU FOR YOUR ATTENTION**