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HIGHLIGHTED HANDOUT

ZOO603T

Fish Biology (Theory)

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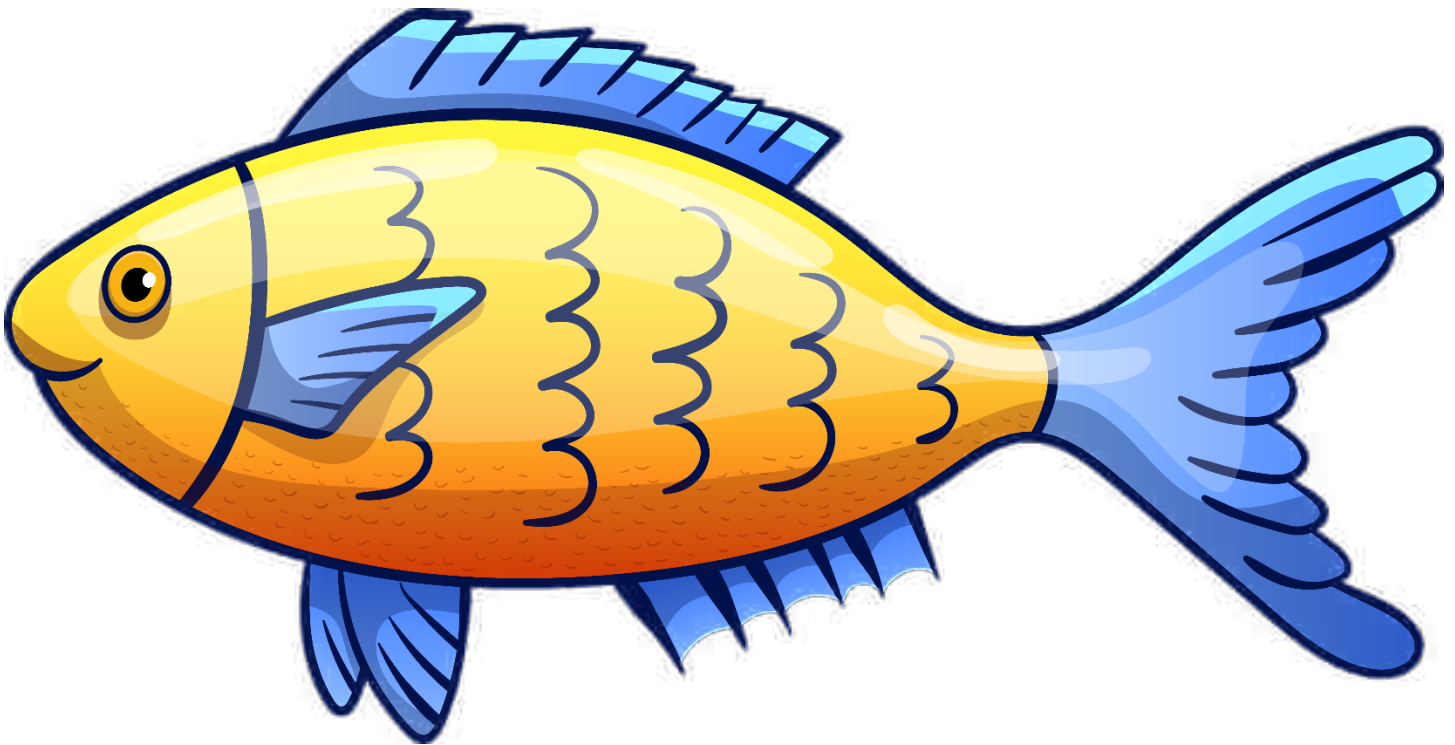
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ZOO 603 - Principles of Fish Biology



HANDOUTS TOPIC NO 1 TO 70

MUHAMMAD IMRAN

1 Basic Terminologies

OUTLINE

- Systematics
- Taxonomy
- Importance of Taxonomy and systematics
- Quality of Systematics work
- Systematic position of fishes

Basic Terminologies

Definitions

- **Systematics** is the study of the diversity of fish and the evolutionary relationships between these organisms
- **Taxonomy** is the scientific study of naming, defining and classifying groups of biological organisms based on shared characteristics

Importance of Taxonomy and systematics

- Sound systematic data are important for conservation. Without accurate taxonomy,
- it is impossible to identify the species and evaluate their conservation status,
- it is impossible to properly manage their fisheries,
- it is impossible to evaluate
- the conservation value of habitats or areas,
- it is impossible to establish strategies
- it is impossible to set priorities.

Quality of Systematics work

- Following are the parameters responsible for the poor quality of systematic

work:

- Poor practices,
- poor theoretical concepts,
- absence of international communications
- nationalism
- Fish taxonomy should be addressed by
- trained taxonomists,
- not by fisheries biologists.

Systematic position of fishes

1. Kingdom: Animalia

2. Phylum: Chordata

3. Series: Pieces

4. Class: Osteichthyses

5. Sub-class: Actinopterygii

6. Order: Siluriformes

7. Family: Pangasiidae

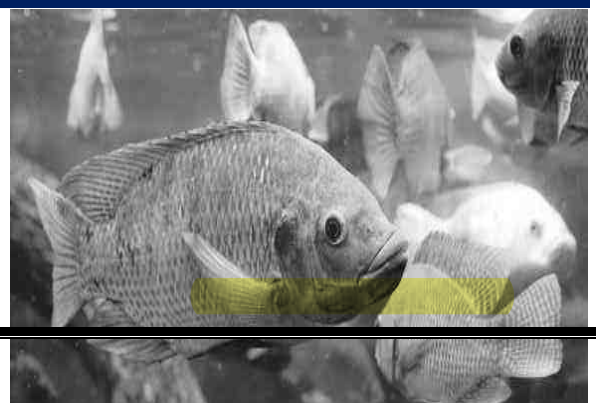
8. Genus: Pangasius



2 Introduction

Outline

- General characteristics
- Habitat



- Ectothermic
- Vertebrate
- Fish scales

General characteristics

- **Fish** are aquatic, gill-bearing animals
- that lack limbs with digits.
- Most fish are cold-blooded,
- allowing their body temperatures to
- vary as ambient temperatures change.

- Fish share with vertebrate a basic body plan of bilateral symmetry with a dorsal supporting structure the notochord as a precursor the series of harder vertebrae,
- The term "fish" most precisely describes any non-tetrapod craniate (i.e. an animal with a skull and in most cases a backbone) that has gills throughout life and whose limbs, if any, are in the shape of fins.
- Their body is divisible into head, trunk and tail. Neck is absent.
- It has a spindle shaped body. It is helpful in swimming.
- Respiration is by gills. Gills are the extensions of the pharynx. In the elasmobranches fishes, the gills will open separate. In bony fishes the gill slits are covered by operculum.
- On the head a pair of nostrils are present internal nostril are absent.
- In Dipnoi Internal nostrils are present

- In the development of fishes amnion is not developed. Hence these animals are called anamniotes.
- On the head a pair of eyes is present.
- On the lateral sides of the body LATERAL LINE SENSE organs are present. They detect the pressure changes of water.
- The body shows paired and unpaired fins. Pelvic and pectoral fins are paired. Dorsal and ventral fins are unpaired. They maintain balance in water. They are useful for locomotion.
- The digestive system is well developed. In the intestine of shark scroll valve is present. The nervous system contains brain and spinal cord. Brain is small & it will not occupy the entire cranial cavity.
- 10 pairs of cranial nerves are present.
- Kidneys are mesonephric.
- Urinary bladder is absent
- The scales of fish originate from the mesoderm (skin);
- they may be similar in structure to teeth.
- Placoid (sharks and rays)
- Cosmoid (lungfishes and some fossil fishes)
- Ganoid (bichirs, Bowfin, paddlefishes, gars, sturgeons)
- Cycloid and Ctenoid (most bony fishes)
- The skeleton of some fishes is made by cartilage. They are called cartilage fishes. In some fishes the skeleton is made by bone. They are called bony fishes.

- In some fresh water fishes accessory respiratory organs are present. They will take up aerial respiration.
- Sexes are separate. In male sharks claspers are present.
- Many fishes are oviparous. Some fishes are viviparous.

3 Classification of fish

Outline

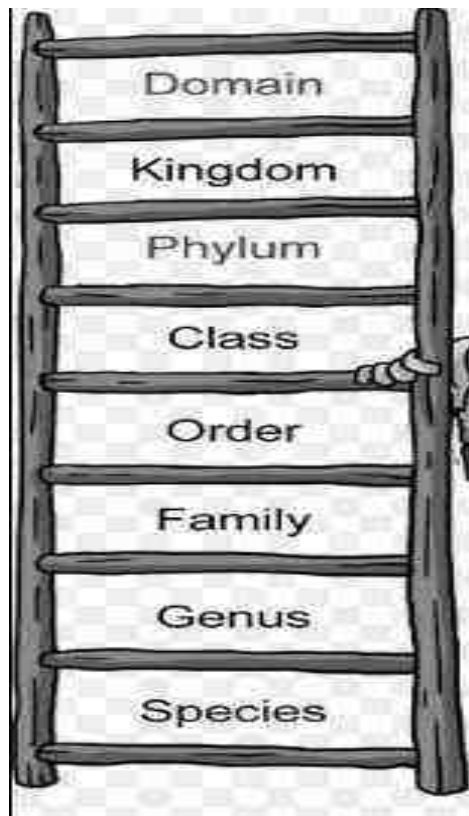
Classification of the Major Taxa of Fish

	examples
<ul style="list-style-type: none"> Phylum Chordata <ul style="list-style-type: none"> Subphylum Vertebrata <ul style="list-style-type: none"> Supraclass Agnatha <ul style="list-style-type: none"> Order Osteostraci Order Anaspida Order Heterostraci Order Coelolepida Order Cyclostomata Class Myxinoidea Class Petromyzontida Class Placodermi <ul style="list-style-type: none"> Order Arthrodiriformes Order Antlarchiformes Supraclass Gnathostomata <ul style="list-style-type: none"> Class Chondrichthyes <ul style="list-style-type: none"> Subclass Elasmobranchii <ul style="list-style-type: none"> Order Cladoseiachiformes Order Xenacanthiformes Order Selachii Order Batoidae Subclass Holocephali <ul style="list-style-type: none"> Order Chimaeriformes Class Acanthodii Class Osteichthyes <ul style="list-style-type: none"> Subclass Actinopterygii <ul style="list-style-type: none"> Infraclass Chondrostei Infraclass Holostei Infraclass Teleostei Subclass Sarcopterygii <ul style="list-style-type: none"> Order Crossopterygii Order Dipnoi 	<p><u>jawless fishes</u></p> <p>hagfish lampreys</p> <p><u>jawed fishes</u></p> <p>extinct Paleozoic sharks Paleozoic freshwater sharks typical sharks skates and rays</p> <p>chimaeras or ratfishes various extinct fishes higher bony fishes ray-finned fishes sturgeon, paddlefish; primitive ray-finned fishes gars, bowfins; dominant ray-finned fishes of Mesozoic most bony fish; dominant in Cenozoic and recent times lobe-finned fishes ancestors of land vertebrates lungfishes</p>

Classification of fish

- Fishes are first evolved in silurian period of palaeozoic era.
- They increased their number in Devonian period.
- Devonian Period is Called;
- "Age of Fishes".
- Fishes are typically divided into three groups:

- superclass Agnatha (jawless fishes),
- class Chondrichthyes (cartilaginous fishes),
- superclass Osteichthyes (bony fishes).
- This hierarchical system moves from largest and most general to smallest and most specific:
- kingdom, phylum, class, order, family, genus, and species.



- **Why is it important to study the classification of fishes?**
- A thorough knowledge of fish diversity, distributions, habitat requirements and life histories is essential to the management of fisheries, and conservation of species and the aquatic environment.
- However, many fish groups are still to be worked on and many areas have not yet been adequately surveyed.

Taxonomic characters:

Taxonomic characters:

Taxonomic Characters, used to classify organisms on the basis of similarities and differences.

1. Morphometric characters:

- used for measureable structures

2. Meristic characters:

- used for any countable structures

3. Molecular characters:

- nuclear DNA and Mitochondrial DNA

4. Anatomical character:

- skeleton and characters of the soft anatomy

Classification of fish

- Devonian period is known as “The Golden Age of Fishes”
- The first fossil vertebrates were found in the rocks of Ordovician period and named as ostracoderms.
- They are small, jawless, bony fish like forms related to cyclostomes
- Cuvier was the first to frame the classification on the basis of external and internal characteristics of fish.
- Swedish naturalist, Peter Artedi (1705-1735) is known as;

‘Father of Ichthyology’.

- He established the methods and principles of systematic ichthyology so perfectly even Linnaeus could not alter it.

4 Muller's classification (1844)

- Recent classification of bony fish was proposed by :
 - Muller Berg
 - Jordan
 - Nelson
 - Romer
 - Regar

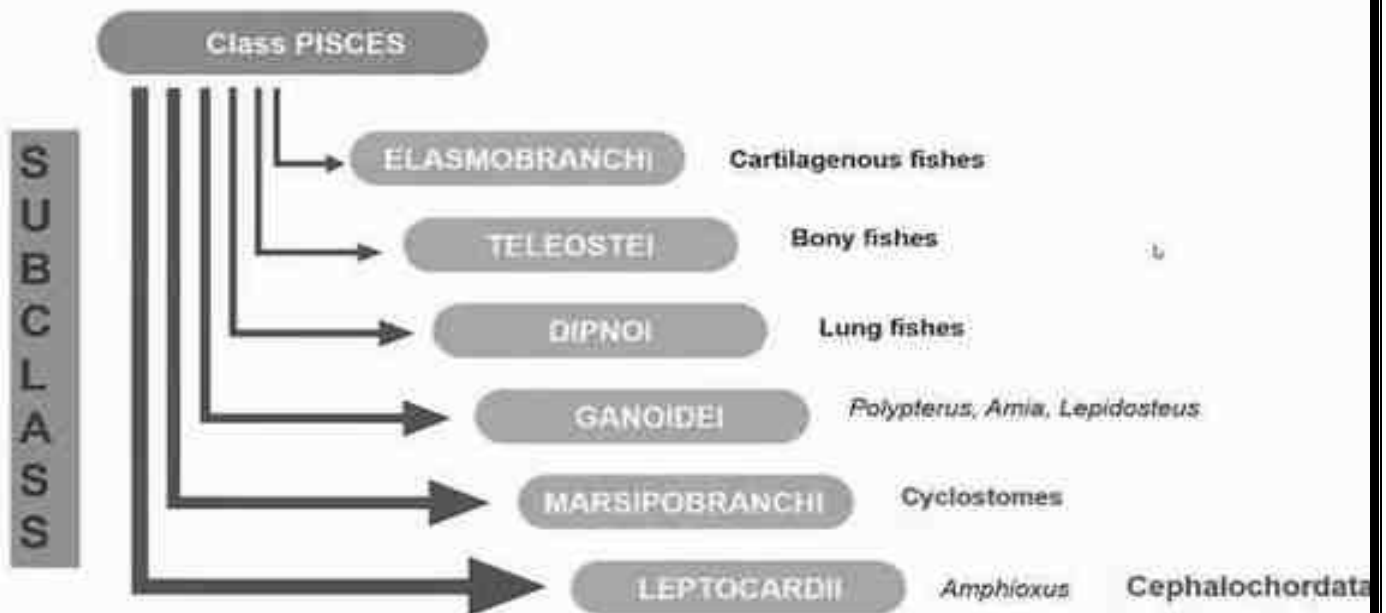
Muller's classification (1844)

- Earliest classification was proposed by J. Muller (1844) who proposed six subclasses in class Pisces.

- **Class PISCES**

Subclasses:

DIPNOI (Lung fishes); **TELEOSTEI** (Bony fishes); **GANOIDEI** (*Polypterus*, *Amia*, *Lepidosteus*); **ELASMOBRANCHI** (Cartilaginous fishes); **MARSIPOBRANCHI** (Cyclostomes); **LEPTOCARDII** (Amphioxus).

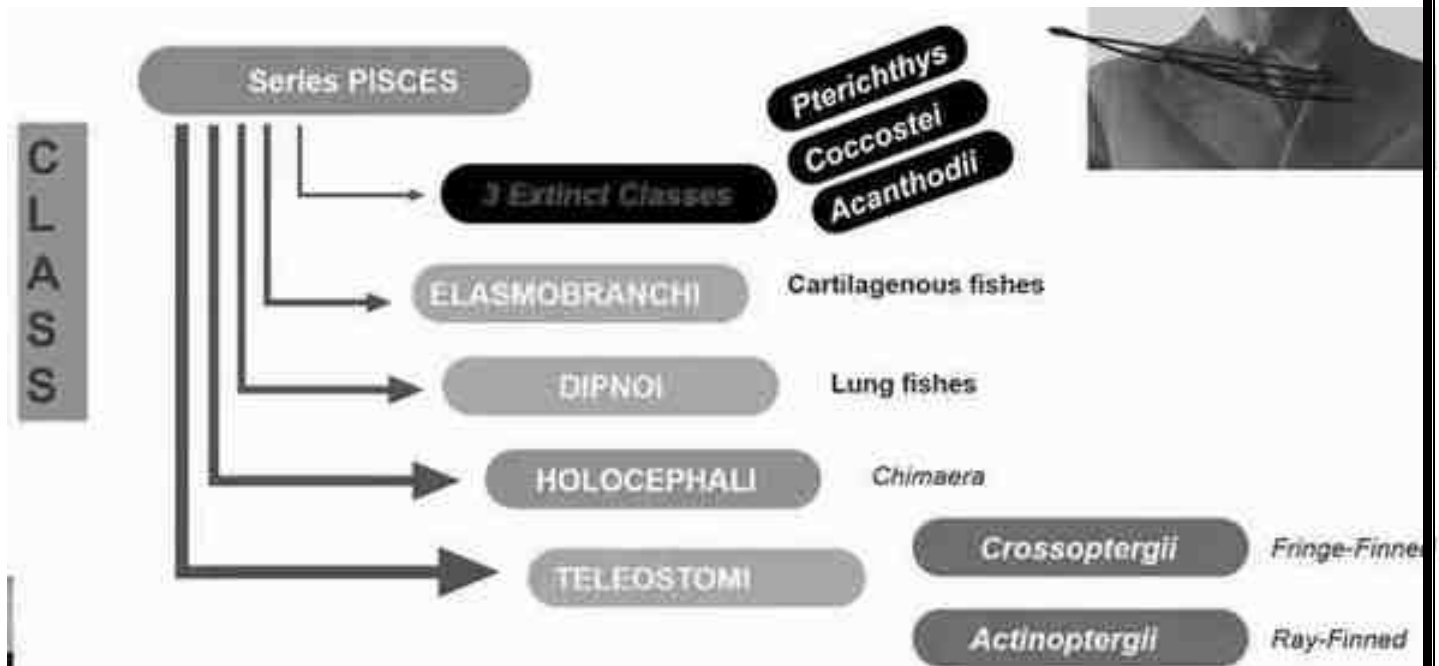


5 Berg's classification (1940)

L.S. Berg classified fishes in to

- seven classes and separated lampreys and hagfishes into a separate class.
- Berg included all the living and the fossils fishes
- within a series-Pieces and
- subdivided the series into seven major classes.





6 Romer's classification (1959)

- Romer's classification (1959)
- Romer's classified fishes into three classes
- Osteichthyes : includes all bony fishes:

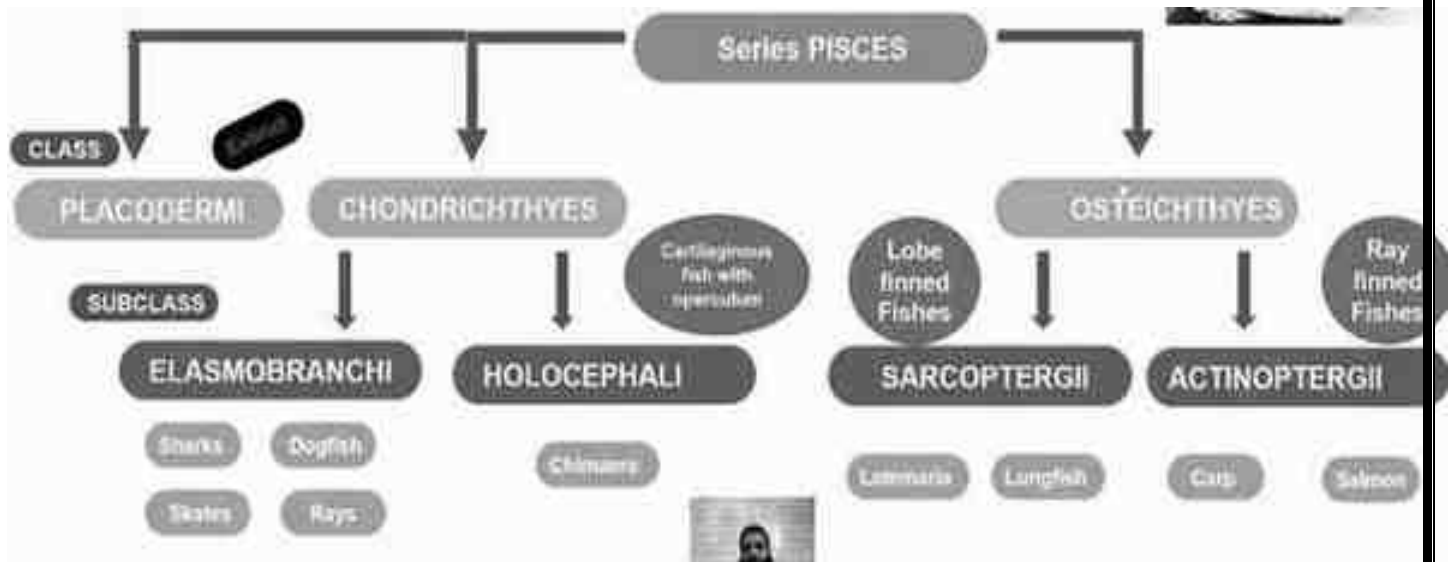
Teleostomi and Dipnoi

- Chondrichthyes: includes all cartilaginous fishes
- Placodermi: including extinct fishes
- Romer's classification (1959)
- Romer's classified fishes into three classes
- Osteichthyes : includes all bony fishes:



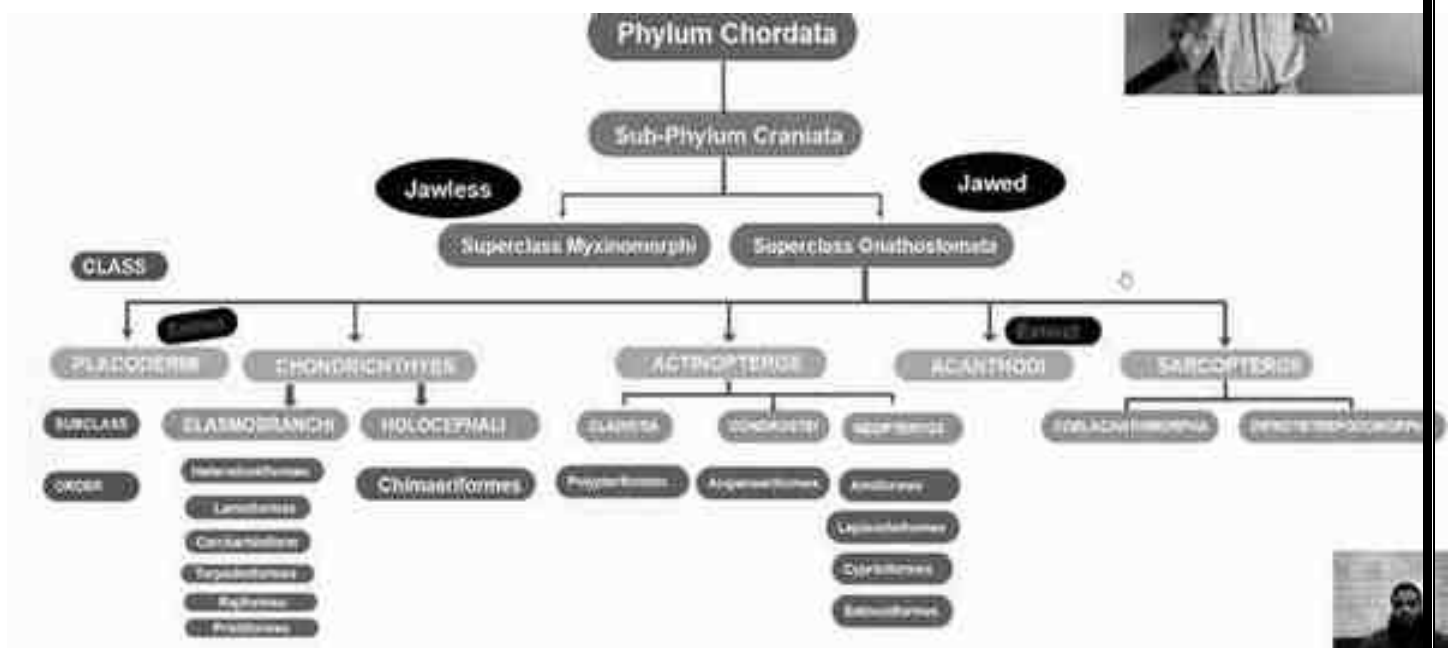
Teleostomi and Dipnoi

- Chondrichthyes: includes all cartilaginous fishes
- Placodermi: including extinct fishes



7 Nelson's classification (2006)

- J.S Nelson (2006) presented the classification of fishes
- in particular and Chordata in general in a linear order
- which reflects their postulated evolutionary relationship (cladistics approach).
- He classified fishes into five classes
- and removed class osteichthyes
- raised sarcoptergii and actinoptergii to class level.



8 Super class Agnatha

Outline

Classification of the Major Taxa of Fish

□ Phylum Chordata	<u>examples</u>
□ Subphylum Vertebrata	
□ Supraclass Agnatha	<u>jawless fishes</u>
□ Order Osteostraci	
□ Order Anaspidi	
□ Order Heterostraci	
□ Order Coelolepida	
□ Order Cyclostomata	
□ Class Myxinoidea	hagfish
□ Class Petromyzontida	lampreys
□ Class Placodermi	
□ Order Arthrodiriformes	
□ Order Antlarchiiformes	
□ Supraclass Gnathostomata	<u>jawed fishes</u>
□ Class Chondrichthyes	
□ Subclass Elasmobranchii	
□ Order Cladoselechiiformes	extinct Paleozoic sharks
□ Order Xenacanthiiformes	Paleozoic freshwater sharks
□ Order Selachii	typical sharks
□ Order Batoida	skates and rays
□ Subclass Holocephali	
□ Order Chimaeriformes	chimaeras or ratfishes
□ Class Acanthodii	various extinct fishes
□ Class Osteichthyes	higher bony fishes
□ Subclass Actinopterygii	ray-finned fishes
□ Infraclass Chondrostei	sturgeon, paddlefish; primitive ray-finned fishes
□ Infraclass Holostei	gars, bowfins; dominant ray-finned fishes of Mesozoic
□ Infraclass Teleostei	most bony fish; dominant in Cenozoic and recent times
□ Subclass Sarcopterygii	lobe-finned fishes
□ Order Crossopterygii	ancestors of land vertebrates
□ Order Dipnoi	lungfishes

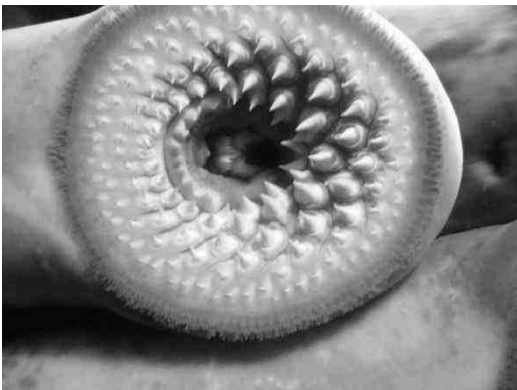
Super class Agnatha

- No jaws
- No paired appendages
- Persistent Notochord
- Cartilaginous skeleton
- All living and most extinct
- Agnatha do not have an identifiable stomach or any appendages

- Two semicircular canals
- Hag fishes, one semicircular canals
- Ostracoderm belong to several classes
- 15cm long
- Fossils: with water scorpions
- Sluggish



- Body armor for defense
- Bottom dwellers
- Filter feeders
- Crack Gastropods shells and Arthropod exoskeleton
- Annelids feeders
- The Agnatha are ectothermic or cold blooded,
- with a cartilaginous skeleton,
- and the heart contains 2 chambers.
- Fertilization and development are both external.
- There is no parental care in the Agnatha class.



9 Order Osteostraci

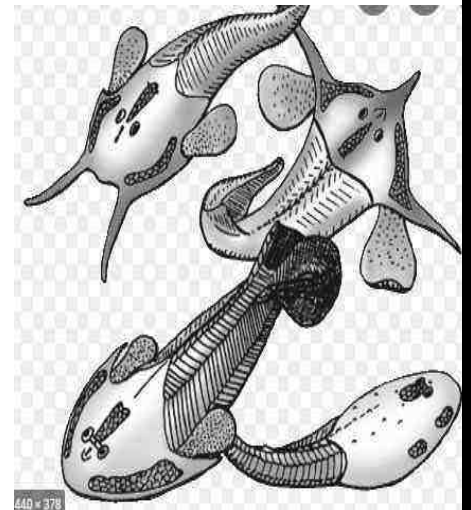
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□ Order Dipnoi	lungfishes

Order Osteostraci

- The class Osteostraci (meaning "bony shells")
- is an extinct taxon of bony-armored jawless fish,
- termed "ostracoderms"
- Lived in what is now North America,
- Europe and Russia from the Middle Silurian to
- Late Devonian.
- Most advanced of all known agnathans
- Due to the development of paired fins,
- and their complicated cranial anatomy.
- The osteostracans were more similar to lampreys than to jawed vertebrates
- in possessing two pairs of semicircular canals in the inner ear
- Good swimmers
- Possessing dorsal fins
- Paired pectoral fins



- A strong tail.
- Complex sensory organs are present

10 Class MYXINI

Outline

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□ Order Dipnoi	lungfishes

Class MYXINI

- Considered as most primitive fishes
- Known for its slimy secretions
- Cartilaginous skeleton
- Hagfish have elongated,
- eel-like bodies, and paddle-like tails.

B. Class Myxini - The Hagfishes



- Sucker like mouth
- Mouth with four pairs of tentacles
- Five to fifteen pairs of pharyngeal slits
- Olfactory sacs apart to mouth
- Live in mud and sand of marine water.
- Hagfish are typically about 50 cm (19.7 in) in length.
- They are scavengers
- (enter in the large fish through mouth, eat internal parts leaving on skin and bones)
- Reproduction: rarely known

Example

- Hag fishes

11 Class cephalospidomorph

Outline

Classification of the Major Taxa of Fish

Phylum Chordata

Subphylum Vertebrata

Supraclass Agnatha

- Order Osteostraci
- Order Anaspida
- Order Heterostraci
- Order Coelolepida
- Order Cyclostomata

Class Myxinoidea

Class Petromyzontida

Class Placodermi

- Order Arthroderminiformes
- Order Antlarchiiformes

Supraclass Gnathostomata

Class Chondrichthyes

Subclass Elasmobranchii

- Order Cladoselechiiformes
- Order Xenacanthiiformes
- Order Selachii
- Order Batoidea

Subclass Holocephali

Order Chimaeriformes

Class Acanthodii

Class Osteichthyes

Subclass Actinopterygii

Infraclass Chondrostei

Infraclass Holostei

Infraclass Teleostei

Subclass Sarcopterygii

- Order Crossopterygii
- Order Dipnoi

examples

jawless fishes

hagfish
lampreys

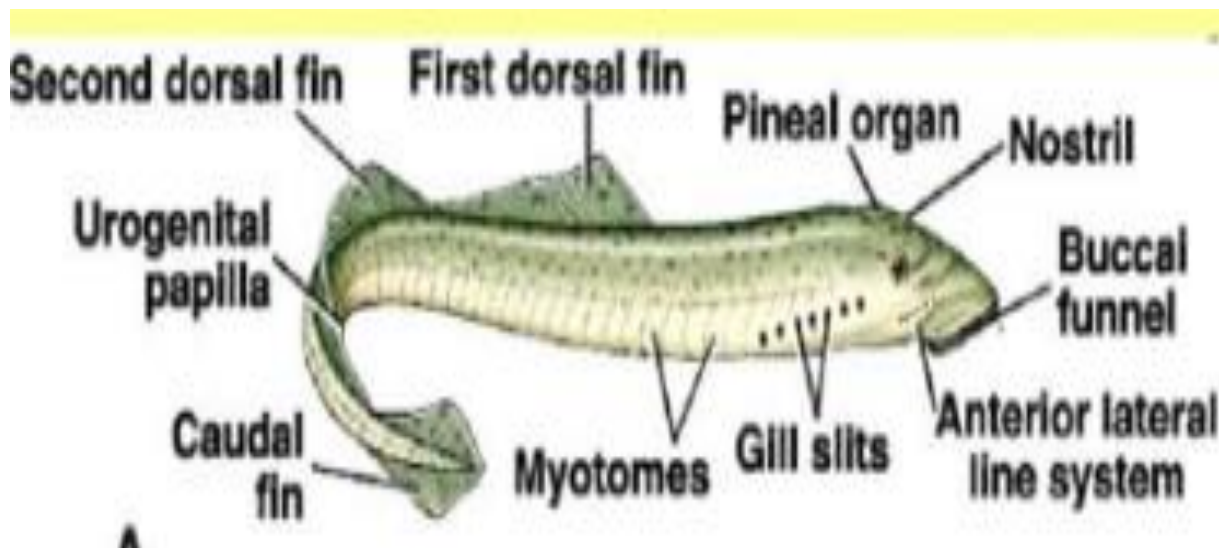
jawed fishes

extinct Paleozoic sharks
Paleozoic freshwater sharks
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skates and rays

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gars, bowfins; dominant ray-finned fishes of Mesozoic
most bony fish; dominant in Cenozoic and recent times
lobe-finned fishes
ancestors of land vertebrates
lungfishes

Class cephalospidomorph

- Sucking mouth
- Teeth are present
- Rasping tongue
- Seven pairs of slits
- Blind olfactory sacs
- Cephalospidomorph were, like most contemporary fishes, **very well armored**.



- They also lacked a swim bladder, and would not have been able to keep afloat without actively swimming.
- The head shield provided some lift though, and would have made the cephalaspidomorphi better swimmers than most of their contemporaries.
- The head shield was particularly well developed, protecting the head, gills and the anterior section of the viscera.

Example

- Lampreys

12 Super class Gnathostomes

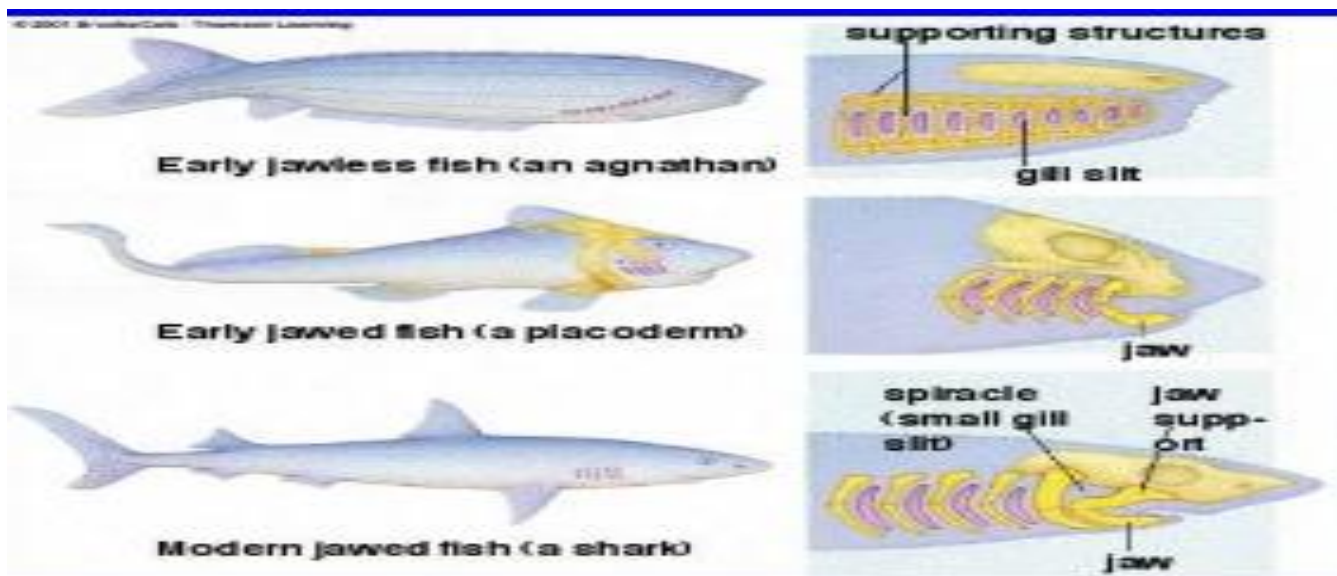
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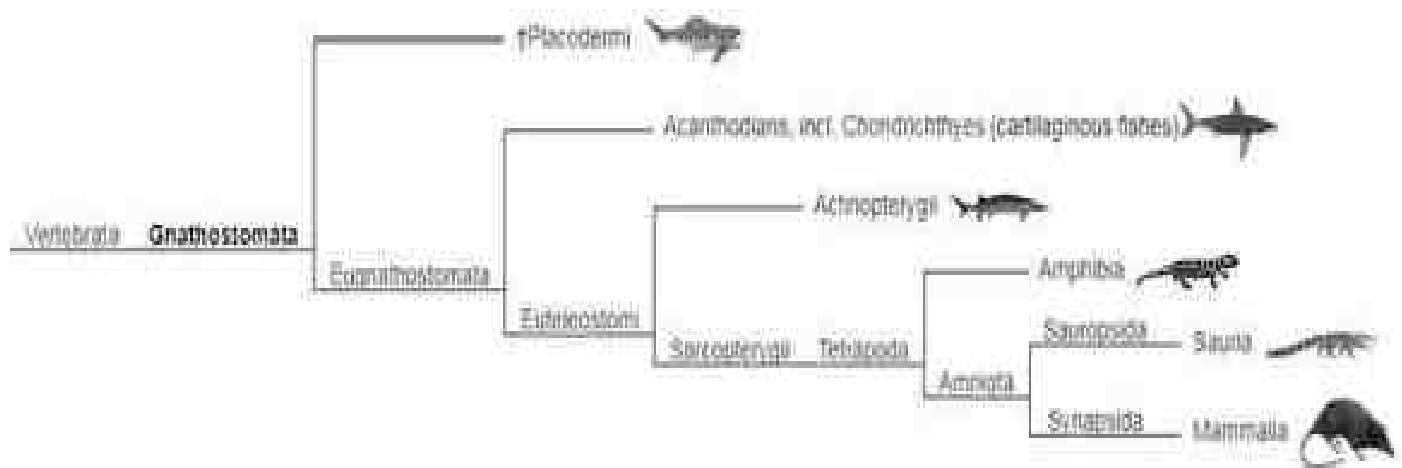
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Super class Gnathostomes

- Hinged jaws
- Jaws are modifications of the anterior gill supports
- Three semicircular canals
- Gnathostome diversity comprises roughly 60,000 species, which accounts for 99% of all living vertebrates, including humans.
- In addition to opposing jaws, living gnathostomes have true teeth (a characteristic which has subsequently been lost in some),
- paired appendages (pectoral and pelvic fins, arms, legs, wings, etc.)

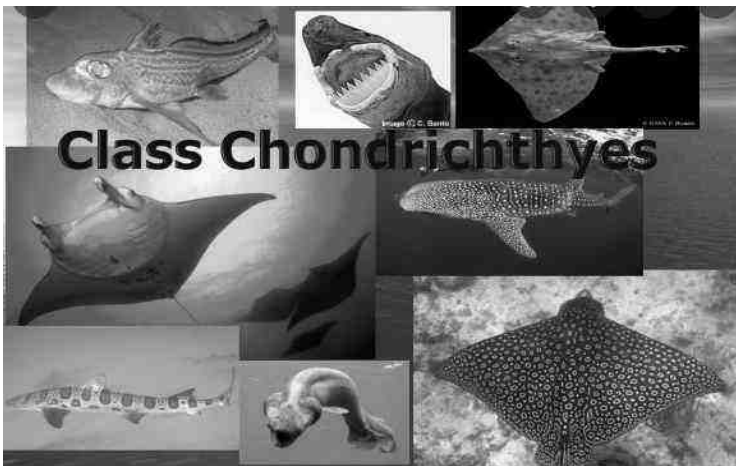


- Vertebral column replace notochord
- Calcified, bony skull and vertebra are characteristic features of Gnathostomata.
- All fishes, amphibians, reptiles, birds and
- mammals are members of this group.



CLASS CHONDRICHTHYES

- Chondrichthyes is a class of fishes included in the division
- Gnathostomata as they have jaws.
- Tail fins
- No swim bladder or lungs
- Large upper lobe



- Cartilage skeleton
- Paired appendages
- Have no operculum
- **Spiracle:** A modified slit behind the eye, assists the shark with taking in water during respiration and plays a major role in bottom dwelling sharks.
- Whale sharks are the second largest vertebrate and the largest fish. Some whale sharks measure up to 15 m in length.
- Control Buoyancy with large livers that excrete oil.
- Mostly marine
- Mostly they are Carnivores and scavengers
- They are predatory fishes, they feed on other fishes, crustaceans and molluscs.

- They filter food particles like planktons from the water current that passes through the mouth, pharynx and gills.
- Some must keep moving to breathe and others can pump water over their gills.
- They contain 5-7 pairs of gills.
- Gaseous exchange occurs through the water current that passes over the gills.
- Biting mouth parts
- **Lateral line system:** Detect motion or vibrations in water

Ampullae of Lorenzini-

- Electoreceptor organs used to detect the electromagnetic fields all living things produce.
- 
- Their teeth are modified placoid scales and are not attached to jawbones. They are embedded in the tissue.
 - Old teeth fall and are continuously replaced by the new teeth formed behind it.
 - Examples:
 - **Sharks, rat fishes, rays and skats**

14 Sub class Elasmobranchi

Outline

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Phylum Chordata

Subphylum Vertebrata

Supraclass Agnatha

- Order Osteostraci
- Order Anaspida
- Order Heterostraci
- Order Coelolepida
- Order Cyclostomata

Class Myxinoidea

Class Petromyzontida

Class Placodermi

- Order Arthrodiriformes
- Order Antlarchiformes

Supraclass Gnathostomata

Class Chondrichthyes

Subclass Elasmobranchii

- Order Cladoselephiformes
- Order Xenacanthiformes
- Order Selachii
- Order Batoida

Subclass Holocephali

Order Chimaeriformes

Class Acanthodii

Class Osteichthyes

Subclass Actinopterygii

Infraclass Chondrostei

Infraclass Holostei

Infraclass Teleostei

Subclass Sarcopterygii

- Order Crossopterygii
- Order Dipnoi

examples

jawless fishes

hagfish
lampreys

jawed fishes

extinct Paleozoic sharks
Paleozoic freshwater sharks
typical sharks
skates and rays

chimaeras or ratfishes
various extinct fishes
higher bony fishes
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sturgeon, paddlefish, primitive ray-finned fishes
gars, bowfins; dominant ray-finned fishes of Mesozoic
most bony fish; dominant in Cenozoic and recent times
lobe-finned fishes
ancestors of land vertebrates
lungfishes

Sub class Elasmobranchi

- Largest and most diverse subclass

of chondrichthyes.

- Cartilaginous

- Partially ossified

- Consist of sharks rays and skates

- 700 species

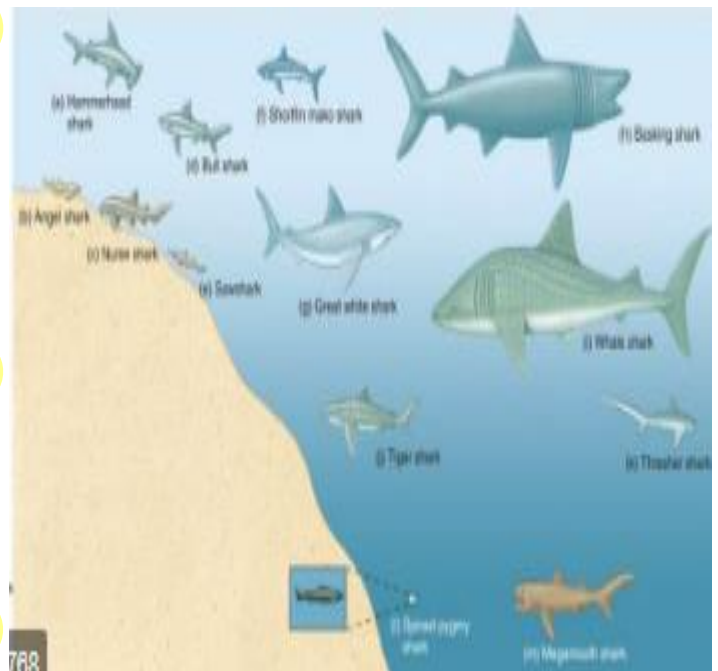
- During Devonian period sharks

arise from early jawed fishes

- Tough skin: dermal placoid scales

- Members of this subclass are characterized by having five to seven pairs of gill clefts opening individually to the exterior,

- rigid dorsal fins and small placoid scales on the skin.



- The teeth are in several series; the upper jaw is not fused to the cranium, and the lower jaw is articulated with the upper.
- The details of this jaw anatomy vary between species, and help distinguish the different elasmobranch clades.
- The pelvic fins in males are modified to create claspers for the transfer of sperm.
- There is no swim bladder; instead, these fish maintain buoyancy with large livers rich in oil.
- Uses of shark scales
- Dried shark scales use for sand paper
- Reduce friction
- Shark teeth are modified placoid scales
- the elasmobranchs (e.g., sharks, rays, and skates)

15 Sub class Holocephali

Ratfish

Sub class Holocephali

- Subclass of cartilaginous fish in the class Chondrichthyes.
- The earliest fossils are of teeth and come from the Devonian period.
- Little is known about these primitive forms.
- Operculum covers the slits



- Crushing teeth
- No scales
- Lateral line system
- Holocephali ("complete heads"), sometimes given the term Euchondrocephali,
- These fishes move by using sweeping movements of their large pectoral fins.
- They are deep sea fish with slender tails, living close to the seabed to feed on benthic invertebrates.
- They lack a stomach
- Their food moving directly into the intestine.
- Example
- Rat fish

16 Class Osteichthyes

Class Osteichthyes



- With more than 29,000 species of bony fishes, it is the largest class of vertebrates.
- It includes both marine and freshwater fishes, most of the commercially used fishes are included in this class.
- The size ranges from less than 8 mm in *Paedocypris progenetica*, which is also the smallest known vertebrate to 4 m and weigh about 1500 kg in the ocean sunfish (*Mola mola*).
- Their endoskeleton is made up of bones.
- Bony skeleton
- Operculum cover gills opening
- 20,000 species
- Present in Freshwater and saltwater
- Pneumatic sacs functions as lungs or swim bladder
- Bone in their skeleton, bony operculum covering the gills openings, lungs or swim bladder.
- Lateral line system

Fins: Dorsal, pectoral, caudal, pelvic, anal.

- Paired and median fins are present, which are supported by long rays of cartilage or bone. Fleshy lobed fins are present in sarcopterygians.
- These types of fins are supported by bones having joints.
- These are adapted to live at the bottom of the sea.
- First fossils of bony fishes are from late Silurian deposits

Example

- Bony fishes

17 subclasses: Actinopterygii and Sarcopterygii

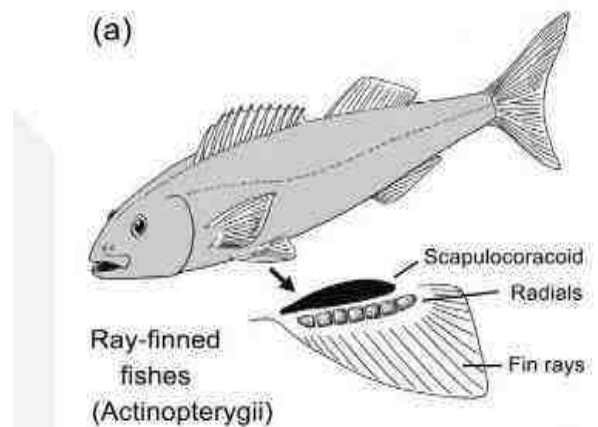
Subclass Actinopterygii

- (Ray-finned fish)
- Their fins lack muscular lobes

that is why called as ray-finned fishes.

- They usually possess swim bladders,

gas filled sacs along dorsal wall of the cavity that regulate buoyancy.



- Paired fins supported by dermal rays
- Base of fins is not muscular
- Tail fins almost equal to upper and lower lobes
- Blind olfactory sacs

Examples

- Ray finned fishes

Subclass Sarcopterygii

- (Lobe-finned fish)
- Have muscular lobes associated with their fins and usually use lungs for gas exchange.
- Pneumatic sacs function as lungs or swim bladder

- Paired fins with muscular lobes

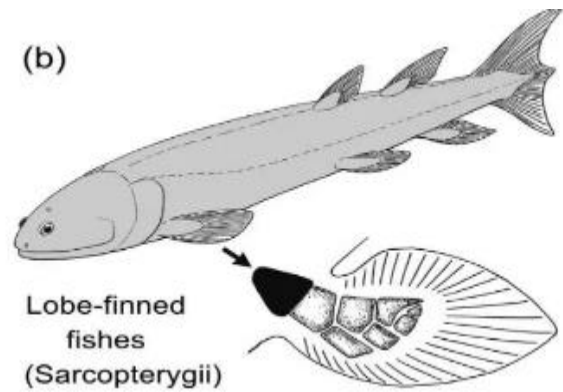
- Some bony fishes are hermaphrodites and a number of species exhibit parthenogenesis

- Fertilization is usually external

- Development is usually oviparous (egg laying) but can be ovoviviparous or viviparous

- Examples

- Lungfishes, coelacanths



18 Fish Morphology

Fish Morphology

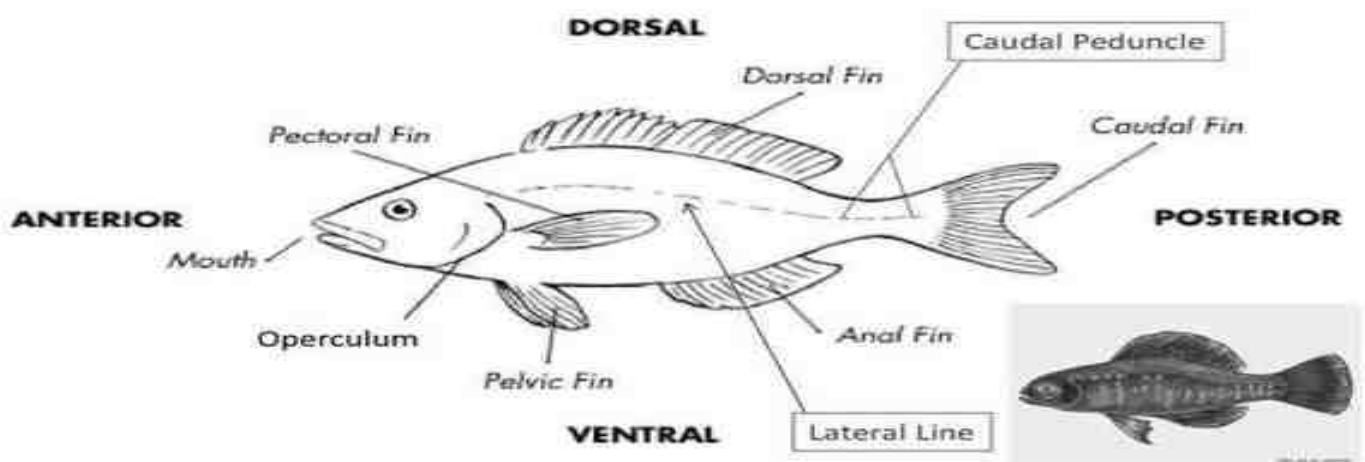


- Morphology involves large amount of different species, plus special terminology of their body parts.

- Morphology plays a key role in identification of the habit and habitat of most of the fishes.
 - The shape, size, and structure of body parts permit different fishes to live in different environments or in different parts of the same environment.
 - It distinguish the niche and the habitat of the fish,
- along with its evolutionary pattern and adaptability.

It includes:

1. Body shape
2. Mouth type
3. Mouth location
4. Scales
5. Gills
6. Fin type
7. Barbels
8. Lateral line system



1. Body shapes

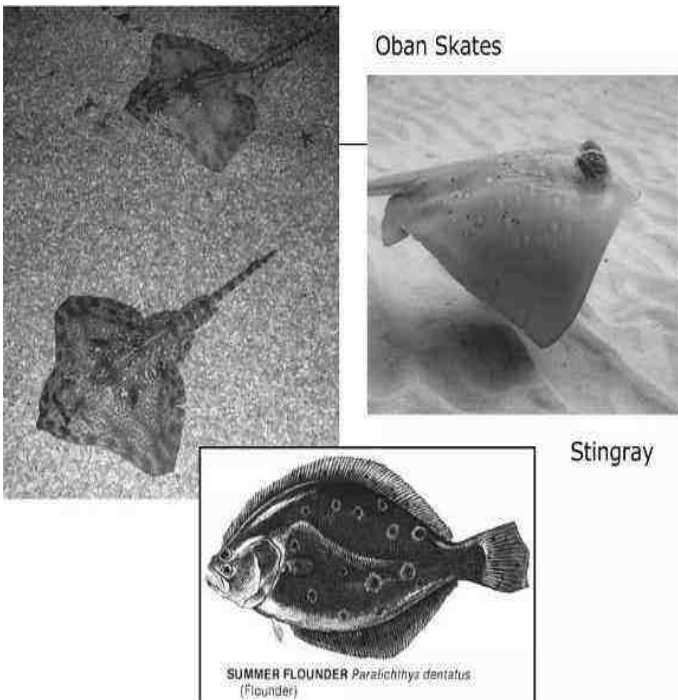


(i) Filiform or long and skinny

- -slither through the water like a snake
- -**example:** American eel

(ii) Depressiform or flat

- -They normally live on the bottom of the sea floor
- -flap their fins up and down to swim through
- the water in the same way a bird flaps its wings.
- **For example:**
- flounder and skates



(iii) Compressiform

- -body shape is well designed for

making quick turns and quick

bursts of speed over short distance

- -shape like that of angelfish looks thin when viewed from the front

- -compressiform fiish commonly live where there are many places to take refuge

such as lakes or coral reefs.



front view



(iv) Sagittiform

- -body shapes are good for rover predators,

which depend on an ability to strike quickly-often from a hiding place.

- -Arrow like
- -example shown is a grass pickerel.
- -other fish with this body type include pikes, gars, killifish, barracuda, topminnows and needlefish.



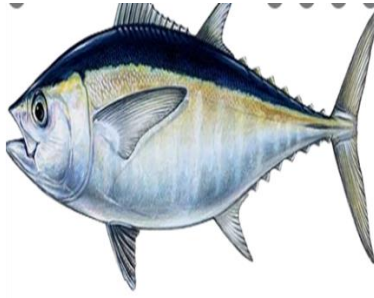
Spotted gar



barracuda

- (v)Fusiform or oval

- -section like a tuna or striped bass are fast swimmers and usually live in open water.



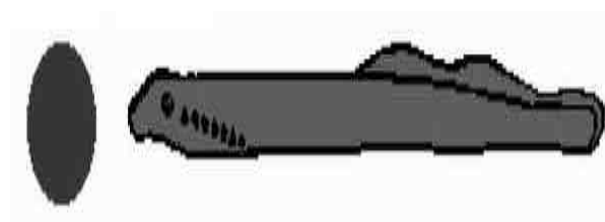
(vi) Taeniform

- -ribbon like
- -example shown is a gunnel.
- -this shape is good for hiding in cracks and crevices

but fishes like this do not move very fast.

(vii) Anguilliform

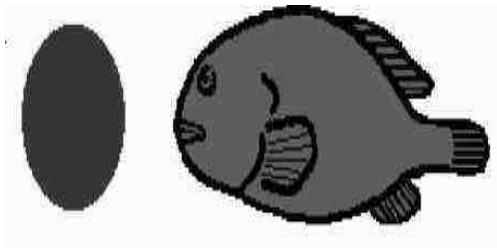
- -Eel like
- -shown is a brook lamprey.
- This shape allows a fish to enter and hide in very narrow openings and also helps the fish resist the force of current.



(viii) Globiform

- -globe like
- -shown is a smooth lumpsucker.

- -This, too, would be an unusual shape in a freshwater environment.



19 Types of Mouth in fish

Fish Morphology

(i) Long and skinny bill

- Tweezer like
- Poking into crevices



(ii) Downward orientation

- Oriented mouth
- Useful to suck food from bottom
- E.g., Janitor fish

(iii) Large mouth

- Tearing large prey



(iv) Beaklike mouth

- -used to graze on small algae growing on hard surfaces
- E.g Parrot fish

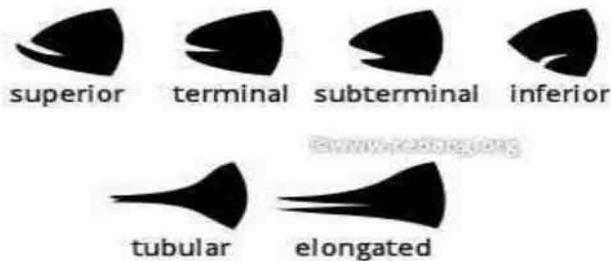
(v) Upward orientation

- Used to capture prey on water surface

20 Mouth position of fish

Mouth Position of fish

Mouth Position of Fish



- Most fish mouths fall into one of three general types:

Superior, or sometimes called supra-terminal, mouths are upturned.

- The superior mouth is oriented upwards, and the lower jaw is longer than the upper jaw.
- Archers, half-beaks, and hatchet fish are all examples of species of aquarium fish that have a superior mouth.



Terminal mouths point straight forward and are the most common mouth type.

Terminal mouths are located in the middle of the head and point forward. Both jaws are the same

length. More fish have this mouth type than any other.

- Most barbs, cichlids, gouramis, and tetras have terminal

mouths.



- **Inferior**, or sub-terminal, mouths are

turned downward.

- Also called a sub-terminal or ventral mouth, the inferior mouth is turned downward. The lower jaw is shorter than the upper jaw, and the jaw will often be protrusible.
- Most members of the catfish family have inferior jaws, and many of them also have a sucker mouth as well.



- **Protrusible mouth**

- A protrusible mouth allows a fish to extend its reach when attempting to snatch prey or food particles.

- For example, kissing gourami uses its protrusible mouth to defend territory against others of the same species.

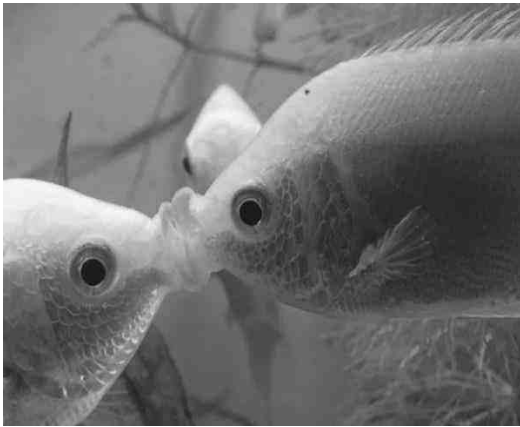
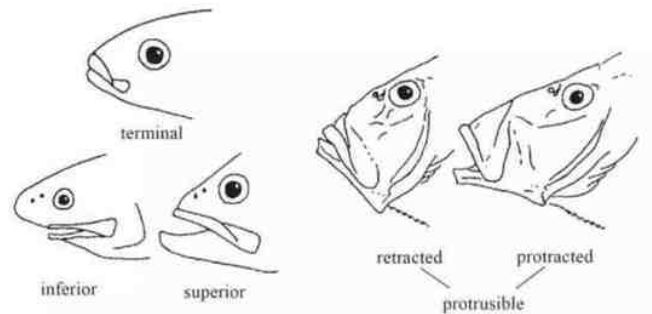
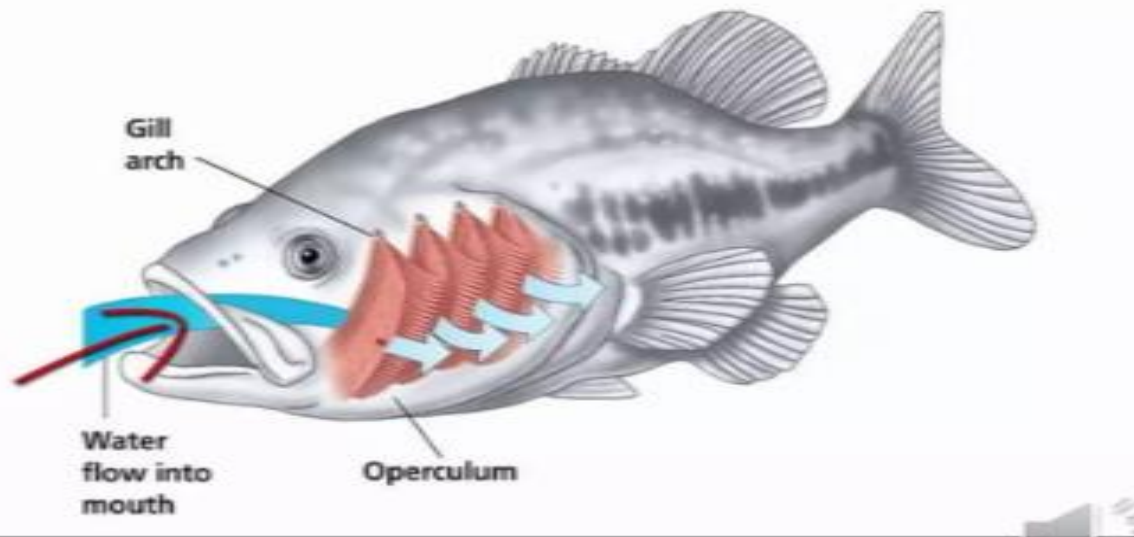


Fig. 5 mouth position and protrusibility

21 Fish gills

The gills

- The fish gill is a multifunctional organ involved in gas exchange, ionoregulation, osmoregulation, acid–base balance, ammonia excretion, hormone production, modification of circulating metabolites and immune defence (Rombough, 2007).
- In filter-feeding species, such as the sardine (*Sardina pilchardus*), the gills may also perform a feeding function.
- Fish gills are organs that allow fish to breathe underwater.
- Most fish exchange gases like oxygen and carbon dioxide using gills that are protected under gill covers on both sides of the pharynx.
- Gills are branching organs located on the side of fish heads that have many, many small blood vessels called capillaries.



Structure of Gill

1. Operculum:

The operculum is a hard, plate-like, bony flap that covers the gills of a bony fish (superclass: Osteichthyes). It protects the gills.

2. Gill Filament:

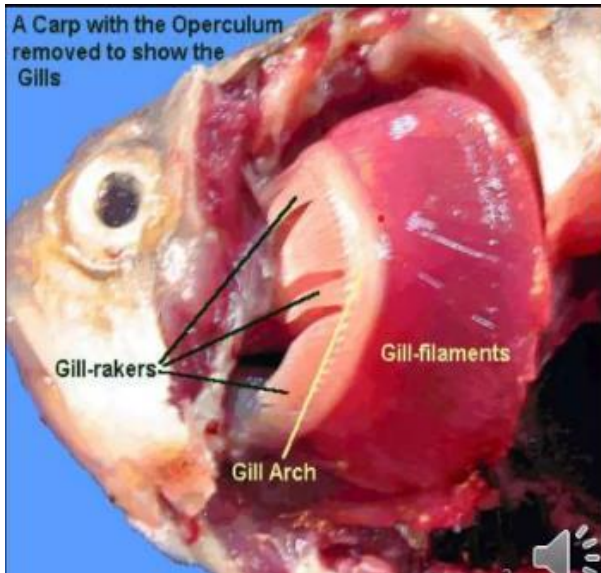
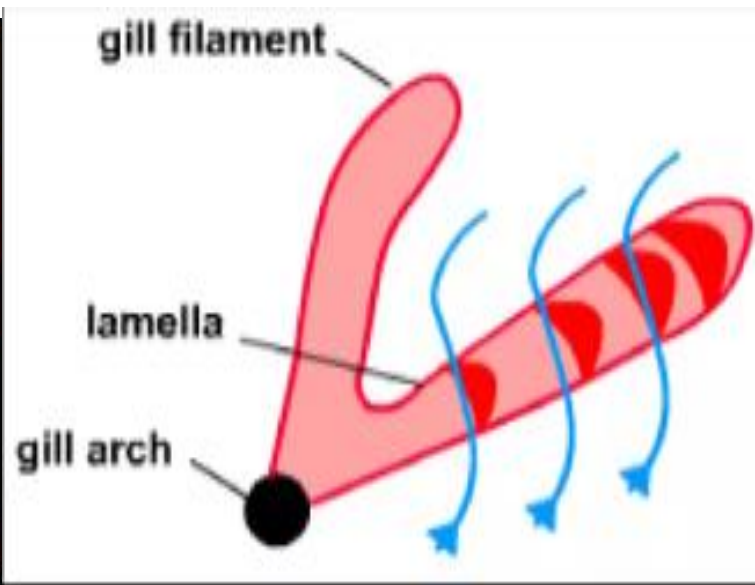
Gills are tissues that are like short threads, protein structures called filaments. These filaments have many functions including the transfer of ions and water, as well as the exchange of oxygen, carbon dioxide, acids and ammonia.

3. Gill Rakers:

help in fish feeding.

4. Gill Arches:

support gills.



- **Adaptation of gills for efficient gas exchange**

1. **Thin (Flattened cell)**

- Short diffusion distance

2. **Permeable membranes**

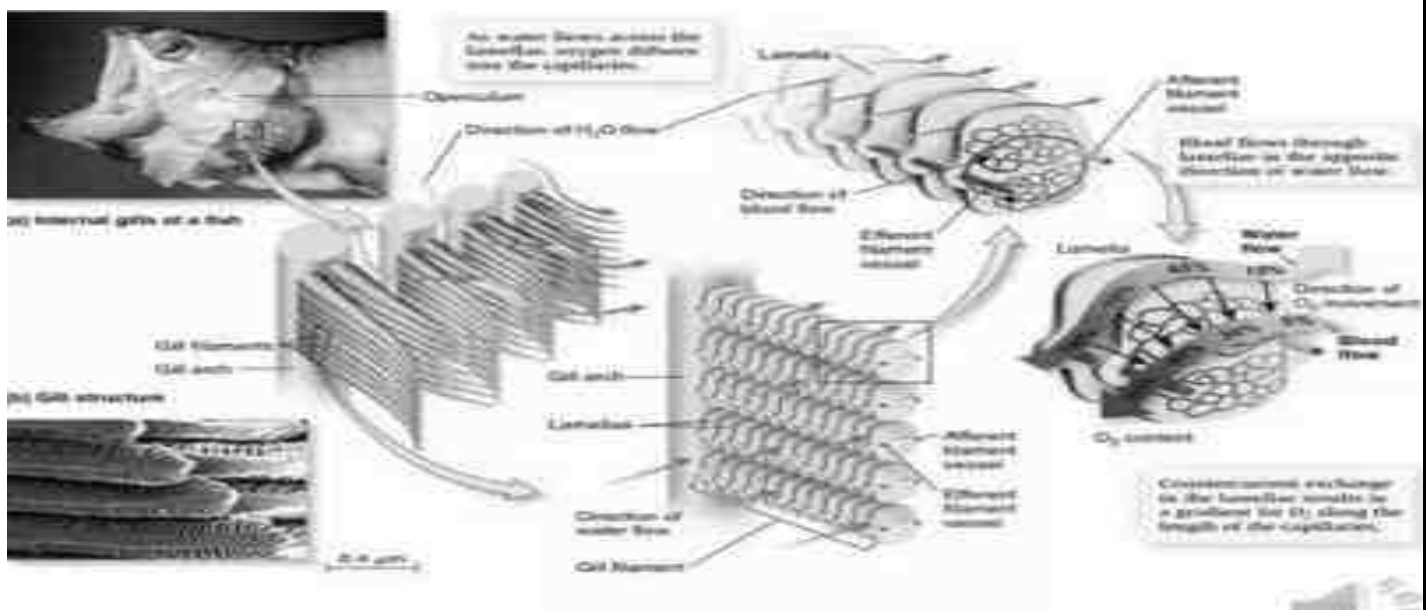
- Allow gases to diffuse

3. **Good vascular supply**

- Maintain concentration gradient

4. **Large surface area**

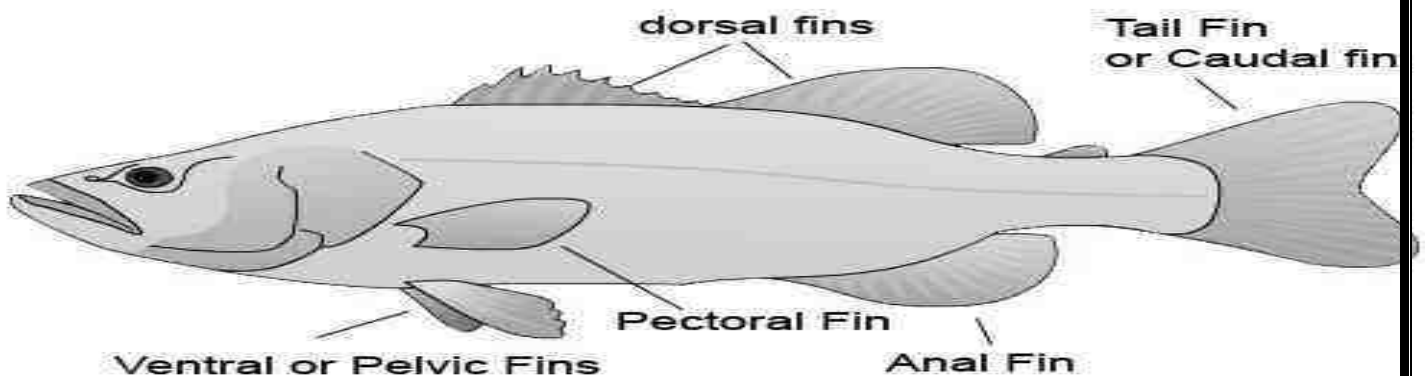
- Allow more diffusion of gases



22 Types of Fins in Fish: Dorsal Fin

- Fins are one of the most distinctive features of a fish and appear in several different forms. Each fin of a fish aids in its maneuverability and the ability to swim. Understanding the types of fins, makes it easier for [scuba divers](#), or [snorkelers](#) identify the variety of fish if they need to look-up their sightings after the dive. There are five main fins on a fish that are commonly described in [fish Identification](#).

- Pectoral
- Dorsal
- Pelvic
- Caudal
- Anal



Fin Type: Dorsal Fin

- Dorsal Fins**

Dorsal fins are located on the back or on the top of the fish, and aid the fish in sharp turns or stops, and assist the fish in rolling. Fish may have up to three distinct dorsal fins, known as proximal, middle, and distal dorsal fins, however

several fish have just two dorsal fins with the middle and distal [fins](#) fused together.

Fin Type

- The type of Dorsal fins are:
 1. Spiny and soft-rayed dorsal fin.
 2. Very long dorsal fin
 3. Tucked dorsal fin
 4. Locking spiny dorsal fin
 5. Three dorsal fins
 6. No dorsal fin

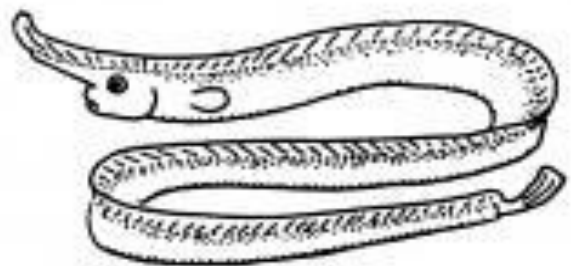
Dorsal fin

1. Spiny and soft-rayed dorsal fin.

Flared to make the fish look bigger

2. Very long dorsal fin

Snake-like locomotion



3. Tucked dorsal fin

Reduces drag in fast swimming fish

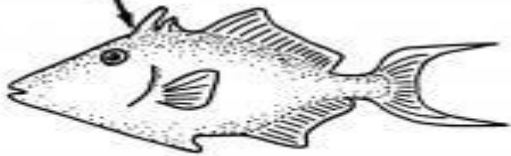
4. Locking spiny dorsal fin

Locking fish into coral crevices

Hidden fin



Locking spine

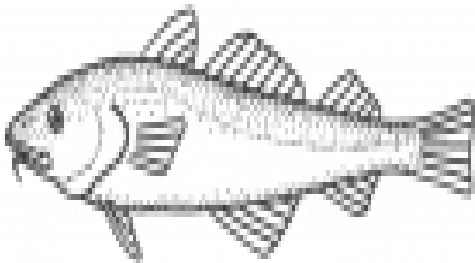


5. Three dorsal fins

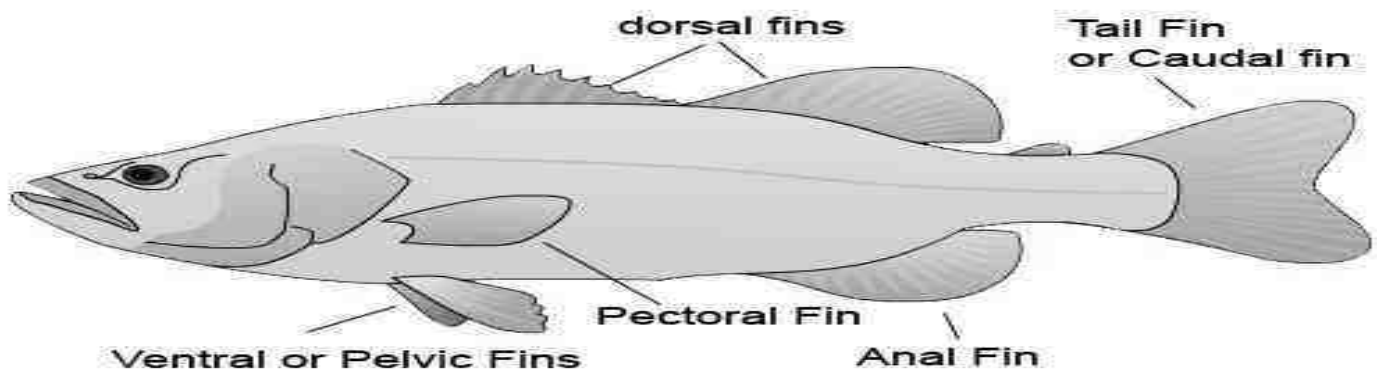
Locomotion

6. No dorsal fin

Snake-like locomotion



23 Types of Fins in Fish: Caudal Fin



• Median Fins

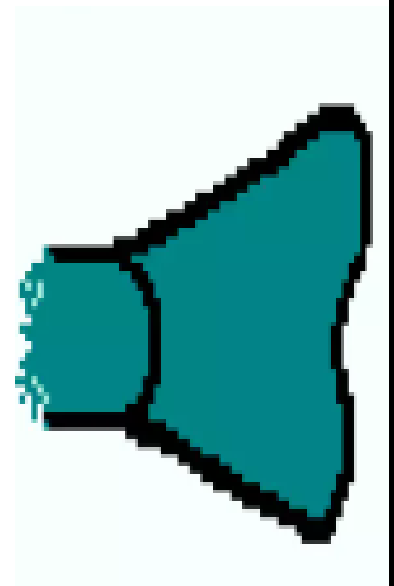
Median fins, like the dorsal, anal, and caudal fins, can function like the keel of a boat and aid in stabilization.

- Median fins can also serve other purposes, like protection in the lion fish
- The Caudal fin or Tail fin is the primary fin of the fish that gives it forward propulsion and speed.
- For [fish identification](#), the type of Caudal fin is used to distinguish one type from another.

The main types of Caudal fins found in bony fish are:

- Homocercal shape tail
- The Heterocercal tail
- Round tail
- Truncated (triangular) tail
- Lunate (moon shaped) tail
- Forked tail

The **caudal fin** is known commonly as the tail fin. It is the primary appendage used for locomotion in many fishes.



1. Homocercal shape tail

- -it is the most common caudal fin shape, shared by most fishes.
- -it includes square, truncate, slightly forked and deeply

forked types.

2. The heterocercal tail

- Possessed by only a few primitive fishes such as sturgeon,

paddlefish and sharks.

- The **caudal peduncle** is the base of the caudal fin.

Peduncle means stem, and the caudal peduncle is where the strong swimming muscles of the tail are found. Together, the caudal fin acts like a “propeller” for the fish, and the caudal peduncle acts like a motor.



3. Rounded tail

Slow swimming, accelerating, and maneuvering

4. Truncated (triangular) tail

Turning quickly



5. Lunate (moon shaped) tail

Continuous long distance swimming

6. Forked tail

Rapid swimming, somewhat sustained
with bursts of speed



24 Types of Fins in Fish: Paired Fin

Fin type :Pectoral fins

- Paired Fins
- Fish have two sets of paired fins: pectoral and pelvic.

The **pectoral fins** are vertical and are located on the sides of the fish, usually just past the operculum.

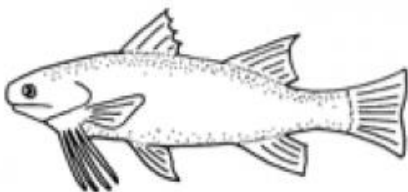
- Pectoral fins are similar to human arms, which are found near the pectoral muscles. Many fish, such as reef fish like wrasses, use their pectoral fins for locomotion, holding position and swimming.

1. Fringe-like pectoral fins

Probing substrate

2. Spiny pectoral fins

Propping on substrate

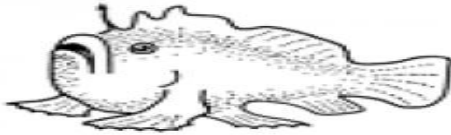


3. Hand-like pectoral fins

Crawling on substrate

4. Wing-like pectoral fins

Soaring and swimming

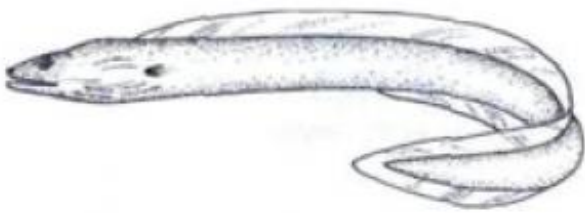
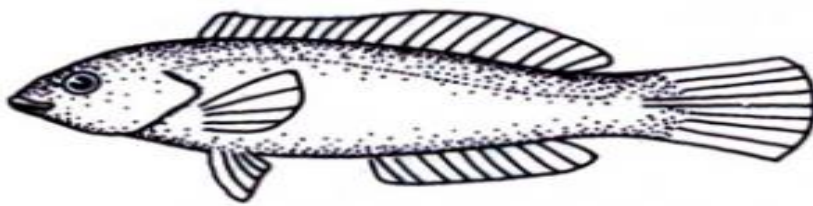


- 5. No pectoral fins

Snake-like swimming

- 6. Normal size pectoral fins

Maneuvering



Fin type :Pelvic fins

The **pelvic fins** sit horizontally on the ventral side of the fish, past the pectoral fins.

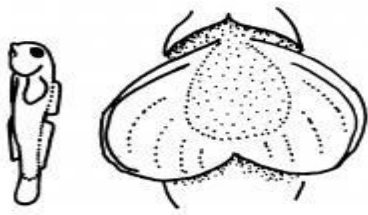
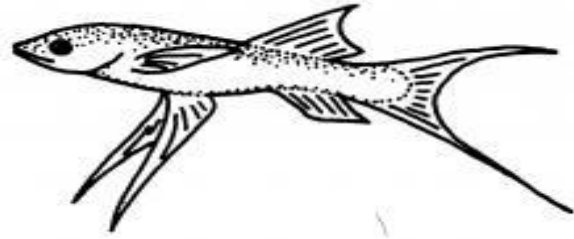
- Pelvic fins are similar to legs. Just like human legs, pelvic fins are associated with the pelvis of the fish. Pelvic fins are usually abdominal, that they are attached midway down the belly.
- When pelvic fins are below the pectoral fins, they are termed thoracic. When a thoracic pelvic fin is attached under gills, it may be called jugular.

1. Sucker-like pelvic fins

Grabbing rocks by suction

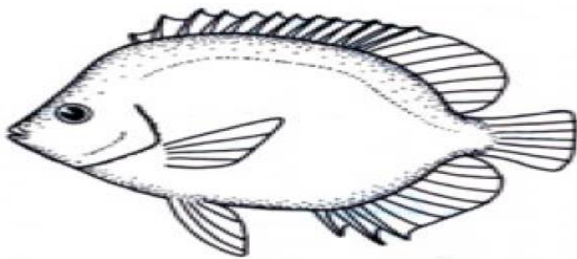
2. Thickened rays on pelvic fins

Sitting on substrate



- 3. Moderate sized pelvic fins

Locomotion



25 Types of scales in fish

Scales in fish

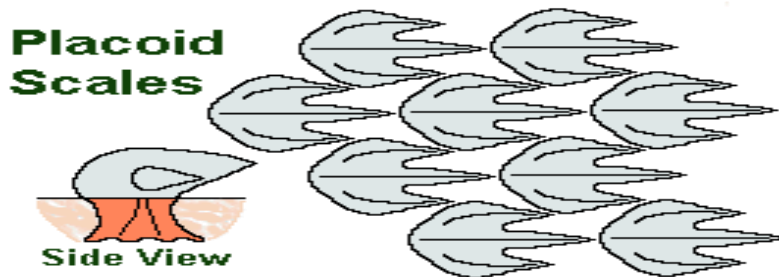
- Different fishes have different types of scales.
- These different types of scales are made of different types of tissue.
- Types of scales also correspond to evolutionary relationships.

There are four main kinds of scales and numerous variations of each kind.

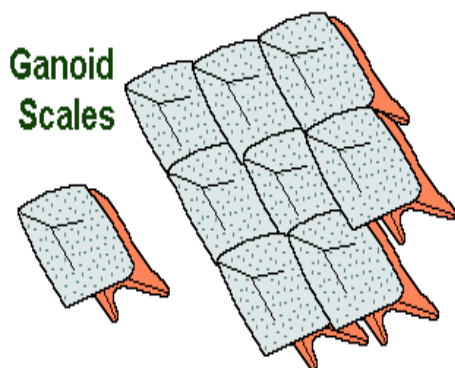
- Placoid (sharks and rays)
- Cosmoid (lungfishes and some fossil fishes)
- Ganoid (bichirs , Bowfin, paddlefishes, gars, sturgeons)
- Cycloid and Ctenoid (most bony fishes)

Placoid scales are found in the sharks and rays.

- Placoid scales are made of a flattened base with a spine protruding towards the rear of the fish.
- These scales are often called dermal denticles because they are made from dentin and enamel, which is similar to the material teeth are made of.



- **Ganoid scales** are flat and do not overlap very much on the body of the fish.
- They are found on gars and paddlefishes.
- In the sturgeon, ganoid scales are modified into body plates called scutes.



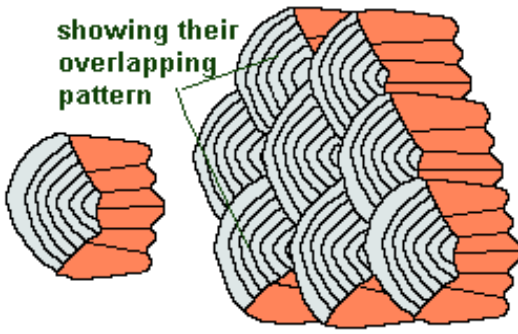
Cycloid scales

Cycloid are found in the vast majority of bony fishes.

- These types of scales can overlap like shingles on a roof, which gives more flexibility to the fish.
- These scales also form growth rings like trees that can be used for determining age.

Cycloid Scales

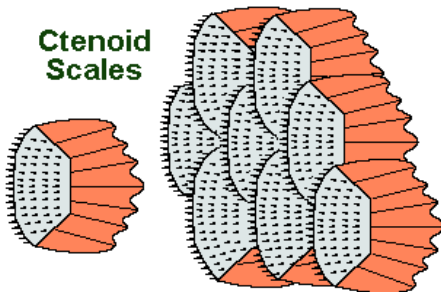
showing their
overlapping
pattern



- **Ctenoid scales**

- Ctenoid scales are different than cycloid scales in that cycloid scales tend to be more oval in shape.
- Ctenoid scales are more clam shaped and have spines over one edge.
- Cycloid scales are found on fishes such as eels, goldfish, and trout.
- Ctenoid scales are found on fishes like perches, wrasses, and parrotfish. Some flatfishes, like flounder, have both cycloid and ctenoid scales.

Ctenoid Scales

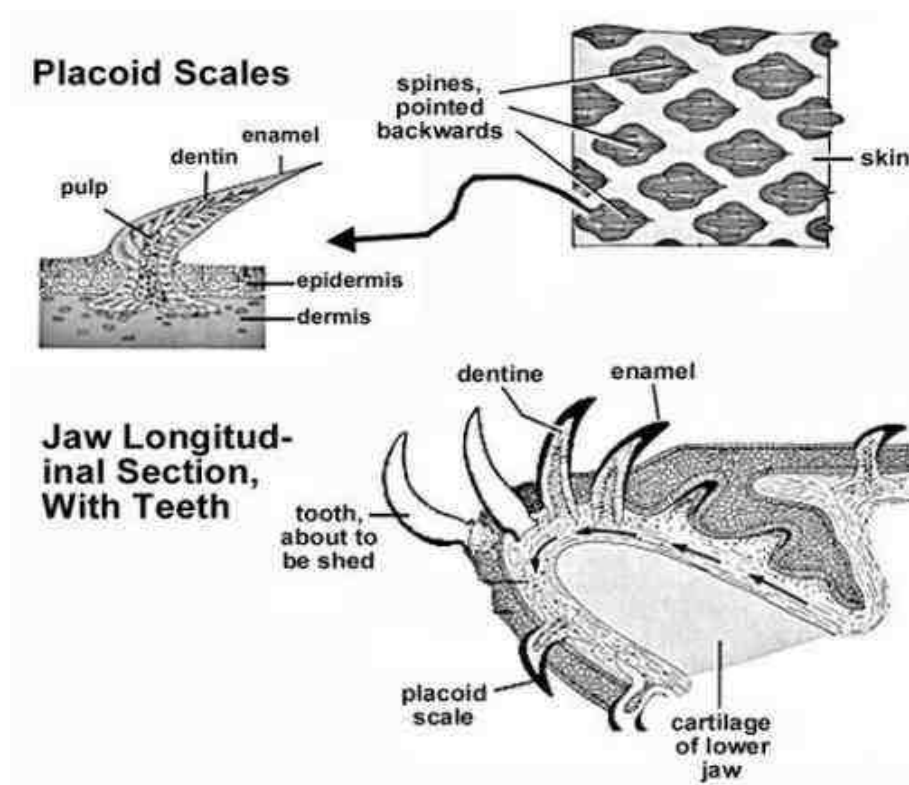


- Beside the scale types, there are also cosmoid scales,

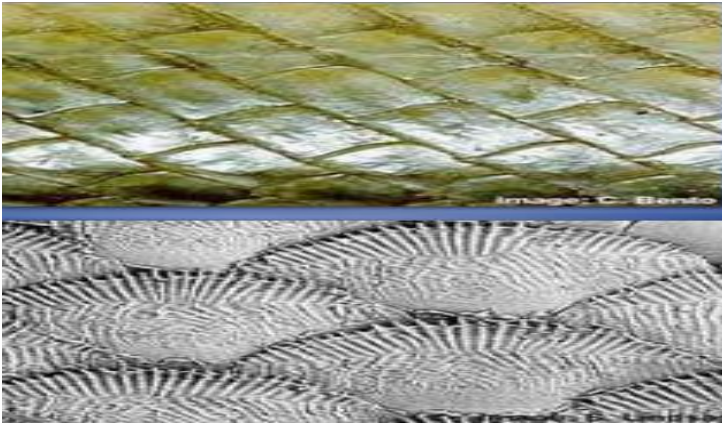
as well scaleless fishes (many catfish, sculpins, some eels and swordfish) and fishes which have scales so deeply buried that they look scaleless (many tunas and anguillid).



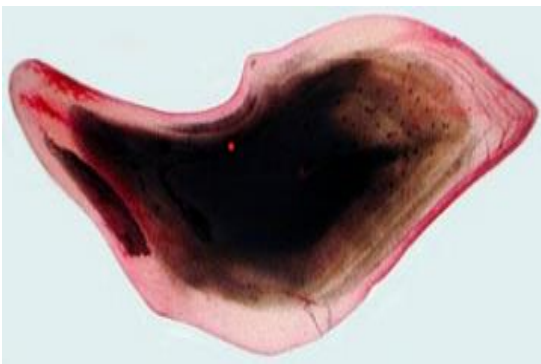
- **Class Chondrichthyes**
- Skin contains placoid scales
- Similar in structure to teeth
- Dentine like core surrounded by enamel-like covering.



- Skin of most bony fishes is covered with mucous glands and embedded dermal scales



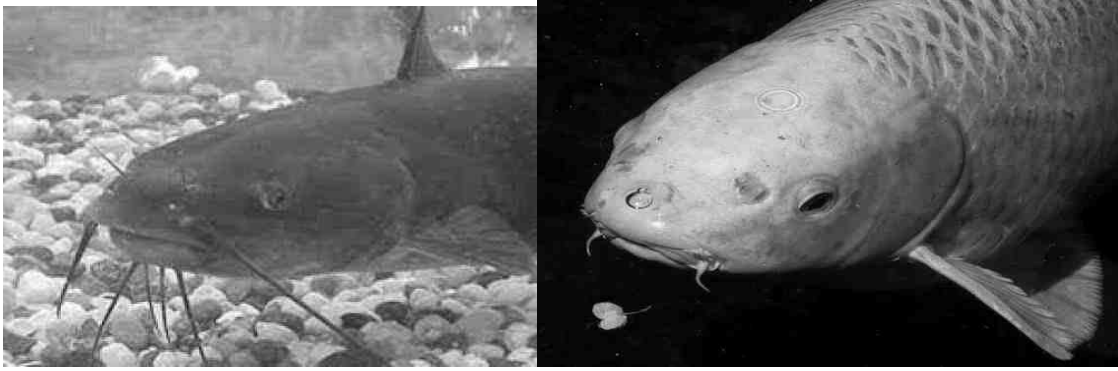
- **Class Osteichthyes**
- Ganoid or rhomboid scales (ganoin)
- Heavy, non-overlapping, diamond shaped
- Primitive fish like gars



26 Barbel and Lateral line system in fish

Barbel

- **A barbel** is a slender, whisker-like sensory organ near the mouth.
- Fish that have barbels include the catfish, the carp, the goatfish, the hagfish, the sturgeon, the zebrafish, the black dragonfish and some species of shark such as the sawshark.

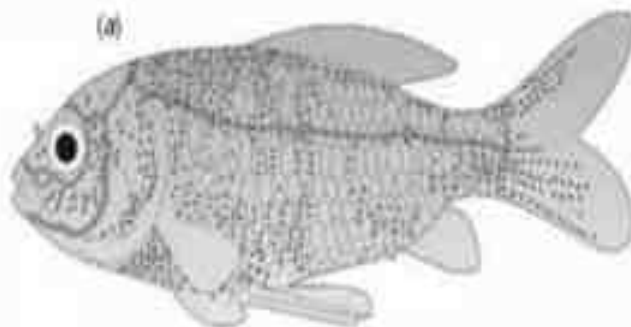


Barbels can be classified as:

- Tender barbels, rigid barbels, barbels without taste buds, with taste buds and without cartilage (Cyprinidae, Carps).
- Barbels with taste buds and cartilage (Catfish, Goatfish) and with an axial rod of striated muscle (Polymixia type)

Lateral line system

- All of the primarily aquatic vertebrates—cyclostomes (e.g., lampreys), fish, and amphibians—have in their outer skin (epidermis) special mechanoreceptors called lateral-line organs.
- These organs are sensitive to minute, local water displacements, particularly those produced by other animals moving in the water.



Structure of the Lateral Line System

The lateral line system consists of 100 or more sensory organs (neuromasts) that are typically arranged in lines on or just under the skin of the head and body. It is absent from all reptiles, birds, and mammals, even those that are aquatic (such as turtles, dolphins, and whales).

LATERAL LINE SYSTEM



Sometimes the lateral line is readily visible, as shown here, and sometimes it is hard to see, or simply not present. The lateral line shown is filled with canal neuromasts.



Most all fishes begin life with superficial neuromasts (those that are free-standing on the skin) only on the head. During development, these superficial neuromasts may be replaced by embedded canal neuromasts, such as is seen in the head pores of this northern pike; the body will also develop a more complex lateral line system.



Not shown: This pike also has submandibular pores on the underside of the jaw.

Pores in the dermal bones of the head containing neuromasts.

Can you spot the other pores not circled?

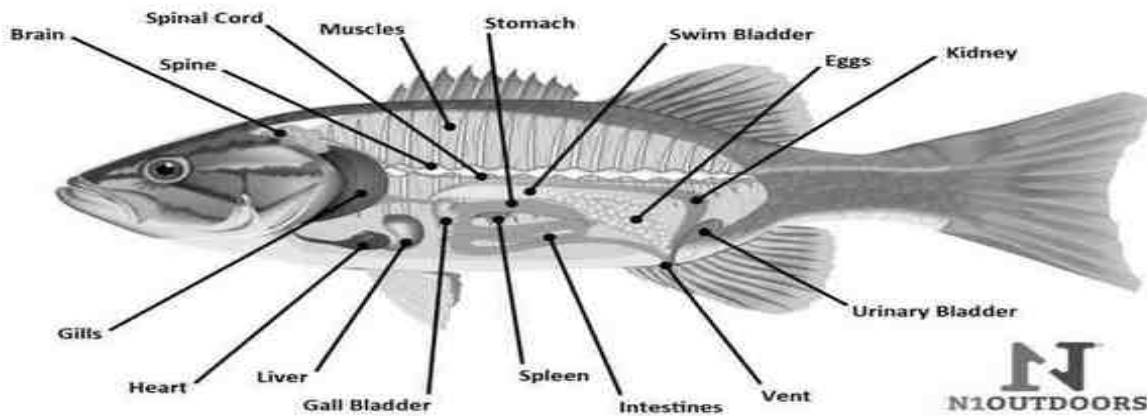
Original photo by Piet Spaan
Modified by Koaw

In the head, the lateral line canal is separated into three canals, one passes forward and above the eye, another forward and below the eye and the other downward and below the jaw. These three canals have numerous pores and together with the lateral line canal, make the lateral line system.

27 The Anatomy of Fish: Skeletal system

- **Anatomy** is the study of an organism's internal structures.
- Fishes come in a diverse array of forms, many with special modifications.
- The shape, size, and structure of body parts permit different fishes to live in different environments or in different parts of the same environment.
- Internal fish anatomy consists of the brain, spine, spinal cord, swim bladder, kidney, stomach and intestines, vent, liver, heart, gonads/eggs, muscles and pyloric caeca.

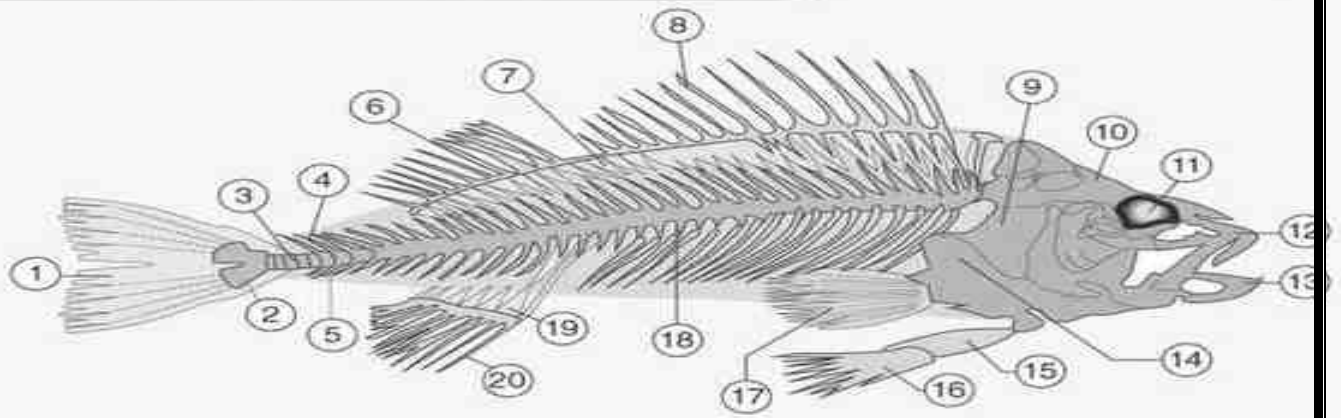
Let's take a look at each below.



Skeleton of a fish

- The skeletal system forms the framework of the body and is mainly composed of bones and tissues. The main functions of the skeletal system are as follows:
- Protection.
- Helps in movement.
- Provides shape and support.
- They are the site for the storage of minerals like calcium.
- General features of fishes include fins, streamlines and scales and tails. But differences are highlighted under their skins.
- Hence classification is much easier based on the skeletal system.
- A variety of fishes is found in aquatic habitats. Some of these fishes are cartilaginous fishes (Chondrichthyes) whereas others are bony fishes (Osteichthyes).
- The skeletal system of fishes is either composed of thin and flexible cartilage or hard calcified bones or both.
- They are good swimmers and their body structures are designed accordingly.

FISH: SKELETAL SYSTEM

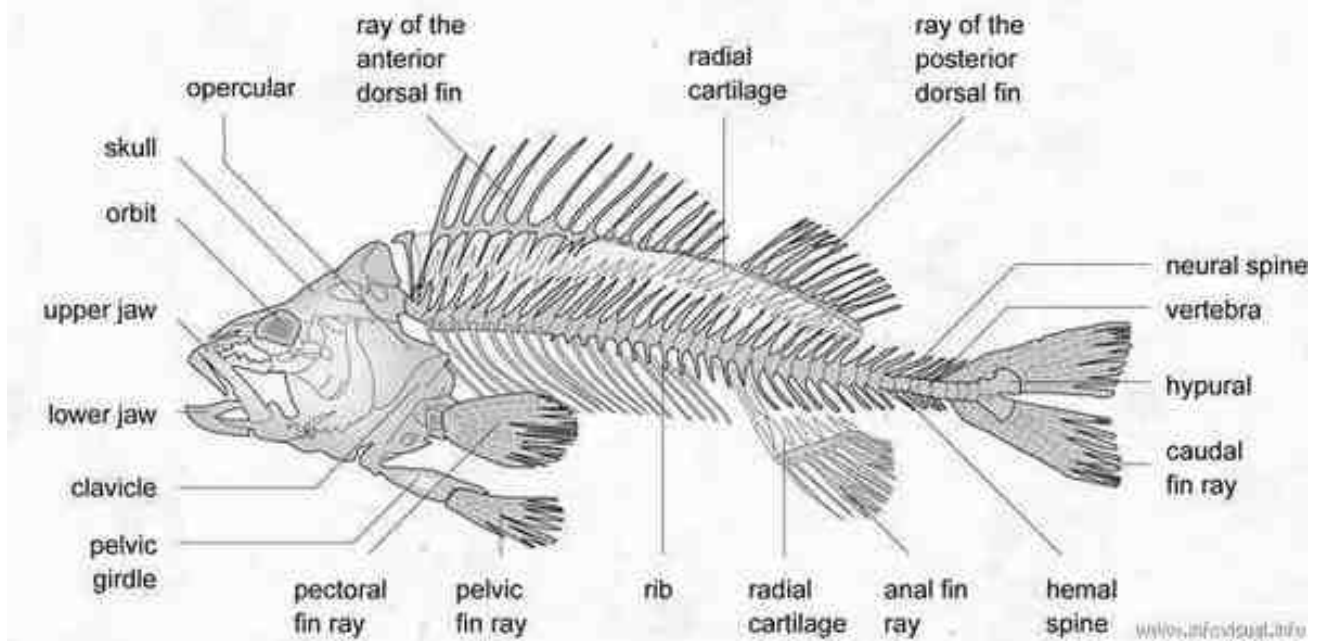


1 Caudal fin ray	6 Ray of the posterior dorsal fin	11 Orbit	16 Pelvic fin ray
2 Hypural	7 Radial cartilage	12 Upper jaw	17 Pectoral fin ray
3 Vertebra	8 Ray of the anterior dorsal fin	13 Lower jaw	18 Rib
4 Neural spine	9 Opercular	14 Clavicle	19 Radial cartilage
5 Hemal spine	10 Skull	15 Pelvic girdle	20 Anal fin ray

Skeletons

- First jawed fishes appeared in the geologic record about 100 million years after jawless fish came about.
- Today, two major groups of jawed fish exist and they are distinguished by what sort of material their skeletons are made of – cartilage or bone.
- The cartilaginous fish include the sharks and rays and are represented by about 165 living species today. Cartilaginous fish have a skeleton made of cartilage – the firm but flexible tissue that forms your nose..
- This group of fish also lack true scales on the skin, the gill flap (or operculum) that covers the gill, and movable fins.
- Bony fishes, on the other hand, have a bone-like (or ossified) skeleton that supports the body tissue.

SKELETON OF A FISH

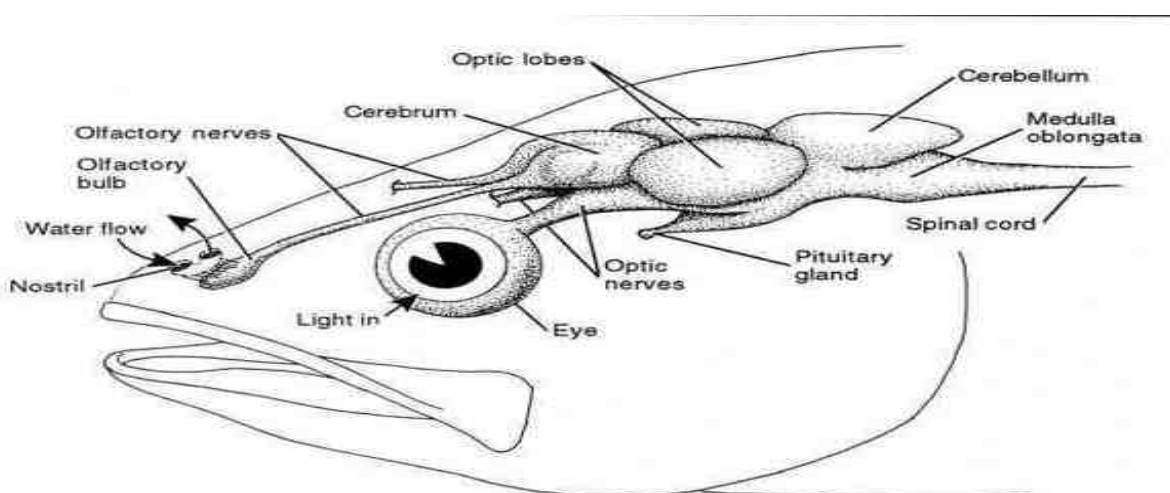


28 The Anatomy of Fish: Nervous system

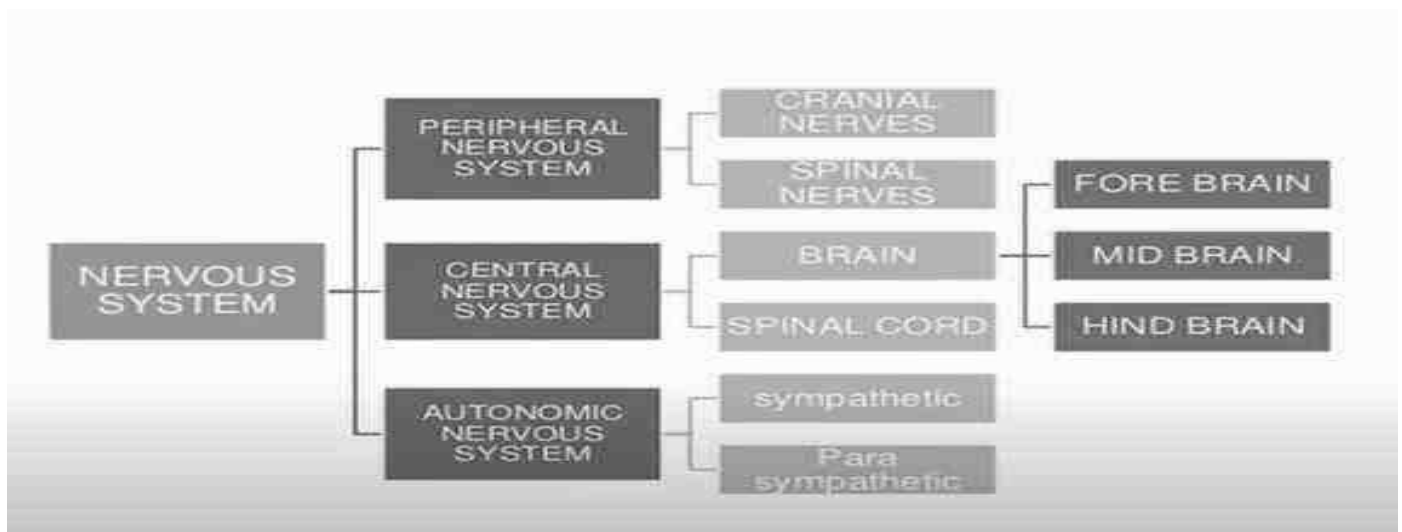
Nervous system

- As in all vertebrates, the nervous system of fishes is the primary mechanism coordinating body

activities, as well as integrating these activities in the appropriate manner with stimuli from the environment.



- Fish typically have quite small brains relative to body size compared with other vertebrates.
- But some fishes like moemyrids and sharks have large brains.
- Brain never fills the entire cavity of the cranium.
- Remaining space filled with a soft gelatinous mass generally fat.
- At the front of olfactory lobes a pair of structure that receive and process signals from the nostrils via two olfactory nerves.



- The nervous system in fishes can be divided into two parts:

the central nervous system and the peripheral nervous system.

- **Central nervous system,**
- The central nervous system, consisting of the brain and spinal cord, is the primary integrating mechanism.

Fish brains are generally divided into general regions.

- Prosencephalon, Mesencephalon and rhombencephalon are the regions of brain.

Prosencephalon gives rise to two parts:

- **Telencephalon (anterior part of the brain)**

Mainly concerned with the receptor and conduction of smell. Telencephalon is

divided into two regions:

Area ventralis and area dorsalis

Ventral area receives secondary olfactory fibers and it is a constant structure

in all bony fishes

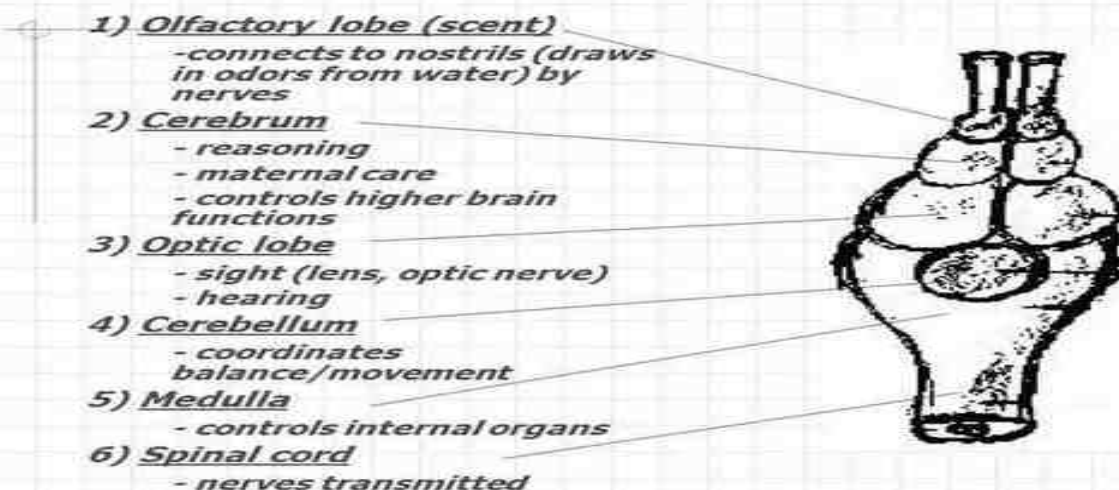
- In adult fishes telecephalon may be formed by invagination and inversion and plays important role in the reproductive behavior of fishes.

- Diencephalon (the sight area of the brain)

- It is divides into three parts

- Epithalamus
- Hypothalamus
- thalamus.

Bony Fish Nervous System



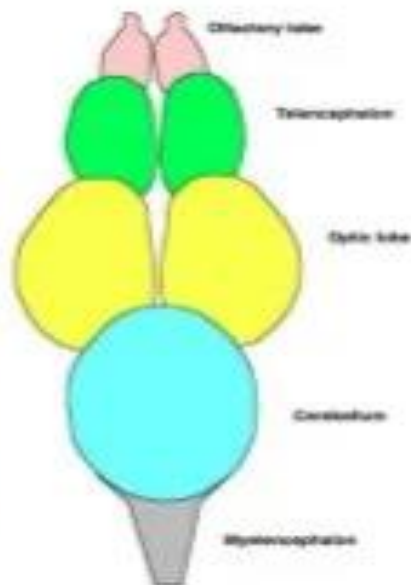
peripheral nervous system,

- The peripheral nervous system, consisting of nerves that connect the brain and spinal cord to various body organs, carries sensory information from special

receptor organs such as the eyes, internal ears, nares (sense of smell), taste glands.

Perch Dissection

► Perch have complex brains



- The peripheral nervous system also carries information via different nerve cells from the integrating centres of the brain and spinal cord.
- This coded information is carried to the various organs and body systems, such as the skeletal muscular system, for appropriate action in response to the original external or internal stimulus.
- The brain of the fish is divided into several anatomical and functional parts, all closely interconnected but each serving as the primary centre of integrating particular kinds of responses and activities.

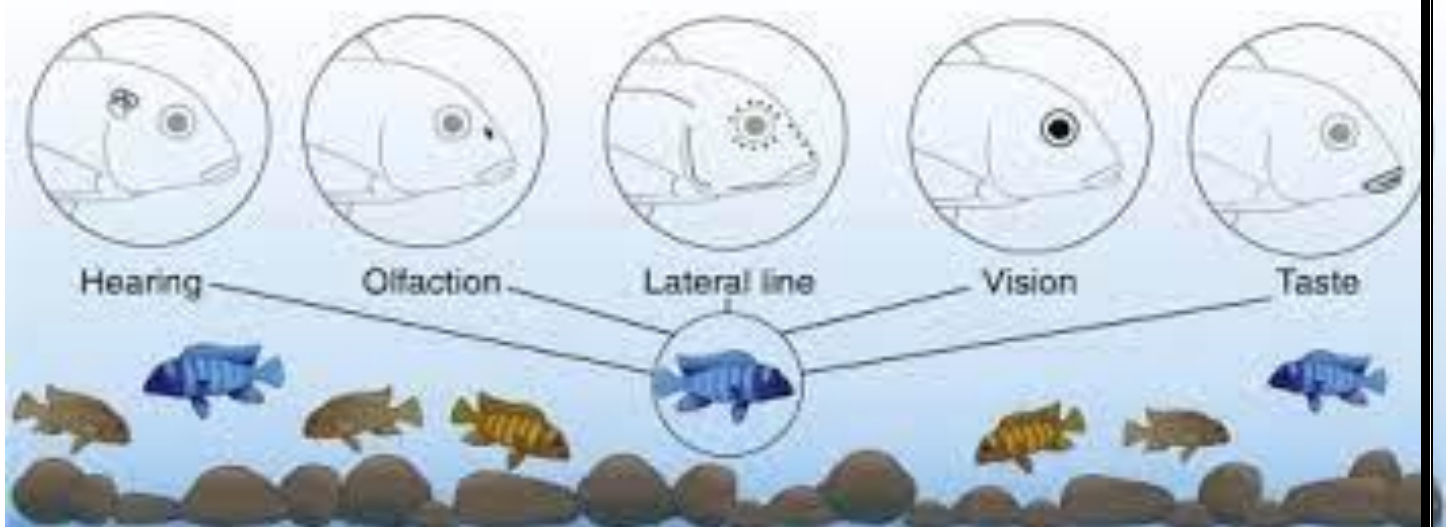
29 The Anatomy of Fish: Sensory organs

Sensory organs

- Fish senses, such as sight, hearing, taste buds (gustation), or smell (olfaction) are utilized to assist in acquiring food, to defend against predators and in some cases for schooling with others of their own species.

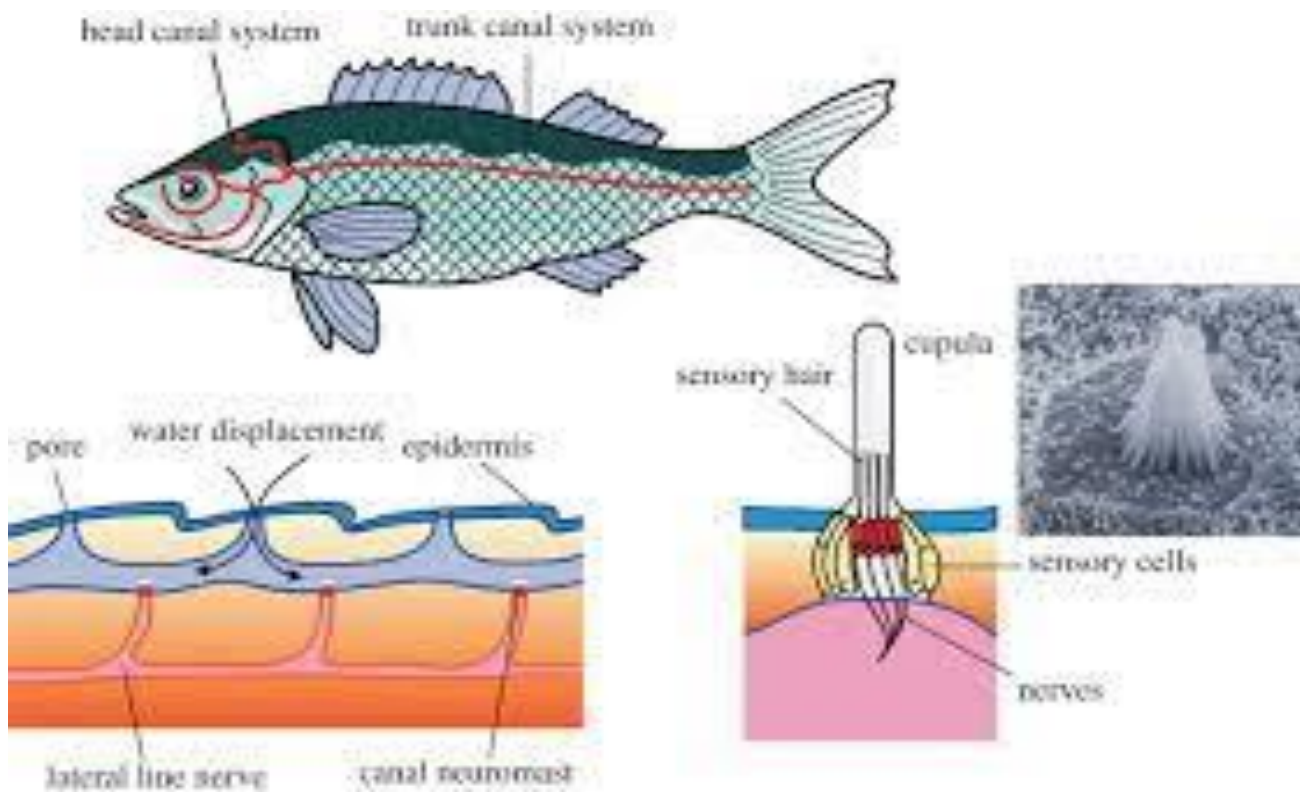
Sight (Eyes are the photoreceptor organ in fishes and resembles in structure with other vertebrates, Fishes have monocular vision. The field of view of each eye is considerably enlarged and extended forward continues laterally to almost behind the fish)

- ❑ **Gustatory system** (feeding)
- ❑ **Olfaction** (Detecting danger, non sexual, social interaction, orientation, reproductive synchrony)



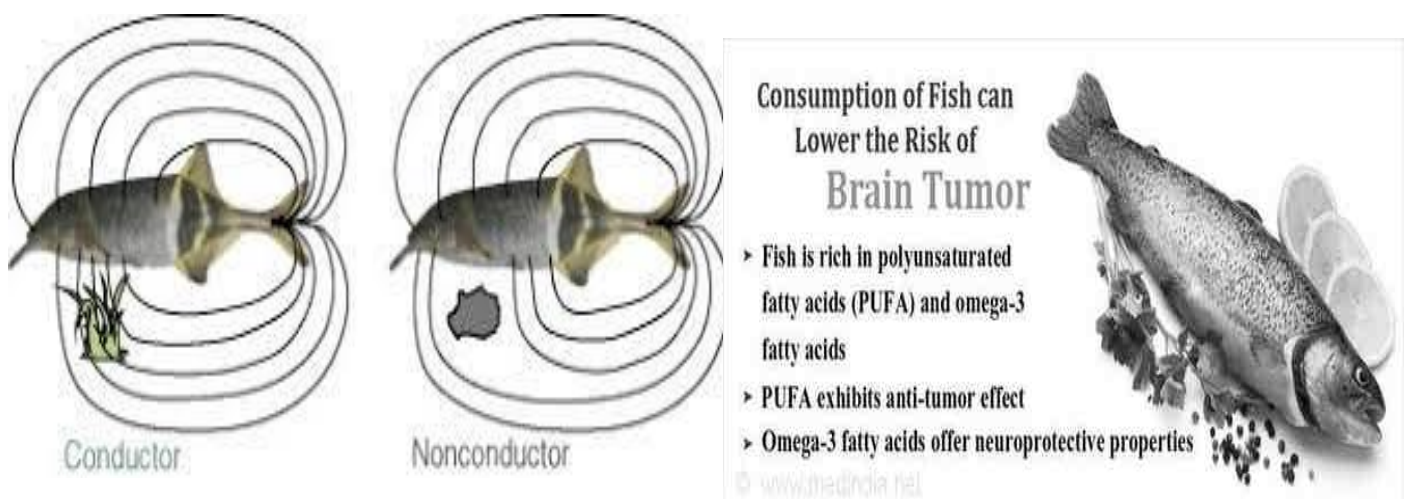
- Fishes also have unique sensory structure or complex organs called lateral lines which generally run down the lateral surfaces of the body starting at the head and ending at or near the start of the tail.
- The lateral line has nerves that are able to pick up sensory information about water displacement.
- With this, fishes can detect when the water around them moves, alerting them of a passing nearby fish.

- Lateral lines in some species contain **electroreceptors**, which can detect electric signals in water generated by other organisms.



Electroreceptors

- A vertebrate organ found especially in fish that contains sensory cells capable of detecting electric fields.
- Fish use passive electroreception to **supplement or replace their other senses when detecting prey and predators**. In sharks, sensing an electric dipole alone is sufficient to cause them to try to eat it.



Human share some common body parts with fishes

HUMAN	FISH
Lungs	Gills
Stomach	Stomach
Liver	Liver
Kidneys	Kidneys
Ears	Lateral line system, otoliths
Skin	Scales and slime layer
Nose	Nares

30 The Anatomy of Fish: Muscular system

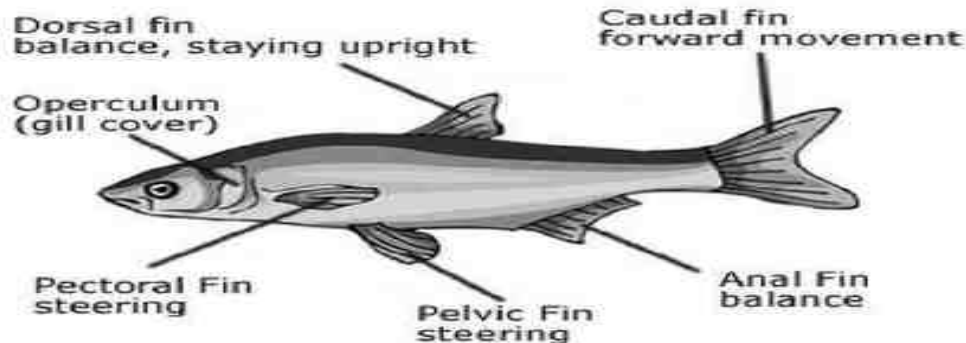
The muscular system

- The major portion of the body of most fishes consists of muscles.
- Most of the mass is trunk musculature, the fin muscles usually being relatively small.
- The **caudal fin** is usually the most powerful fin, being moved by the trunk musculature.
- The body musculature is usually arranged in rows of chevron-shaped segments on each side.
- Contractions of these segments, each attached to adjacent vertebrae and vertebral processes, bends the body on the vertebral joint, producing successive undulations of the body, passing from the head to the tail, and producing driving strokes of the tail.

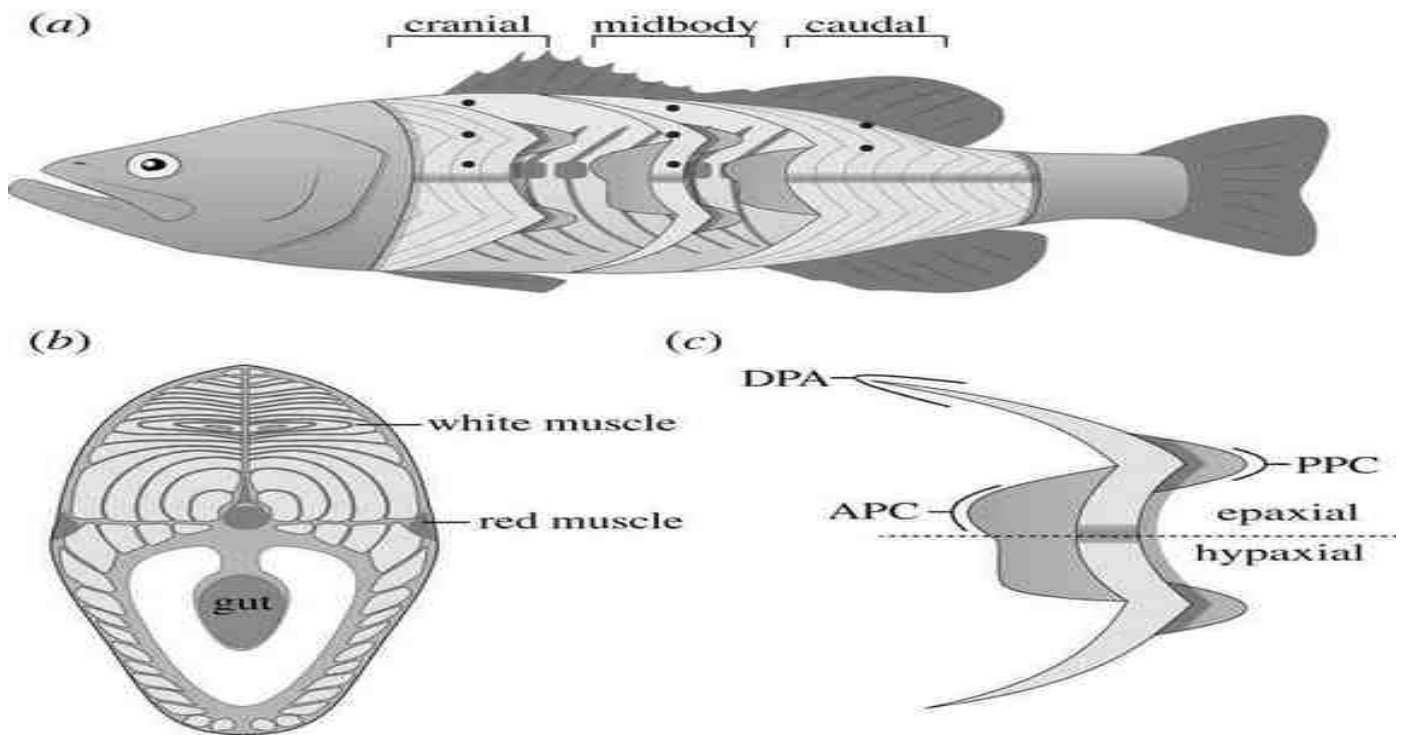
- It is the latter that provides the strong forward movement for most fishes.

Muscular system

- Provides external and internal movement



- Fish muscle is structurally similar to that of other vertebrates,
- fishes possess the same three kinds of muscles,
- but differ in that a greater **proportion (40–60%)** of the mass of a fish's muscle is made up of locomotory muscle.
- **Hagfishes and lampreys** have a simple arrangement of striated skeletal muscles.
- These primitive fishes have no paired appendages to interrupt the body musculature.
- Skeletal muscle behind the head is uniformly segmental and is composed of shallow W-shaped myomeres.



- In jawed fishes, two major masses of skeletal muscle lie on each side of the fish, divided by the horizontal connective tissue septum.
- The **epaxial muscles** are the upper pair, and the **hypaxials** are the lower pair.
- A third, smaller, wedge-shaped mass of **red muscle** lies under the skin along the horizontal septum.
- This band of red muscle is poorly developed in most bony fishes although it is much more extensive and used for sustained swimming in fishes such as the tunas (see Heterothermic fishes)

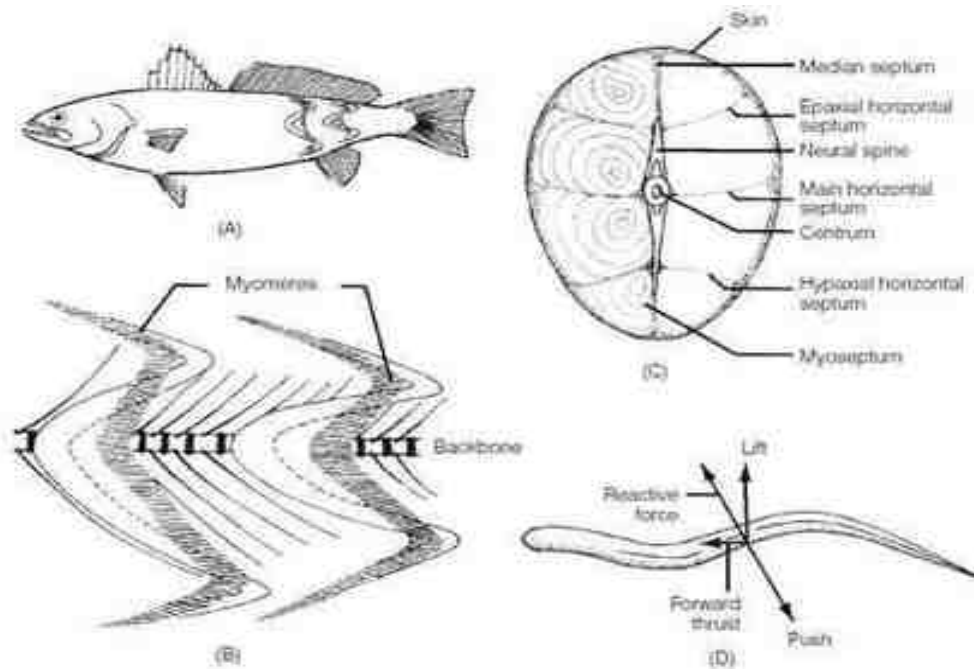
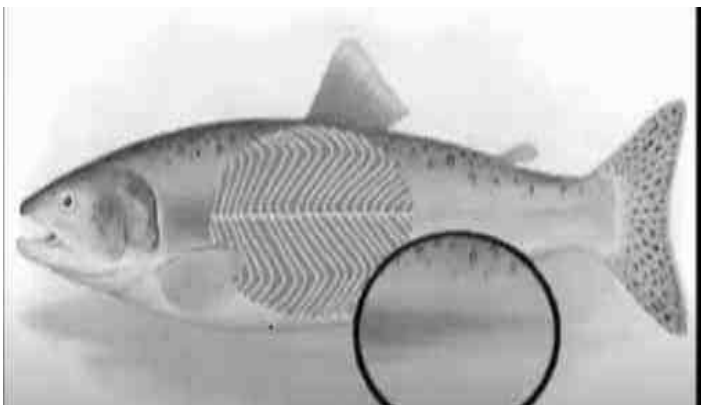


Figure 8.1

The anatomy of swimming in teleosts. (A) Lateral view of a Spotted Sea Trout, *Cyanocephalus nebulosus*, with the skin dissected away to show the location of two myomeres on the left side. (B) The same myomeres as they appear relative to the backbone in a sea trout. The hatched region is the part of the myomere located closest to the skin, the dashed line shows the interior portion of the myomere where it attaches to the vertebral column. The anterior and posterior surface of each myomere is covered by a myoseptum made of collagen fiber in a gel matrix, shown as a slightly thickened line. (C) Cross-section of a generalized teleost near the tail, showing the distribution of the various septa and their relationship to the backbone. Myosepta join to form median and horizontal septa. (D) How contractions produce swimming in a generalized fish (an eel is shown here). Progressive, tailward passage of a wave of contractions from the head to the tail push back on the water, generating forward thrust as one component of the reactive force. Sideways slippage (lift) is overcome by the inertia of the large surface area presented by the fish's head and body. After Wainwright (1983) and Pough et al. (1989).

- A male salmon or Tuna consist of **70 percent muscle**, that is why these fishes are so good to eat.



31 The Anatomy of Fish: Digestive system

The digestive system of fish

- The structural components of a fish's digestive system include the **mouth, teeth and gill rakers, esophagus, stomach, pylorus, pyloric caeca, pancreatic tissue (exocrine and endocrine), liver, gall bladder, intestine and anus.**
- Not all components are present in all fish
- The digestive system, in a functional sense, starts at the **mouth**, with the teeth used to capture prey or collect plant foods.
- **Mouth** shape and tooth structure vary greatly in fishes, depending on the kind of food normally eaten.
- Most fishes are **predacious**, feeding on small invertebrates or other fishes and have simple conical teeth on the jaws, on at least some of the bones of the roof of the mouth, and on special gill arch structures just in front of the esophagus.



- The latter are throat teeth.
- Most predacious fishes swallow their prey whole, and the teeth are used for grasping and holding prey, for orienting prey to be swallowed (head first) and for working the prey toward the esophagus.
- There are a variety of **tooth types** in fishes.
- Some fishes, such as sharks and piranhas, have cutting teeth for biting chunks out of their victims.

- A **shark's tooth**, although superficially like that of a piranha, appears in many respects to be a modified scale, while that of the piranha is like that of other bony fishes, consisting of dentine and enamel.



- **Parrot fishes** have beaklike mouths with short incisor-like teeth for breaking off coral and have heavy pavement like throat teeth for crushing the coral.

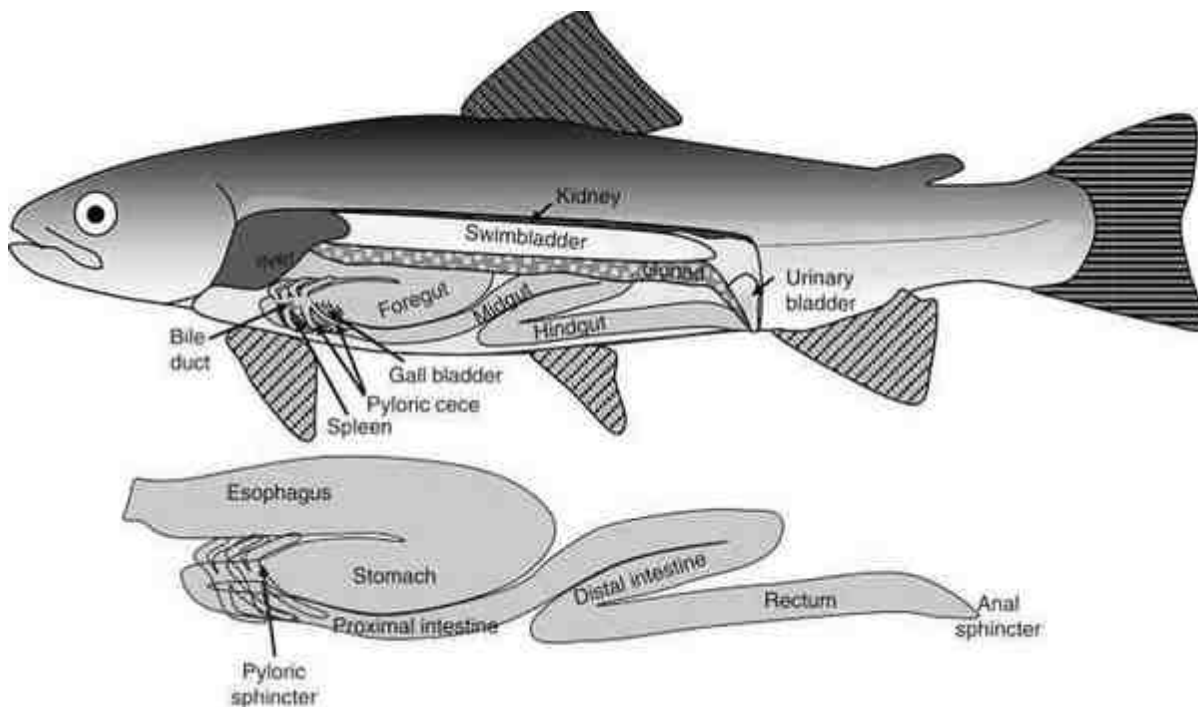


- Some **catfishes** have small brush-like teeth, arranged in rows on the jaws, for scraping plant and animal growth from rocks. Many fishes (such as the Cyprinidae or minnows) have no jaw teeth at all but have very strong throat teeth.

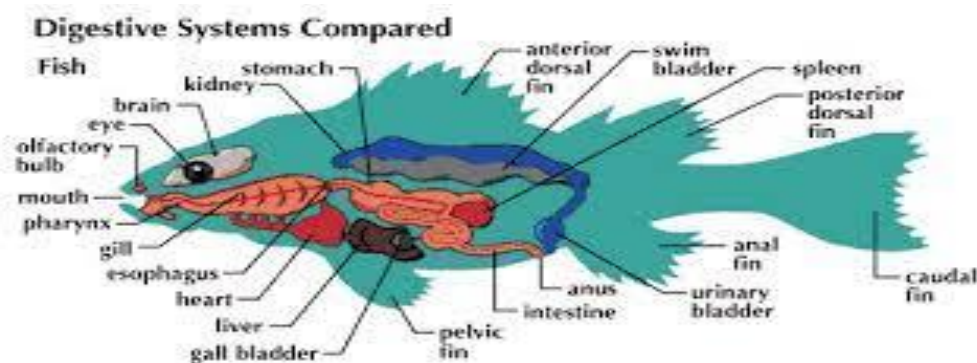


- Some fishes gather planktonic food by straining it from their **gill cavities** with numerous elongate stiff rods (gill rakers) anchored by one end to the gill bars.
- The food collected on these rods is passed to the **throat**, where it is swallowed.

- Most fishes have only **short gill rakers** that help keep food particles from escaping out the mouth cavity into the gill chamber.
- Once reaching the throat, food enters a short, often greatly distensible **esophagus**, a simple tube with a muscular wall leading into a stomach.



- The **stomach** varies greatly in fishes, depending upon the diet.
- In most predacious fishes it is a simple straight or curved tube or pouch with a muscular wall and a glandular lining.
- Food is largely digested there and leaves the stomach in liquid form.



- Between the stomach and the intestine, ducts enter the digestive tube from the **liver and pancreas**.

- The liver is a large, clearly defined organ.
- The pancreas may be embedded in it, diffused through it, or broken into small parts spread along some of the intestine.
- The junction between the stomach and the intestine is marked by a muscular valve.
- **Pyloric ceca** (blind sacs) occur in some fishes at this junction and have a digestive or absorptive function or both.
- The intestine itself is quite variable in length, depending upon the fish's diet.
- It is short in predacious forms, sometimes no longer than the body cavity, but long in herbivorous forms, being coiled and several times longer than the entire length of the fish in some

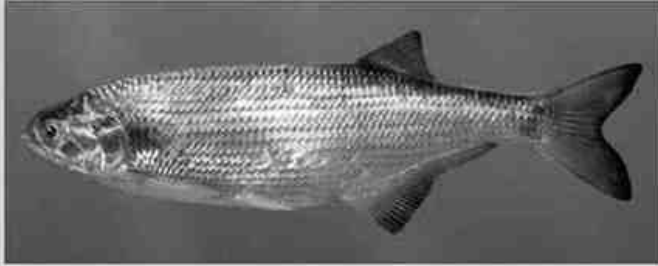
species of **South American catfishes**.

- The intestine is primarily an organ for absorbing nutrients into the bloodstream.
- The larger its internal surface, the greater its absorptive efficiency, and a spiral valve is one method of increasing its absorption surface.
- Sharks, rays, chimaeras, lungfishes, surviving chondrosteans, holosteans, and even a few of the more primitive teleosts have a spiral valve or at least traces of it in the intestine.

Some primitive teleosts

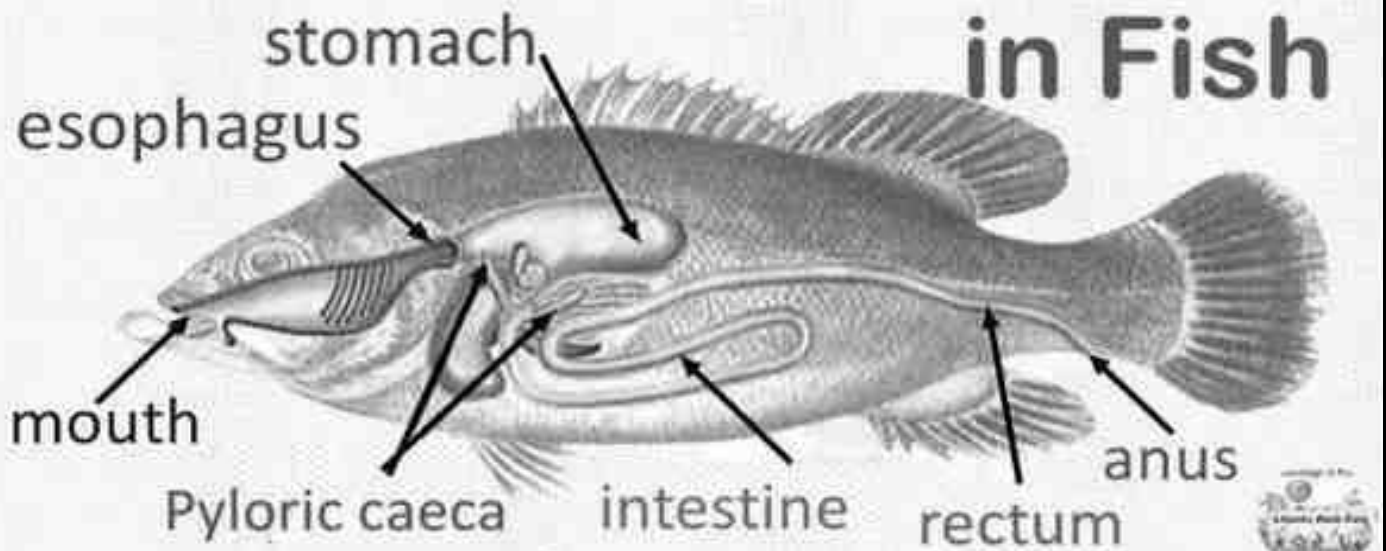


Bony-tongues



- Most modern teleosts have increased the area of the intestinal walls by having numerous folds and villi (fingerlike projections) somewhat like those in humans.
- Undigested substances are passed to the exterior through the anus in most teleost fishes.
- In lungfishes, sharks, and rays, it is first passed through the **cloaca**, a common cavity receiving the intestinal opening and the ducts from the urogenital system.

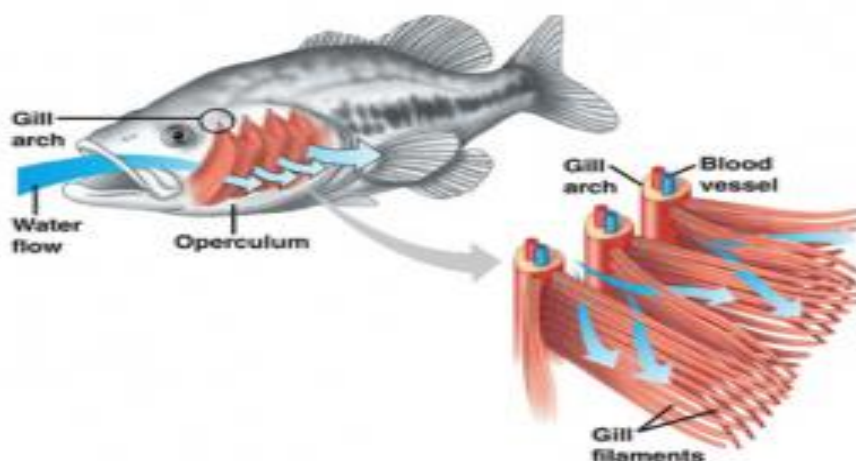
DIGESTIVE SYSTEM in Fish



32 The Anatomy of Fish: Respiratory system

The respiratory system

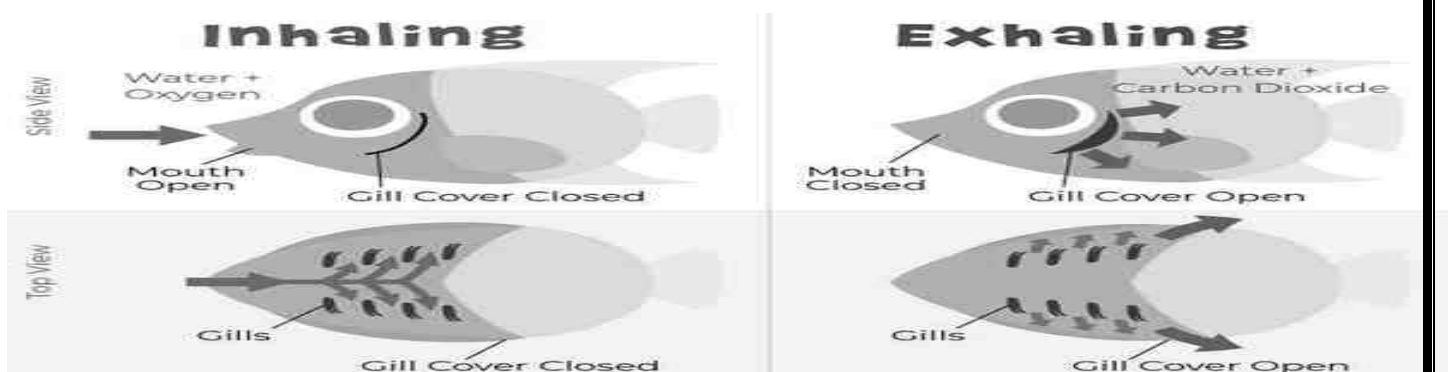
- Oxygen and carbon dioxide dissolve in water, and most fishes exchange dissolved oxygen and carbon dioxide in water by means of the gills.
- The gills lie behind and to the side of the mouth cavity and consist of fleshy filaments supported by the gill arches and filled with blood vessels, which give gills a bright red colour.



- Water taken in continuously through the mouth passes backward between the gill bars and over the gill filaments, where the exchange of gases takes place.
- The gills are protected by a gill cover in teleosts and many other fishes but by flaps of skin in sharks, rays, and some of the older fossil fish groups.
- The blood capillaries in the gill filaments are close to the gill surface to take up oxygen from the water and to give up excess carbon dioxide to the water.
- Most modern fishes have a hydrostatic (ballast) organ, called the swim bladder, that lies in the body cavity just below the kidney and above the stomach and intestine.
- It originated as a diverticulum of the digestive canal.
- In advanced teleosts, especially the acanthopterygians, the bladder has lost its connection with the digestive tract, a condition called physoclastic.
- The connection has been retained (physostomous) by many relatively primitive teleosts.
- In several unrelated lines of fishes, the bladder has become specialized as a lung or, at least, as a highly vascularized accessory breathing organ.
- Some fishes with such accessory organs are obligate air breathers and will drown if denied access to the surface, even in well-oxygenated water.
- Fishes with a hydrostatic form of swim bladder can control their depth by regulating the amount of gas in the bladder.
- The gas, mostly oxygen, is secreted into the bladder by special glands, rendering the fish more buoyant; the gas is absorbed into the bloodstream by

another special organ, reducing the overall buoyancy and allowing the fish to sink.

- Some deep-sea fishes may have oils, rather than gas, in the bladder.
- Other deep-sea and some bottom-living forms have much-reduced swim bladders or have lost the organ entirely.
- The swim bladder of fishes follows the same developmental pattern as the lungs of land vertebrates.
- There is no doubt that the two structures have the same historical origin in primitive fishes.
- More or less intermediate forms still survive among the more primitive types of fishes, such as the lungfishes *Lepidosiren* and *Protopterus*.

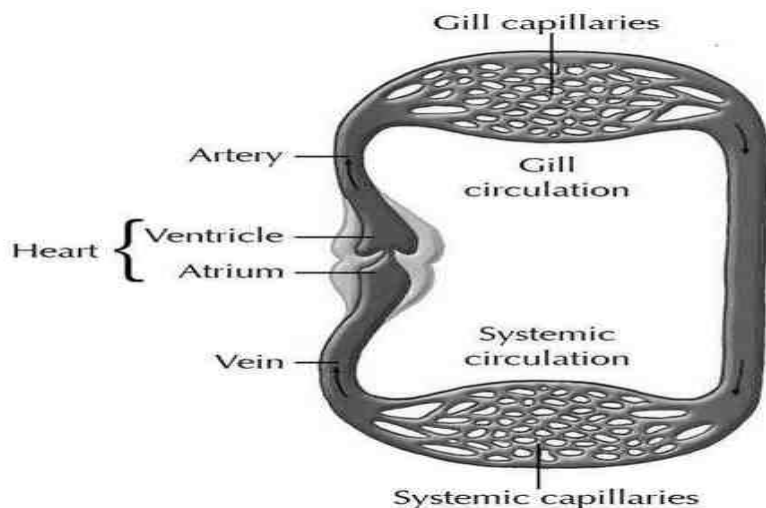


33 The Anatomy of Fish: Circulatory system

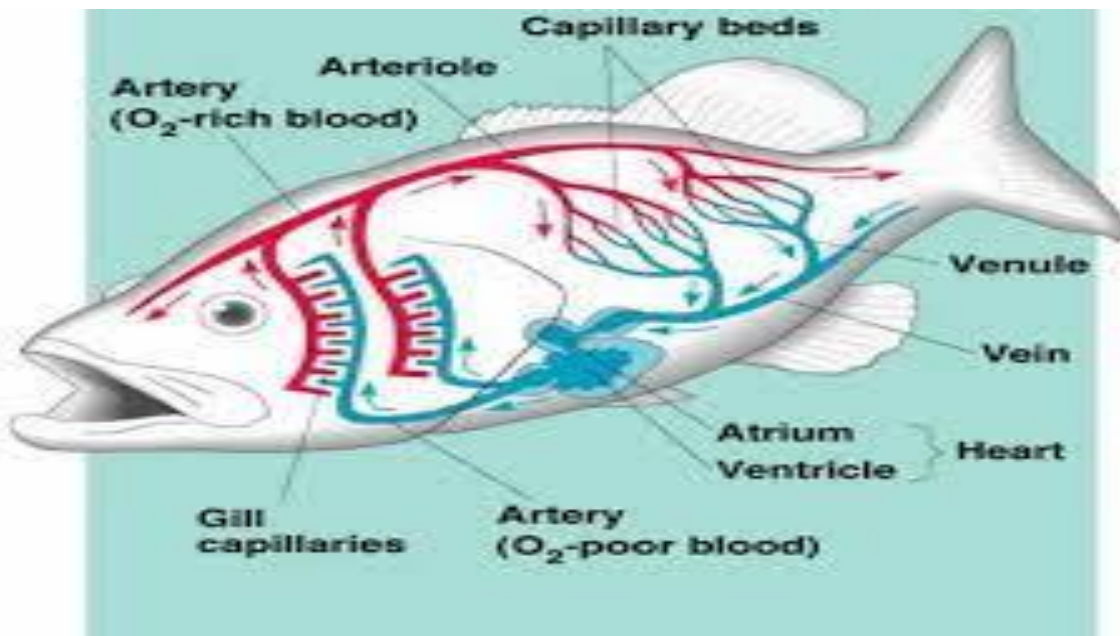
Circulatory System

- The circulatory, or blood vascular, system consists of the heart, the arteries, the capillaries, and the veins.
- It is in the **capillaries** that the interchange of oxygen, carbon dioxide, nutrients, and other substances such as hormones and waste products takes place.

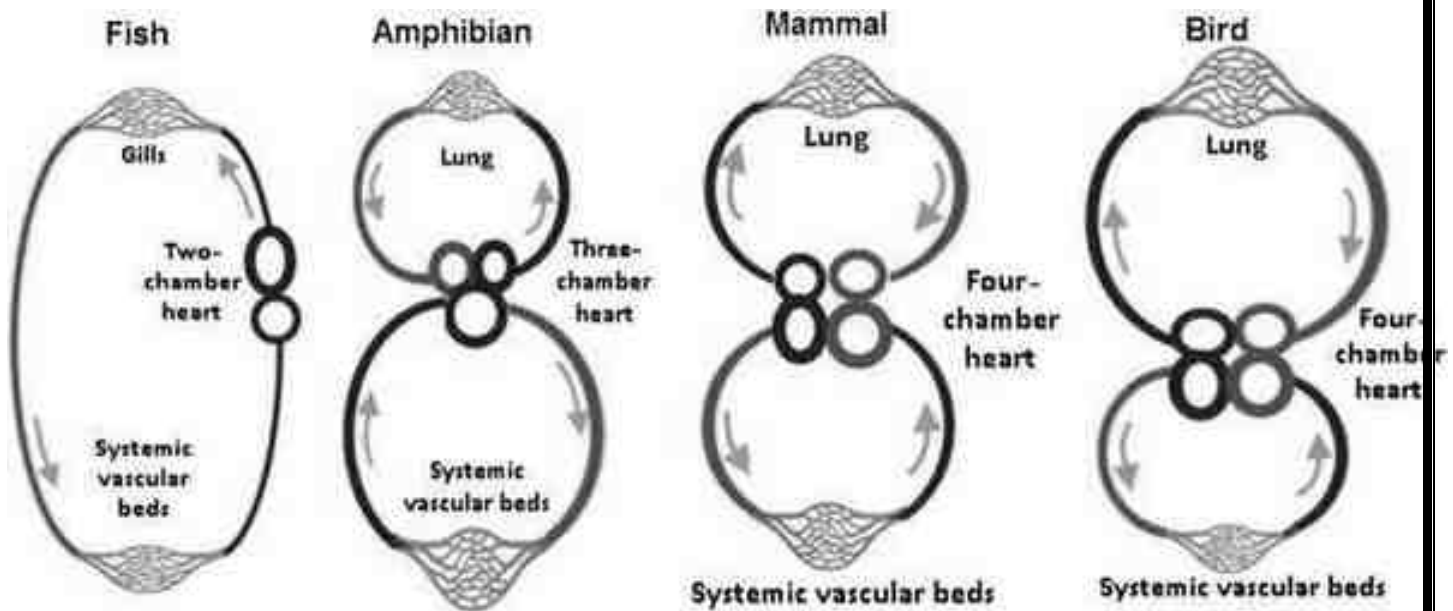
- The capillaries lead to the veins, which return the venous blood with its waste products to the heart, kidneys, and gills.
- There are two kinds of capillary beds: those in the gills and those in the rest of the body.



- The **heart**, a folded continuous muscular tube with three or four saclike enlargements, undergoes rhythmic contractions and receives venous blood in a sinus venosus.
- It passes the blood to an auricle and then into a thick muscular pump, the ventricle.
- From the ventricle the blood goes to a bulbous structure at the base of a ventral aorta just below the gills.



- The blood passes to the afferent (**receiving**) **arteries** of the gill arches and then to the gill capillaries.
- Their waste gases are given off to the environment, and oxygen is absorbed.
- The oxygenated blood enters efferent (exuant) arteries of the gill arches and then flows into the dorsal aorta.
- From there blood is distributed to the tissues and organs of the body. One-way valves prevent backflow.
- The circulation of fishes thus differs from that of the reptiles, birds, and mammals in that oxygenated blood is not returned to the heart prior to distribution to the other parts of the body.

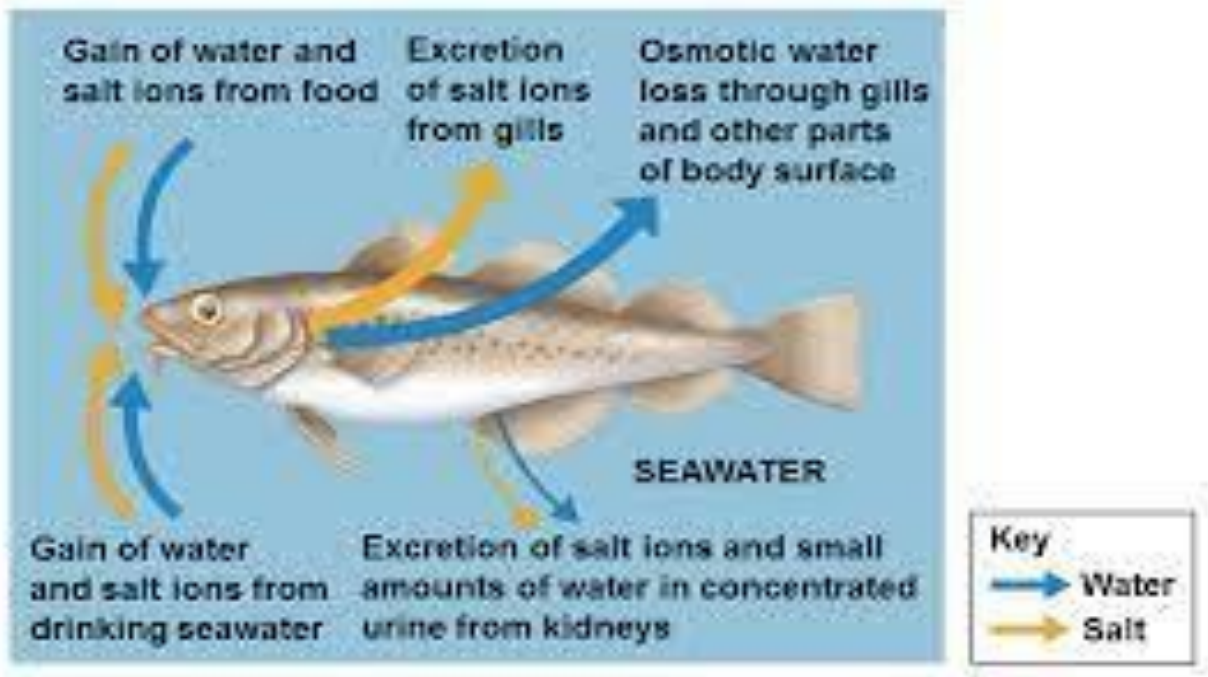


34 The Anatomy of Fish: Osmoregulatory system

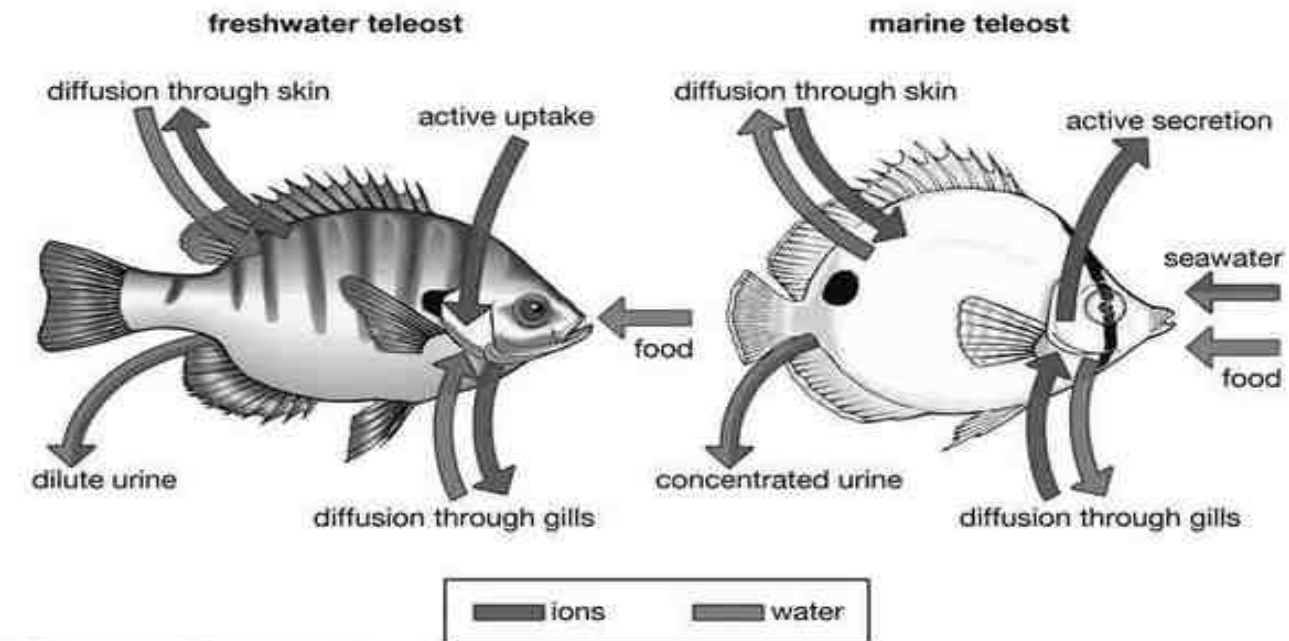
Excretory organs

- The primary excretory organ in fishes, as in other vertebrates, is the **kidney**.
- In fishes some excretion also takes place in the **digestive tract, skin, and especially the gills** (where ammonia is given off).
- Compared with land vertebrates, fishes have a special problem in maintaining their internal environment at a constant concentration of water and dissolved substances, such as salts.
- Proper balance of the internal environment (homeostasis) of a fish is in a great part maintained by the excretory system, especially the kidney.

Marine fish



- **Osmotic regulation in teleost fishes**
- The kidney, gills, and skin play an important role in maintaining a fish's internal environment and checking the effects of osmosis.
- **Marine fishes** live in an environment in which the water around them has a greater concentration of salts than they can have inside their body and still maintain life.
- **Freshwater fishes**, on the other hand, live in water with a much lower concentration of salts than they require inside their bodies.
- Osmosis tends to promote the loss of water from the body of a marine fish and absorption of water by that of a freshwater fish.



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- Mucus in the skin tends to slow the process but is not a sufficient barrier to prevent the movement of fluids through the permeable skin.
- When solutions on two sides of a permeable membrane have different concentrations of dissolved substances, water will pass through the membrane into the more concentrated solution, while the dissolved chemicals move into the area of lower concentration (diffusion).
- The kidney of **freshwater fishes** is often larger in relation to body weight than that of marine fishes. In both groups the kidney excretes wastes from the body, but the kidney of freshwater fishes also excretes large amounts of water, counteracting the water absorbed through the skin.
- Freshwater fishes tend to lose salt to the environment and must replace it.
- They get some salt from their food, but the gills and skin inside the mouth actively absorb salt from water passed through the mouth.
- This absorption is performed by special cells capable of moving salts against the diffusion gradient.

- Freshwater fishes drink very little water and take in little water with their food.
- Marine fishes must conserve water, and therefore their kidneys excrete little water.
- To maintain their water balance, marine fishes drink large quantities of seawater, retaining most of the water and excreting the salt.
- Most nitrogenous waste in marine fishes appears to be secreted by the gills as ammonia.
- Marine fishes can excrete salt by clusters of special cells (chloride cells) in the gills.
- There are several teleosts—for example, the salmon—that travel between fresh water and seawater and must adjust to the reversal of osmotic gradients.
- They adjust their physiological processes by spending time (often surprisingly little time) in the intermediate brackish environment.
- Marine hagfishes, sharks, and rays have osmotic concentrations in their blood about equal to that of seawater and so do not have to drink water nor perform much physiological work to maintain their osmotic balance.
- In sharks and rays the osmotic concentration is kept high by retention of urea in the blood. Freshwater sharks have a lowered concentration of urea in the blood.

35 Hag fish

- Kingdom: Animalia
- Phylum: Chordata
- Infraphylum: Agnatha

- Superclass: Cyclostomi

- Class: Myxini

- Order: Myxiniformes

- Family: Myxinidae

- Hagfish, of the class Myxini and order Myxiniformes are eel-shaped, slime-producing marine fish (occasionally called slime eels).

- They are the only known living animals that have a skull but no vertebral column, although hagfish do have rudimentary vertebrae.

- Along with lampreys, hagfish are jawless; the two form the sister group to jawed vertebrates, and living hagfish remain similar to hagfish from around 300 million years ago.



Body features

- Hagfish have elongated, eel-like bodies, and paddle-like tails.

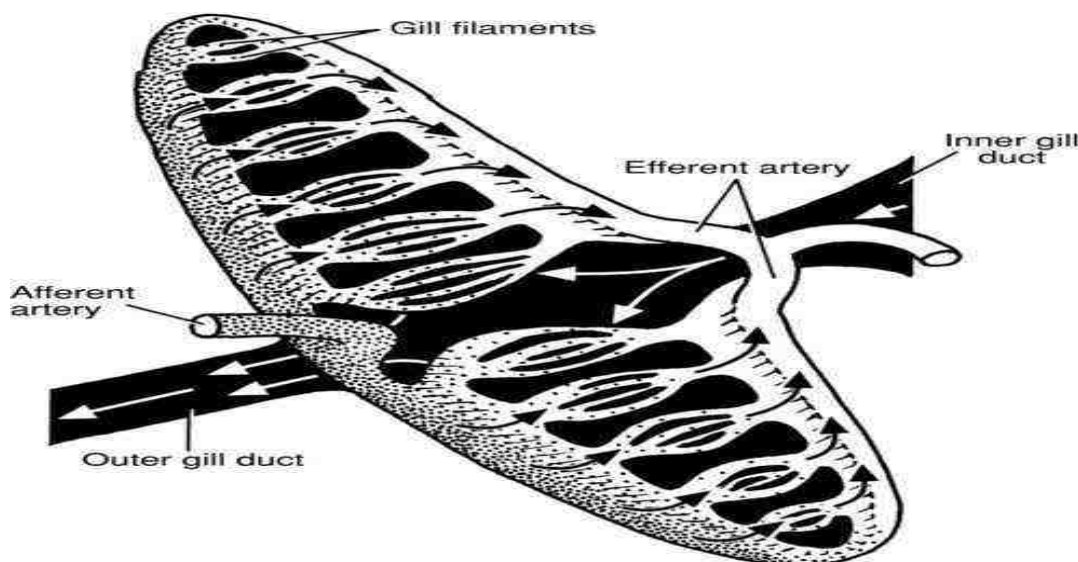
- The skin is naked and covers the body like a loosely fitting sock. They are generally a dull pink color and look quite worm-like.
- They have cartilaginous skulls (although the part surrounding the brain is composed primarily of a fibrous sheath) and tooth-like structures composed of keratin.
- Colors depend on the species, ranging from pink to blue-grey, and black or white spots may be present.
- Eyes are simple eyespots, not lensed eyes that can resolve images.
- Hagfish have no true fins and have six or eight barbels around the mouth and a single nostril.
- Instead of vertically articulating jaws like Gnathostomata (vertebrates with jaws), they have a pair of horizontally moving structures with tooth-like projections for pulling off food.
- The mouth of the hagfish has two pairs of horny, comb-shaped teeth on a cartilaginous plate that protracts and retracts.
- These teeth are used to grasp food and draw it toward the pharynx.

Respiration

- A hagfish generally respire by taking in water through its pharynx and bringing the water through the internal gill pouches, which can vary in number from five to 16 pairs, depending on species.
- The gill pouches open individually, but in Myxini, the openings have coalesced, with canals running backwards from each opening under the skin, uniting to form a common aperture on the ventral side known as the branchial opening.

- The esophagus is also connected to the left branchial opening, which is therefore larger than the right one, through a pharyngocutaneous duct (esophageocutaneous duct), which has no respiratory tissue.
- Hagfish also have a well-developed dermal capillary network that supplies the skin with oxygen when the animal is buried in anoxic mud, as well as a high tolerance for both hypoxia and anoxia, with a well developed anaerobic metabolism.
- The skin has also been suggested to

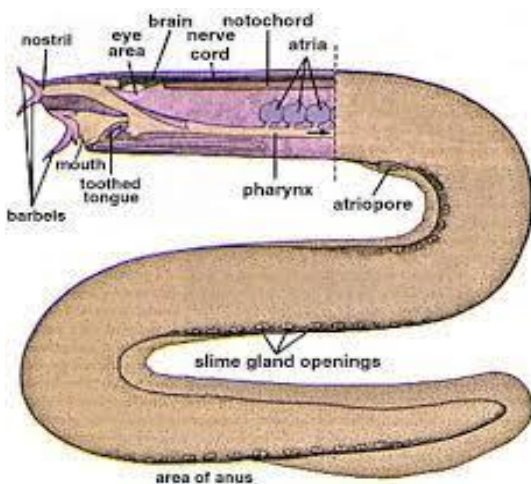
be capable of **cutaneous respiration**.



Nervous system

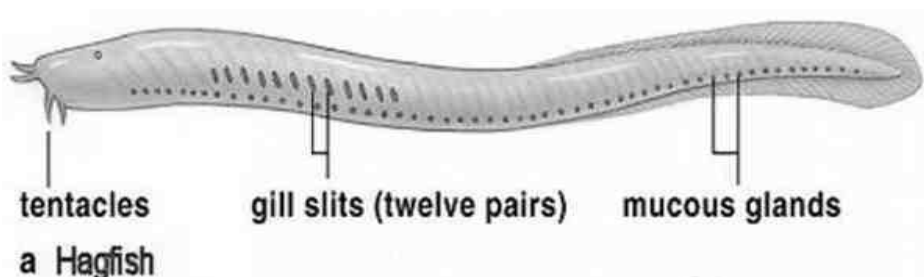
- The hagfish neuroanatomy is similar to that of lampreys.
- A common feature of both cyclostomes is the absence of myelin in neurons.
- The brain of a hagfish has specific parts similar to the brains of other vertebrates.
- The dorsal and ventral muscles located towards the side of the hagfish body are connected to spinal nerves.

- The spinal nerves that connect to the muscles of the pharyngeal wall grow individually to reach them.



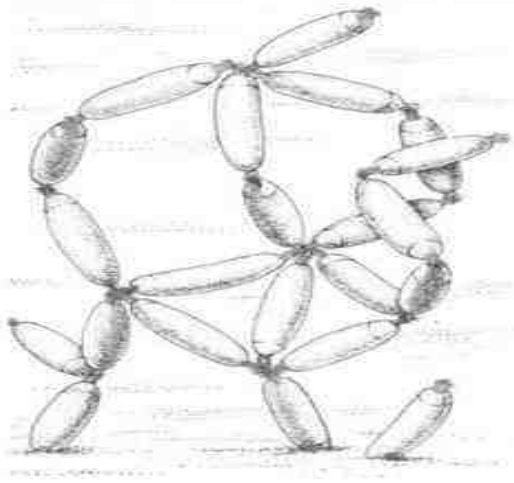
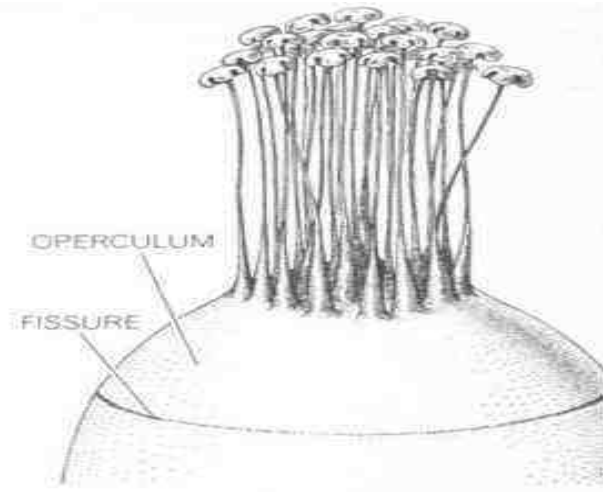
Eye

- The hagfish eye lacks a lens, extraocular muscles, and the three motor cranial nerves (III, IV, and VI) found in more complex vertebrates, which is significant to the study of the evolution of more complex eyes.
- A parietal eye is also absent in extant hagfish.
- Hagfish eyespots, when present, can detect light, but as far as it is known, none can resolve detailed images.
- In Myxine and Neomyxine, the eyes are partly covered by the trunk musculature.



Reproduction

- Both ovaries and testes are present but only one is functional
- Female lays large sausage shaped (2-3cm) eggs numbering 20-30.



36 Carp (*Cyprinus carpio*)

Domain: Eukarya
 Kingdom: Animalia
 Phylum: Chordata
 Class: Actinopterygii
 Order: Cypriniformes
 Family: Cyprinidae
 Genus: *Cyprinus*
 Species: *C. carpio*



Habitat

- Carp, widely, any of several fish species classified in the genus *Cyprinus* in the family Cyprinidae but usually, and narrowly, the common, or European, carp (*Cyprinus carpio*) and its close relatives within the genus *Cyprinus*.

- The carp is a hardy greenish brown fish.
- It is native to Eurasia but has been introduced into North America and elsewhere.

Habitat:

- Carp are usually found in still or slowly flowing waters at low altitudes, especially in areas where there is abundant aquatic vegetation.
- They are also found in brackish lower reaches of some rivers and coastal lakes.
- They are capable of tolerating a range of environmental conditions.

Biological features

- They have a greater tolerance of low oxygen levels, pollutants and turbidity than most native fish, and are often associated with degraded habitats, including stagnant waters.
- Changes to water flows, declining water quality and other changes to river habitats over the past few decades have negatively affected many native fish while favoring carp.
- Body bilaterally symmetrical, moderately elongate, its dorsal profile more arched than the ventral profile.
- Head without scale, body with cycloid scale.
- Eyes dorsolateral in position, not visible from outside of head.
- Snout fairly depressed, projecting beyond mouth, without lateral lobe.
- Carp can grow to a very large size, with overseas reports of fish as large as 1.2 meters in length weighing 60kg.

- Pharyngeal teeth in three rows; upper jaw not extending to front edge of eye; simple (unbranched) dorsal fin rays three or four, color bluish on black, silvery on flanks and belly shading to golden yellow.



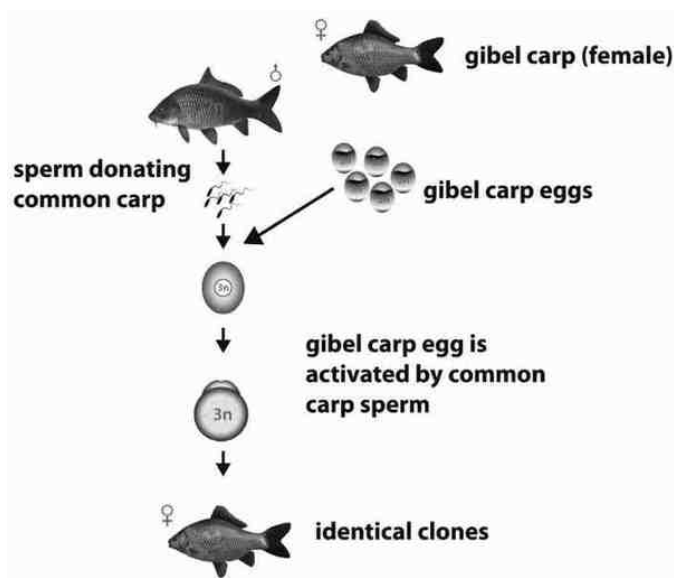
Feeding

- Carp are omnivorous, and their diet varies depending on what is available.
- They consume a range of small food items such as molluscs, crustaceans, insect larvae and seeds.
- These food items are sucked up (along with mud and water) from the bottom and filtered out using the gill rakers.
- They can also consume plant material and general organic matter, especially when other food sources are not available (during winter, for example).
- Carp rarely eat fish, but may consume fish eggs and larvae and disturb breeding sites.
- Adult carp have no natural predators.
- Large predatory native fish, such as Murray cod, golden perch and bass, may consume juvenile carp, although it appears they are not a favored prey item.

Reproduction

- Under suitable conditions, carp are highly prolific.

- They mature early – as early as 1 year for males and 2 years for females – and the females produce large numbers of sticky eggs (up to 1.5 million for a 6kg fish).
- Carp migrate to and from breeding grounds during the breeding season, sometimes travelling hundreds of kilometers.
- Most eggs and larvae die before they reach adulthood, although more may survive if environmental conditions are suitable.
- Floods seem to provide especially favourable conditions for carp breeding as well as abundant food for juveniles.
- This may help explain why carp experienced such a population explosion during the large floods of the 1970s.



Impacts of carp

- Carp are widely believed to have detrimental effects on native aquatic plants, animals and general river health, particularly through their destructive feeding habits.

- **Reduced water quality:** Carp contribute to poor water quality by uprooting vegetation and stirring up sediments during feeding, leading to increased turbidity.
- This in turn reduces light penetration, which can also decrease plant growth, and suspended sediments can smother plants and clog fishes' gills.
- **Algal blooms:** There have been suggestions that carp may increase the likelihood of algal blooms by preying on animals that eat algae, stirring up nutrients trapped in bottom sediments, damaging aquatic plants, and reducing plant growth via greater turbidity. However, carp densities may have to be very high to significantly increase the likelihood of an algal bloom.
- **Erosion:** Carp feeding habits can undermine river banks leading to the collapse of banks and vegetation. However, clearing of riparian vegetation, changes to river flows through river regulation, and trampling by livestock are more important factors in bank erosion. Restoration of riparian vegetation can minimize the risk of damage by carp.
- **Impacts on invertebrates:** Juvenile carp feed mainly on zooplankton, but start consuming larger (macro-) invertebrates once they reach around 15 cm in length. There is strong evidence that carp impact on native invertebrates in still waters, but only anecdotal evidence for their impacts in running waters.
- **Impacts on aquatic plants:** Carp have significant effects on native aquatic plants both through direct grazing and through uprooting plants while feeding, leading to a reduction in plant density and biomass. Soft-leaved, shallow-rooted and submerged plants are most likely to be affected.

- **Disease:** In other parts of the world, carp have been associated with the distribution of a range of parasites and fungal, bacterial and viral diseases. However, there have been few disease outbreaks attributed to carp in Australia.
- **Reduction in native fish numbers:** The effects of carp on native fish are not well understood. Negative impacts of carp are thought to include competition for food and habitats and effects on recruitment (population replenishment). However, many native species (such as golden perch, Murray cod, silver perch and freshwater catfish) had experienced well-documented declines even before carp became widespread.

37 Chondrosteian

- **Chondrosteian** are thought to be the most primitive of the ray-finned fishes.
- They were at their greatest diversity during the Paleozoic and Mesozoic eras.
- **Ancestral chondrosteans** had a bony skeleton, but living members, the sturgeons and paddlefishes, have cartilaginous skeletons.
- Chondrosteans also have a tail with a large upper lobe.
- Most **sturgeons** live in the sea and migrate into rivers to breed.
- (Some sturgeons live in freshwater but maintain the migratory habits of their marine relatives.)
- They are large (up to 1,000 kg), and bony plates cover the anterior portion of the body.
- **Heavy scales** cover the tail.
- The sturgeon mouth is small, and **jaws are weak**.

- Sturgeons feed on invertebrates that they stir up from the sea or riverbed using their snouts.
- Because sturgeons are valued for their caviar (eggs), they have been severely overfished.

Shovelnose sturgeons (*Scaphirhynchus platyrhynchus*)



- **Paddlefishes** are large, freshwater chondrosteans.
- They have a large, **paddle like rostrum** that is innervated with sensory organs believed to detect weak electrical fields.
- They swim through the water with their large mouths open, filtering crustaceans and small fishes.
- They are found mainly in lakes and large rivers of the **Mississippi River** basin and are also known from western North America and China

Paddlefish (*Polydon spathula*)



- The second group of actinopterygians (**Neopterygii**) flourished in the Jurassic period and succeeded most chondrosteans.
- Two very primitive genera occur in temperate to warm freshwaters of North America. **Lepisosteus**, the garpike, has thick scales and long jaws that it uses to catch fishes.
- **Amia**s commonly referred to as the dogfish or bowfin.
- Most living fishes are members of this group and are referred to as **teleosts** or modern bony fishes.
- They have a **symmetrical caudal fin** and a **swim bladder** that has lost its connection to the digestive tract.
- After their divergence from ancient marine actinopterygians in the late Triassic period, teleosts experienced a remarkable evolutionary diversification and adapted to nearly every available aquatic habitat.
- The number of teleost species exceeds 20,000.

Bottom fish

- (***Pseudopleuronectes americanus***)



Sarcastic

fringehead

(***Neoclinus blanchardi***)



Yellowtail

snapper

(*Ocyurus chrysurus*)



38 Poisonous fish

Poisonous glands of fishes

- Any specialized gland in some fishes and amphibians that secretes a mucus like substance containing poisonous material or venomous.
- Poisonous glands may occur in cartilaginous fishes as well as bony fishes.
- In cartilaginous fishes it occurs in the skin.
- While in bony fishes these glands are associated with spines on the fins, tail, and gill cover.
- Poisonous glands of fishes are simple or branched structures which use a holocrine method of secreting a mucous like substance.

- **Holocrine method** is a mode of secretion in some exocrine glands in which plasma membrane ruptures releasing the cell cytoplasm into lumen of the gland.
- Poisonous fishes are those which cause poisoning when eaten, in contrast to the venomous fishes like stone fishes which possess venomous spines with which they inflict nasty stings. There are three types of fish poisoning that are common, namely tetrodotoxic, ciguatera and scombroid poisoning

Pufferfish poisoning

- Tetrodotoxic poisoning occurs following the ingestion of pufferfish, boxfish or porcupine fish.
- This is also known as puffer or fugu poisoning.
- The poisoning is due to toxin known as tetrodotoxin which is concentrated in the internal organs such as liver, ovary and intestines.
- The skin also contains some glands which secrete these toxins.
- Usually the body muscles are free of the toxin.



Ciguatera poisoning

- Ciguatera poisoning is due to the consumption of fishes contaminated with ciguatoxin, a toxin which acts as a sodium channel agonist.
- This toxin is produced by a microscopic marine dinoflagellate *Gambierdiscus toxicus* and through the food chain it reaches the fish, mainly the reef fishes.

- The toxin accumulates mainly in the liver and testis of the fish as well as other viscera, while the flesh (muscle) of the fish is much less affected.
- Cooking or storage of the fish has no effect on the toxicity.
- Some of the fishes which have been implicated with ciguatera poisoning are groupers, barracuda, amberjack, sturgeon fish.



Scromboid poisoning

- Scromboid poisoning is a form of food poisoning caused by eating spoiled fish that have undergone toxic changes due to the action of bacteria on the spoilt fish tissue.
- Most cases of poisoning are attributed to the eating of mackerel, mackerel-like fishes, the tunas, etc.
- These are fish which are normally safe to eat, but can become poisonous if prepared wrongly or stored incorrectly.
- If the fish is stored at room temperature or above 20°C for several hours or in the sun they are predisposed to bacterial action.

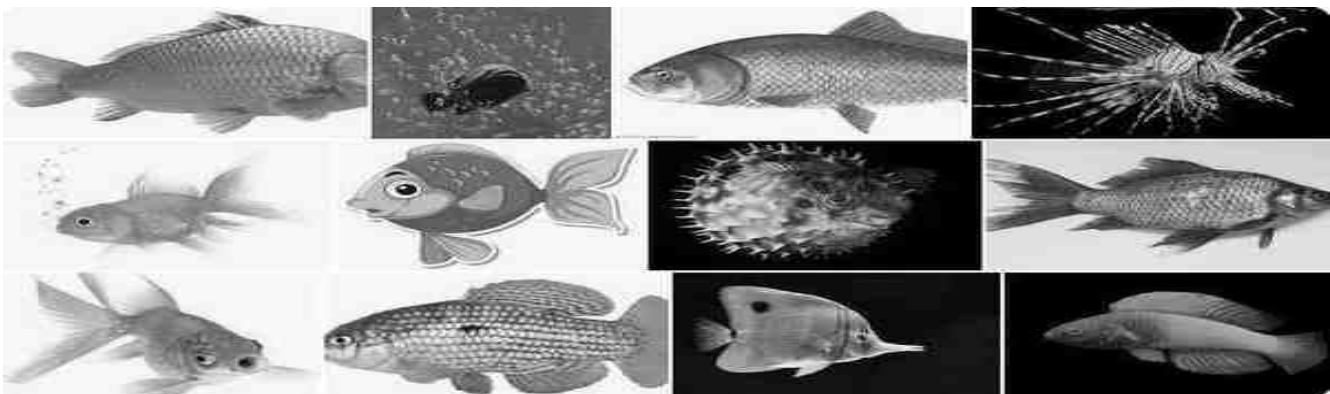
- The bacteria involved include *Proteus morganii* and *P. vulgaris* and also *Clostridium*, *Escherichia*, *Salmonella* and *Shigella* have been implicated.
- These bacteria act on the flesh of the fish and cause an increase in histamine levels in the tissue so that histamine is considered as the major cause of clinical toxic symptoms



Fig 33.12: Bombay Duck (*Harpadon nehereus*)

39 Trophic biology

- Trophic biology is the
- study of fish food and
- feeding habitats.

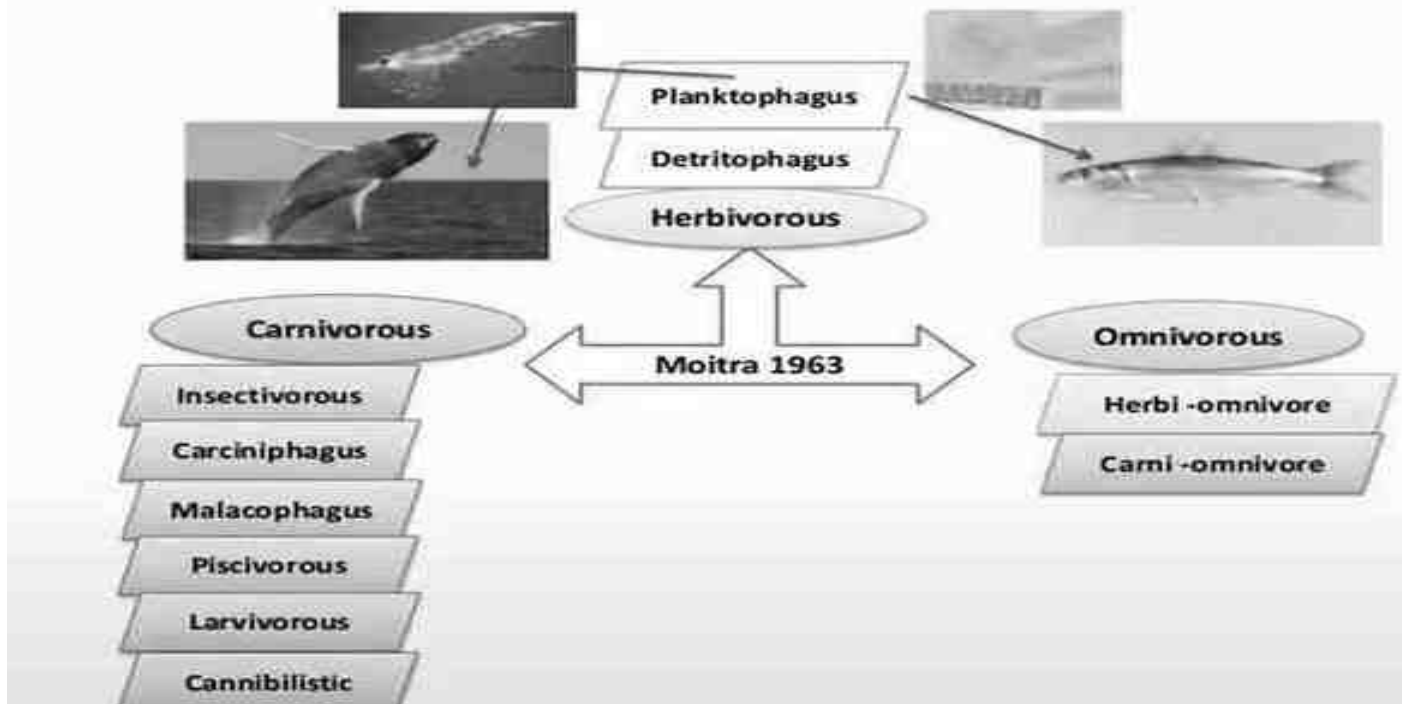


- Fishermen and nutritionists may make the most of feed
- by knowing the feeding behaviors, processes, and mechanisms.
- The study of fish diets in their natural environments contributes

- to our understanding of growth,
- abundance,
- productivity of organisms.
- Continuous research is being done
- on the topic of understanding:
 - How fish feed?
 - What they eat?
- For the farmers, the pellets' physical quality is of utmost significance.
- The pellet must have the proper sinking rate,
- Be able to resist storage,
- And not crumble or release fat.
- The meal must have the necessary nutritional composition,
- Be easily digested, and
- Attractive to the fish.



40 Feeding groups of fishes



- Classification of fish on the basis of feeding habitats
- Basic eating groups among fish are:

Carnivores

- Fish exclusively consume animal matters as food.

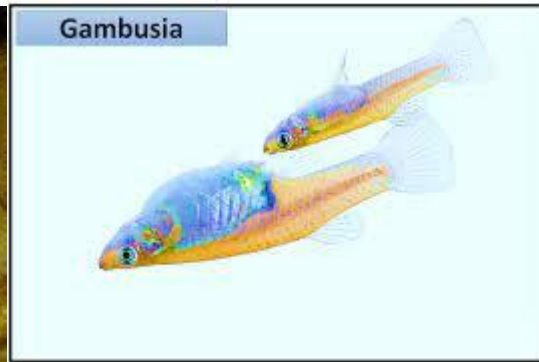
Herbivores

- Fish exclusively consume plant matters as food.



Parrotfishes are among the most important herbivores on the Mesoamerican Reef.

- **Omnivores**
- Fish consume both plant and animal matters as food.
- **Larvivores**
- Fish exclusively consume insect larvae as food.



- **Planktivorous**

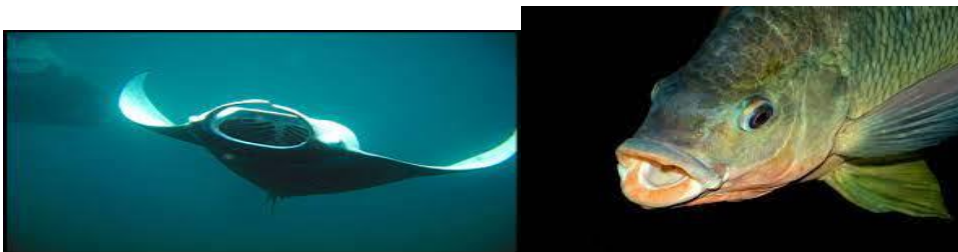
- Fish exclusively consume plankton as food.

- **Voracious**

- Fish consuming or craving large quantities of food.

- **Detritovores**

- Fish consume decaying plants and animals.



- ❑ **Cannibalistic**

- Cannibalism is the act of consuming another individual

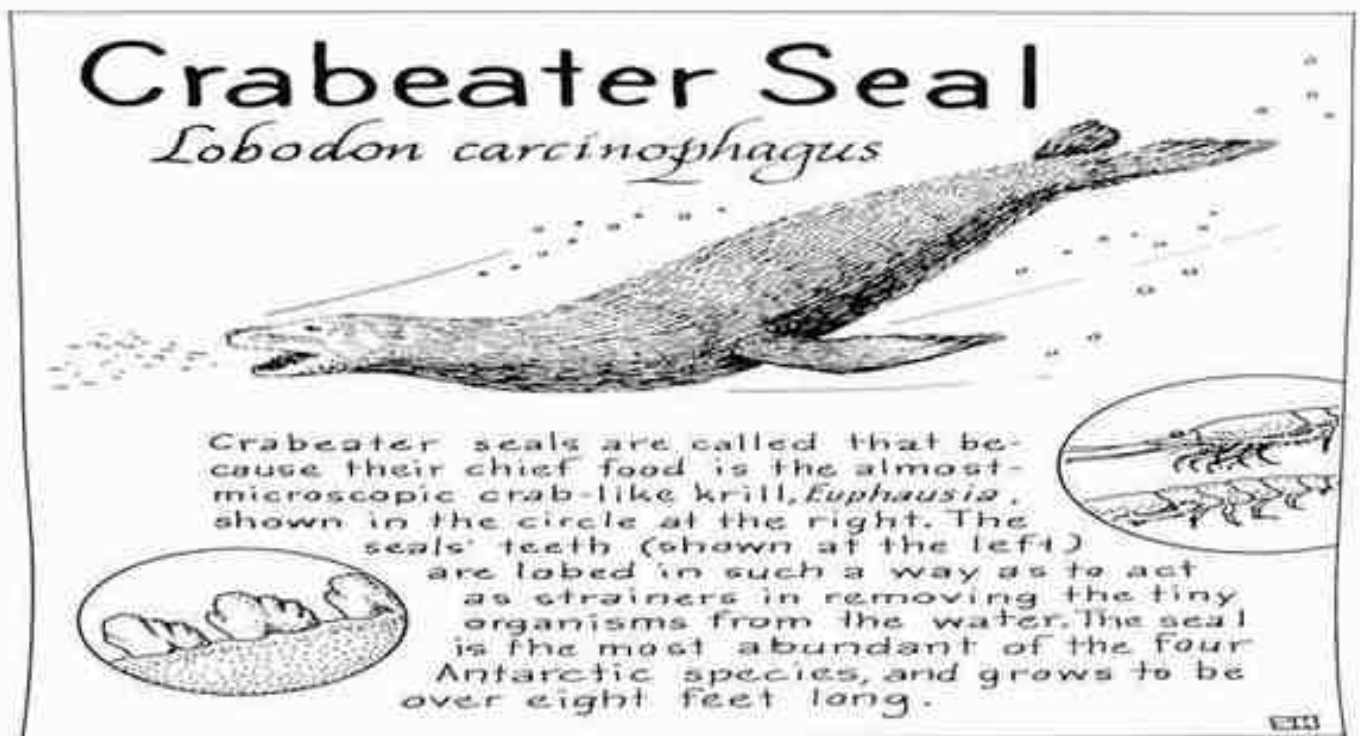
of the same species as food.

- ❑ **Piscivores**

- A piscivore is a carnivorous animal that eats primarily fish.



❑ Carcinophagus

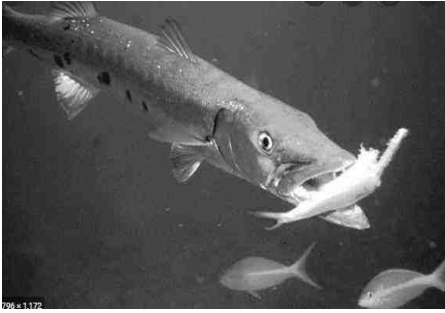


41 Carnivorous fish

❖ Carnivores

- Carnivores are fish that consume animal matters as food.
- While they will never harm plants.
- If a carnivore is kept in an aquarium with smaller fish, those fish will eventually find their way into the stomach of the carnivore.

- Their digestive track is developed to handle large pieces of meat and
- Have room for a whole fish in their stomach.



- Most carnivorous freshwater fish have predatory instincts, but that doesn't mean that they are all aggressive and/or territorial.
- There are some gentle-giants and some speedy & stealthy species among freshwater carnivores.
- Predatory fish such as sharks, mahi-mahi, billfish, and tuna form a part of the human diet and are targeted by fisheries, but they tend to concentrate significant quantities of mercury in their bodies if they are high in the food chain, especially as apex predators, due to biomagnification.
- Predators are an important factor to consider in managing fisheries, and methods for doing so are available and used in some places.
- Carnivores need at least 45% of protein in their food, without which they become severely malnourished.



- **Recommended food for the carnivores would be:**

- Carnivores are happiest when they are fed live food like worms.
- Earthworms
- Red worms
- Daphnia
- Tubifex worms
- Shrimps
- Oysters
- Clams and other fish.
- Lean chicken and salmon. These should be cooked, but never fried.

Examples of carnivorous fishes

- salmon
- billfish
- barracuda
- pike
- walleye
- perch
- shark



42 Herbivorous fish

- – Fish exclusively consume plant matters as food.
- – Herbivorous fish most frequently graze,
- – and whether or not they receive regular food,
- – They nip at plant life.
- – Plastic plants are frequently kept in aquariums by aquarists who enjoy herbivores.
- – The aquarium bears the risk of having a badly destroyed garden if real plants are used.
- – A useful method is to plant leafy plants like spinach into the substrate.
- – These will continue to get nip by the fish.
- – Their intestine break down the food because they do not have true stomach as in carnivorous fishes.



- Herbivory is one of the most important processes in maintaining ecological balance on the Mesoamerican Reef.

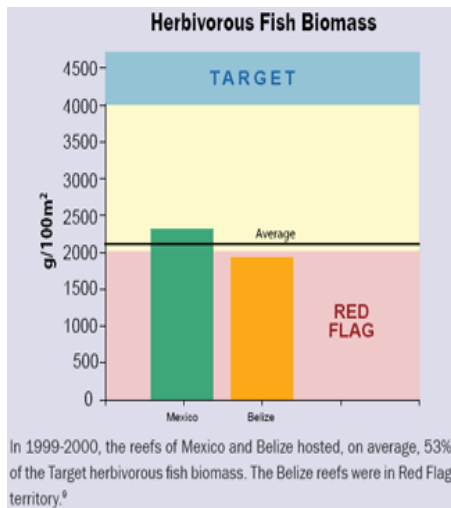
- There, the primary herbivores are Diadema sea urchins

(F12) and large (>30 cm) plant-eating fish.

- By grazing on non-encrusting algae, these herbivores help

keep the algae in check, which in turn helps slow-growing

corals to compete for limited reef space.



- Herbivorous fish feed on the algae that grow on corals and compete with them for light and oxygen.
- By eating the algae, these tiny fish play a big role in the survival of the entire ecosystem.
- Species of these herbivorous fish include: parrotfish, which eat corals that break off the reef and excrete them as white sand; damselfish, which fend off the macro algae growth that kills coral; and surgeonfish, whose most famous representative is Dory from Finding Nemo.
- But corals are quickly losing their greatest allies.
- Populations of herbivorous fish are dwindling, particularly in the Caribbean.
- The overfishing of commercial species is driving artisanal fishermen to capture even the youngest herbivorous fish, preventing those species from replenishing their numbers.
- Recommended food for the herbivores would be:
 - – Vegetable matter
 - – Peas

- – Potatoes
- – Cucumber
- – Sea Food
- – Fresh algae

Types of herbivorous feeding strategies

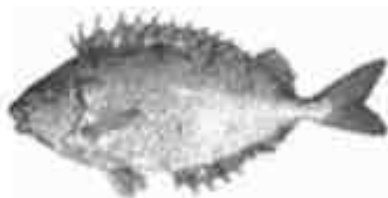
Feeding strategy	Diet
Algivores	Algae
Frugivores	Fruit
Folivores	Leaves
Nectarivores	Nectar
Nucivores	Nuts
Granivores	Seeds
Palynivores	Pollen
Mucivores	Plant fluids, i.e. sap
Xylophages	Wood

• Examples

• Parrotfish

• Damselfish

• Surgeonfish



a) *Siganus fuscescens*



b) *Calotomus japonicus*



c) *Kyphosus bigibbus*



d) *Kyphosus vaigiensis*



e) *Kyphosus pacificus*



f) *Kyphosus cinerascens*

43 Omnivorous fish



- **Omnivores**

- – Fish consume both plant and animal matters as food.
- – Omnivore fish are destructive to plants and
- – other small animals because they will feed just about anything.
- – Additionally, they are voracious eaters.
- – These animals frequently exhibit the urge to overfeed,
- – and when they do, the fat tends to accumulate quickly.

- The mouth is smaller and is usually devoid of teeth except for

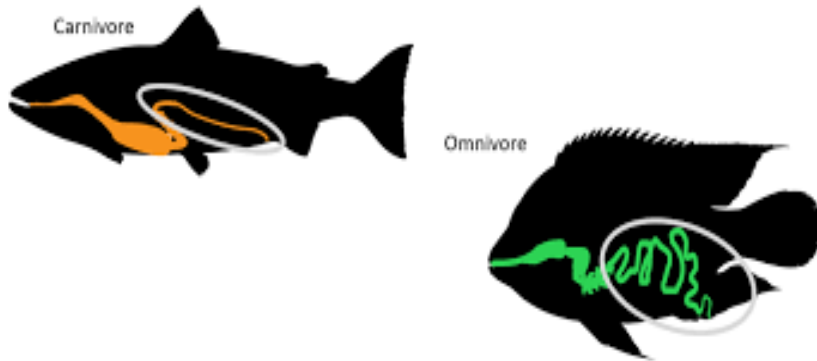
- – pharyngeal teeth that may be blunt and flat (molariform)
- – for grinding or sharp and long for shredding.



- This group of fish ingests both higher proteins and vegetable matter.
- They also comprise the easiest fish to feed as they like almost any type of food; flake foods, live foods and pretty much anything else.

- With the most versatile stomachs,

omnivores' digestive tracts can derive nutrients from a variety of dietary options.



- **Recommended food for the omnivores would be:**

- – Omnivorous fish eat almost anything from vegetable and plant matter to insects,
- – crustaceans and meat proteins
- – a variety of seaweed,
- – Shellfish
- – plankton
- – shrimp
- – macroalgae
- – octopi
- – squid
- – brine and
- – fish smaller than themselves

Examples

- – Angelfish. ...
- – Arowana. ...
- – Cherry Barbs. ...
- – Catfish. ...
- – Discus. ...
- – Goldfish. ...
- – Guppies. ...
- – Mollies.



HERBIVORES, CARNIVORES VS OMNIVORES

Only eat plant materials	Only eat meat	Eat both meat and plant materials
Have complex facial muscles	Reduced facial muscles	Reduced facial muscles
Jaw is above the plane of molars	Jaw on the same plane as molars	Jaw on the same plane as molars
Have Masseter and Pterygoids	Have Temporalis	Have Temporalis
Mouth to head ratio is small	Mouth to head ratio is large	Mouth to head ratio is large
Broad, flat, spoon-shaped incisors	Short, pointed incisors	Short, pointed incisors
Dull, short or long canines	Extremely sharp, long, curved canines	Sharp, long, curved canines
Flat molars with cusps	Long, sharp and curved molars	Long, sharp and curved molars
Very high chewing capacity	Do not chew	Do not chew often
Can detoxify vitamin A	Can not detoxify vitamin A	Can not detoxify vitamin A
Extremely longer intestines	5-6 times of body length intestine	4-6 times of body length intestine
Blat are modified into hooves	Sharp claws	Sharp claws
Long and complex colon	Simple, short and smooth	Simple, short and smooth

Did you know that some fish eat wood?

- Well, bizarre as it sounds, the Panaque genus of fish contains roughly ten species of wood-eaters, while the Hypostomus genus has almost 30. All of these fish rely on ingesting wood to supplement the rest of their diet. In fact, these fish graze on algae that they scrape from driftwood, consuming wood as they do so.



- Panaque nigrolineatus, a Brazilian armoured catfish, is able to eat and digest wood and survive for a long period of time on a wood-only diet.
- It maintains this xylophagous (wood-eating) lifestyle through microbes in its digestive system that digest cellulose and fix nitrogen, but the bacteria have never been studied.

44 Larvivores' fish

- **Larvivores**
 - – Fish exclusively consume insect larvae as food.
 - – Larvivores are specialized on only one type of food
 - – and are referred to as;
 - – Larvivoros
 - – insectivores
 - – mollusks feeders
 - – piscivorous and
 - – Crustacean's eaters.



- Larvivoracious fish are those that feed on immature stages of mosquitoes.

According to Job15, larvivores' fish must be small, hardy and capable of getting about easily in shallow waters among thick weeds where mosquitoes find suitable breeding grounds.

- Fishes like **Gambusia** are introduced into ponds to control the spread of malaria.

- Some fish species eat mosquito larvae and pupae. In disease control policy documents, the World Health Organization (WHO) includes biological control of malaria vectors by stocking ponds, rivers, and water collections near where people live with larvivorous fish to reduce Plasmodium parasite transmission.

- **Recommended food for the Larvivores would be:**

- Mosquito larvae and pupae

- **Examples**

- – dwarf gourami fish
- – Dwarf snakehead fish
- – spotted snakehead
- – striped snakehead



Colisa lalia



Channa gachua



Channa punctatus



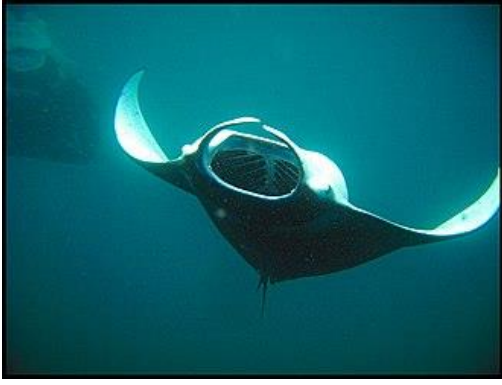
Channa striatus

45 Planktivorous fish

- – Fish exclusively consume phytoplankton and zooplankton as food.
- Plankton are defined as any type of organism that is unable to swim actively against currents and are thus transported by the physical forcing of tides and currents in the ocean.
- – Young forage fish mostly feed on phytoplankton and as they mature they start to consume larger organisms.
- – Older herrings feed on zooplankton, tiny animals that are found in oceanic surface water and fish larvae and fry.
- There is a tremendous diversity of feeding strategies and behaviors that planktivores utilize to capture prey.
- Some planktivores utilize tides and currents to migrate between estuaries and coastal waters; other aquatic planktivores reside in lakes or reservoirs where diverse assemblages of plankton are present, or migrate vertically in the water column searching for prey.



- Planktivore populations can impact the abundance and community composition of planktonic species through their predation pressure, and planktivore migrations facilitate nutrient transport between benthic and pelagic habitats.
- Planktivores are an important link in marine and freshwater systems that connect primary producers to the rest of the food chain. As climate change causes negative effects throughout the global oceans, planktivores are often directly impacted through changes to food webs and prey availability.
- Additionally, harmful algal blooms (HABs) can negatively impact many planktivores and can transfer harmful toxins from the phytoplankton, to the planktivores, and along up the food chain.
- **Recommended food for the Planktivores would be:**
 - – They feed on diatoms and other protozoans by secreting digestive juices into their food to dissolve it.
- **Examples**
 - – menhaden
 - – herrings
 - – Catla catla



46 Voracious fish

- **Voracious**

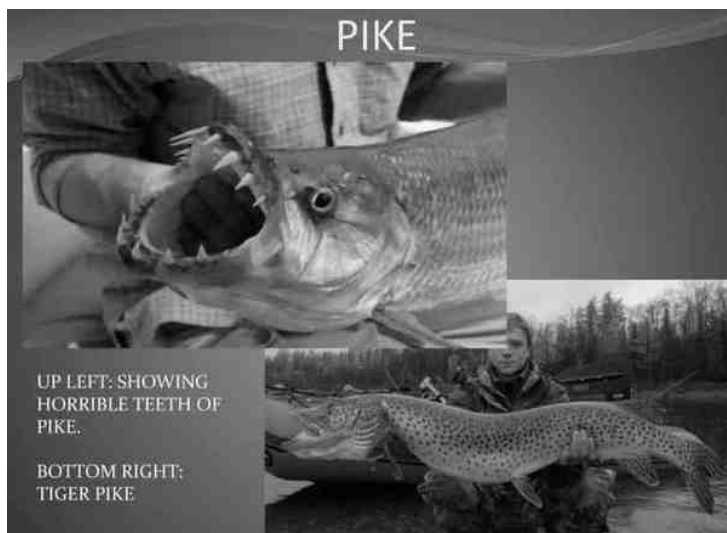
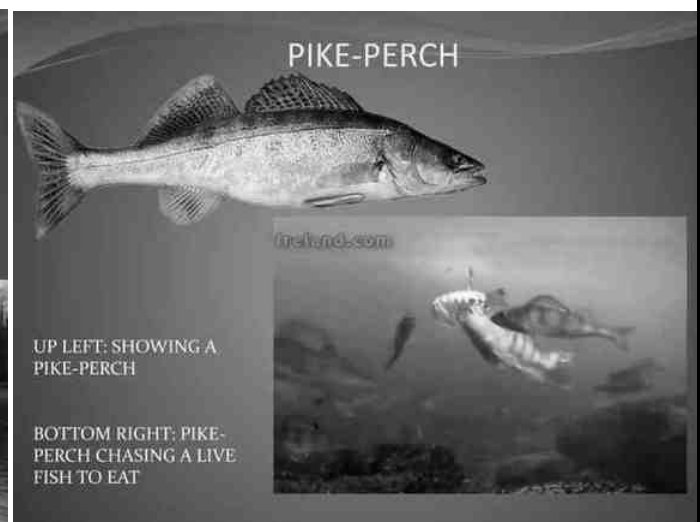
- Fish consuming or craving large quantities of food.
- Having or marked by an insatiable appetite for an activity or pursuit; greedy.
- voracious predators sucking body fluids of many insects or blood of fish , tadpoles and frogs .

- **Recommended food for the voracious would be:**

- – Shark is an active, voracious predator of fish and invertebrates.
- – Eels are various carnivores and consume a variety of fishes.
- – and invertebrates such as worms, crayfish, snails and insects.

- **Examples**

- Piranhas
- Barracuda
- Pike



- **Less voracious fish** are those which:
- In particular are competitors of food
- Get into unprotected ponds
- Get into badly installed water inlets.
- Or if ponds are not maintained; intervals.
- Between drying are too long irregular.
- **Examples**
- *Hemichromis* specie in Africa
- **Black bullhead (*Ictalurus melas*) in Europe**

LESS VORACIOUS FISH

BLACK BULL HEAD



HEMICHROMIS *spcs*



SEA-PIKES.

71

The Barracoota of the West Indies (*Sphyræna barracuda*, Cuv.), is reckoned among the number of marine monsters greedy of human flesh. It is common in the seas that wash those lovely tropical islands, where it attains the length of ten or twelve feet, though it is more generally met with about half that size. The thickness is not in pro-



BARRACOOTA.

portion to the length. The mouth is wide, the lower jaw projects beyond the upper, and is armed with formidable teeth, with two larger pointed canines in front; the upper jaw has many large and strong teeth scattered among minute ones. The two dorsals are placed far apart, the first immediately above the ventrals, the second above the anal. The formula of the fin-rays is as follows: D. 5; 1—9; C. 19; P. 12; V. 1—5; A. 1—9. The tail is much forked. The upper parts are dark greyish brown, becoming paler on the sides, the belly white. It is covered with small thin scales.

This formidable and voracious fish is much dreaded in the seas which it inhabits. It not unfrequently attacks and devours men while bathing; Dutertre affirms that it is even more dangerous than the dreadful shark, inasmuch as noise and motion, so far from intimidating it, only excite it

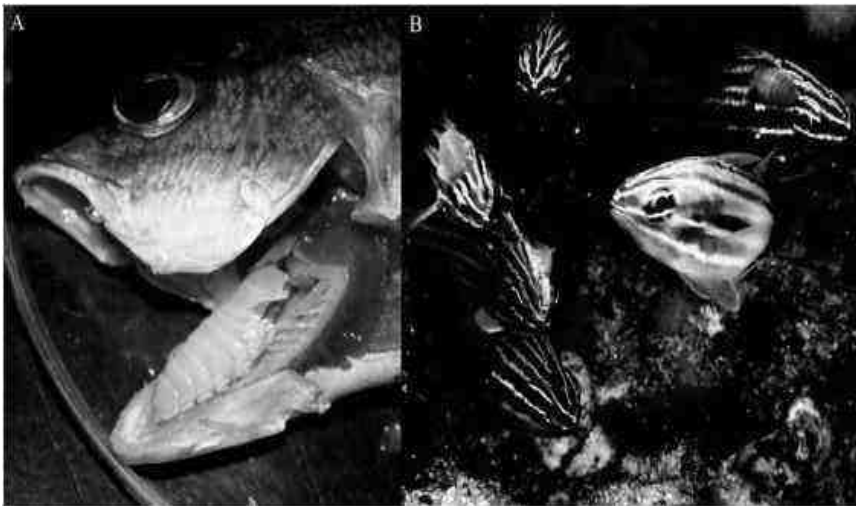
47 Detritivores

- – Fish consume decaying plants and animals matter as food.
- – 10 percent of all fish species
- – feed on decomposing organic matter

- Detritivores may also obtain nutrition by coprophagy, which is a feeding strategy involving the consumption of feces.

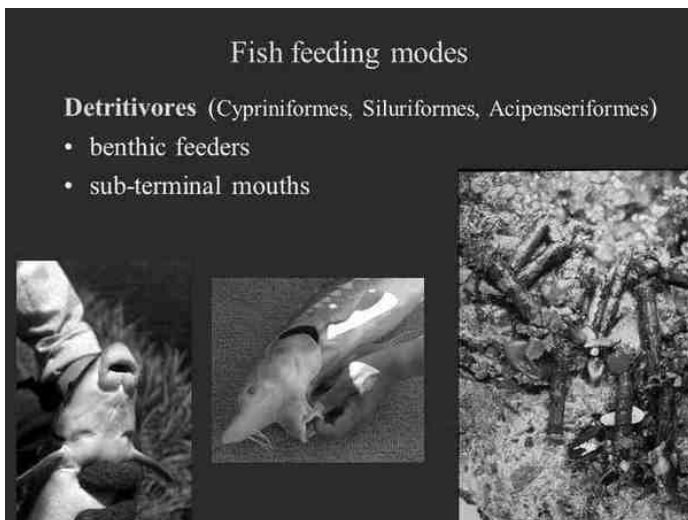
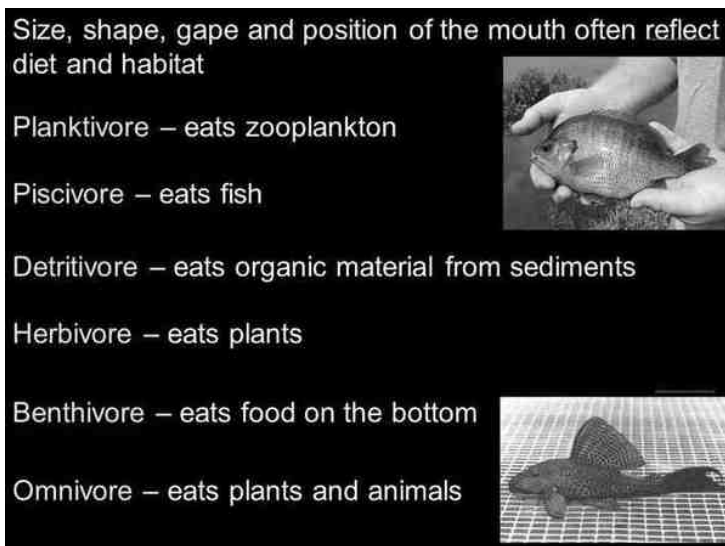
- **Examples**

- – lobsters
- – fiddler crabs

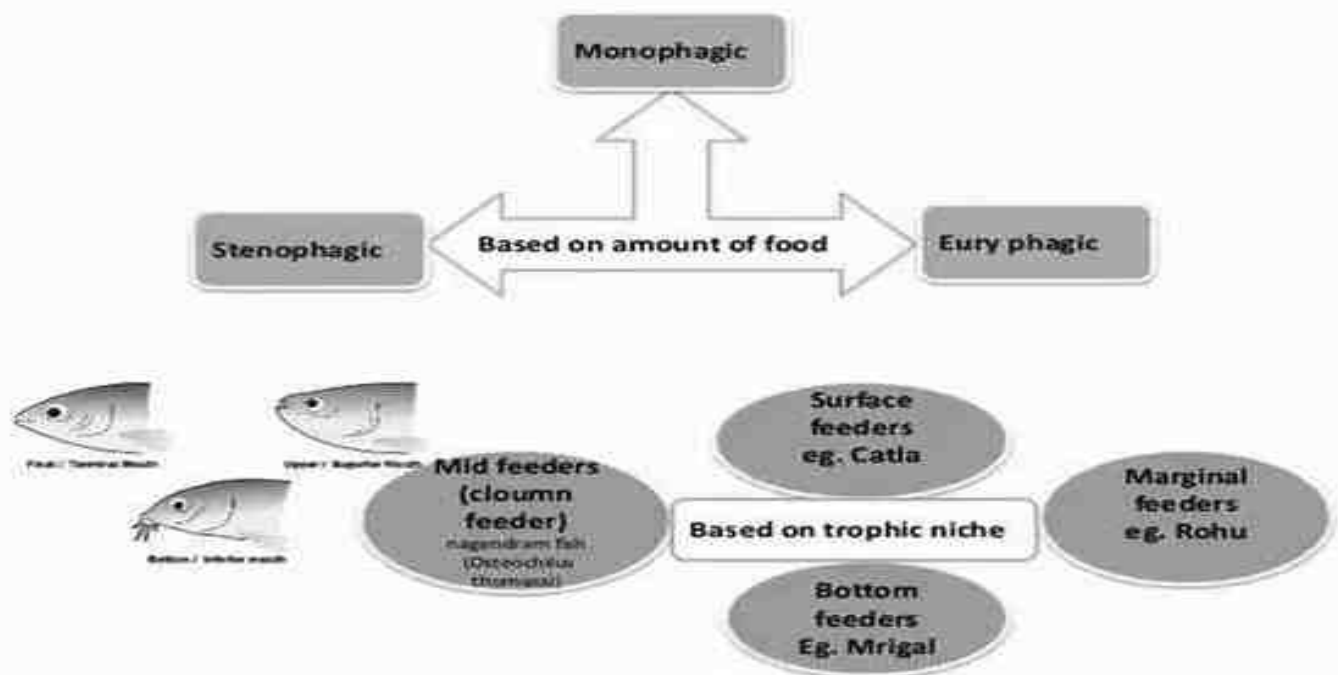


- Detritivorous fishes form an important part of the ichthyomass in the Amazon basin.
- Most of these fishes are contained in the orders Characiformes and Siluriformes (catfishes).
- The Characiformes constitute more than 30% of the total fish yield in the Amazon basin, whereas the catfishes are of minor importance.
- Stable isotope data indicate that Characiformes species receive most of their carbon through food chains originating with phytoplankton, while the Siluriformes receive a significant part of their energy from other plant sources.
- Examples of detritivores in marine environments are crustaceans such as crabs and lobsters, echinoderms such as sea stars or sea cucumbers.

- Many of these marine detritivores occupy a similar niche to terrestrial soil-dwellers, living on or within the seabed known as the benthos.
- These organisms are often called “bottom-feeders”.
- Alternatively in aquatic ecosystems, stationary polychaete worms, barnacles and some corals derive their energy through filter feeding on floating organic detritus called “marine snow”.



48 Surface feeders



- 1. Based on the **characteristics of the food**, fish are divided into the following four groups, viz

Plankton Feeders

- Fish that feed on plankton (phytoplankton and zooplankton) are called plankton eaters.
- Most immature adult fish are usually plankton eater.
- However, some adult fish, such as the Peruvian encovi (Engaruls ringrens) and the Atlantic Menheaden (Bravoortla), rely more on phytoplankton than on zooplankton.
- They feed by sieving through large gill rakers or by mucus secreted from the epibranchial glands.
- In such filtration methods, zooplankton is seldom taken as food. Such eater eats zooplankton like fish larvae.

Herbivorous

- This type of fish eats aquatic plants, flowers, fruits, seeds, leaves and young stems. They also eat algae that grow on rocks or pebbles by mouth using wide lips under their snout.
- Most of the herbivores live in the sea and are specially adapted to eating a variety of foods.
- Some sturgeon fish (Acanthuridae), rabbit fish (Siganidae) and parrot fish (Scaridae) feed on the algae created on the rocks by grazing by their serrated teeth.
- Parrot fish use their beaks and rabbit fish use jaw-cutting nature structures.

Carnivorous

- Carnivorous fish that eat things made from animals such as aquatic invertebrates and vertebrates (fish larvae, fry and small fish mollusks, crustaceans) are called carnivorous fish. Such fish are usually predatory.

Omnivorous

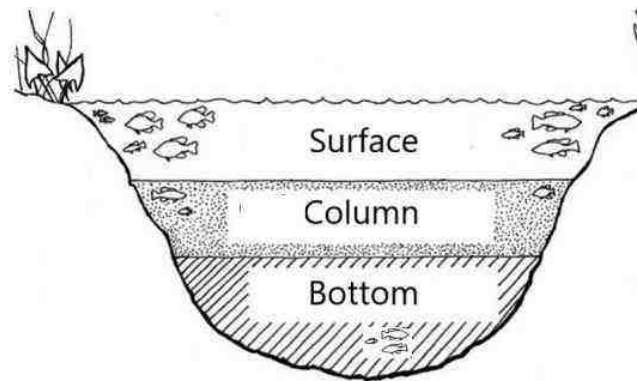
- Fish that feed on both plants and animals are called omnivorous fish.

2. Based on the variety of food choices, Nikolsky (1983) divided fish into the following three groups, viz.

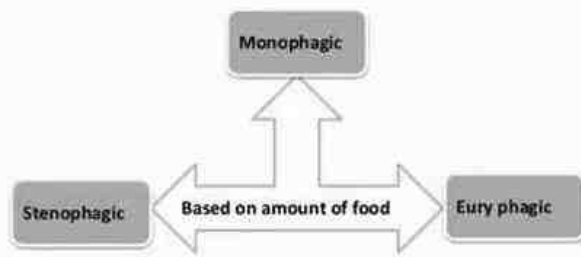
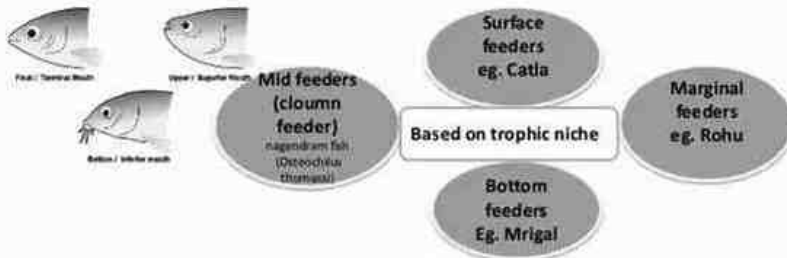
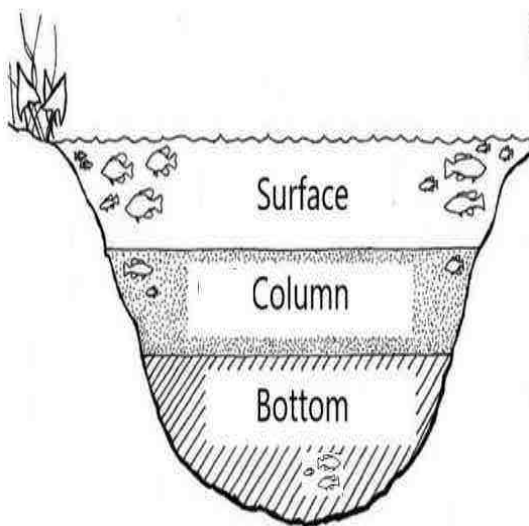
- **(1) Monophagic:** This type of fish eats one kind of food.
- **(2) Stenophagic:** This type of fish eats certain selected foods.
- **(3) Euryphagic:** This type of fish eats a variety of foods.
- **3. Based on the trophic niche in water, fish are divided into the following three groups, viz**

(1) Surface feeders:

- They are plankton-eating in nature.
- Surface feeders typically live in the upper layers of the aquaculture and consume food from the surface.
- Their bodies are long and streamlined, and
- their lips are frequently angled upward to aid in the capture of insects.
- E.g. *Catla catla*, *Rhinomugil corsula*, *Hypoithalamchthys molitris*.



49 Marginal feeders; Column feeders: Middle feeders



• Marginal feeders

- Marginal feeders prefers algae and other submerged vegetation,
- And is primarily a herbivorous column feeder.

• Example:

Rohu

• Column feeders:

- They are carnivorous or omnivorous.
- Such as- Rohu fish- Labeo rohita



Middle feeders (middle-water fish)

- **Middle feeders (middle-water fish)**

- • Middle feeders (middle-water fish) often live in the middle layer of the aquarium
- • and have small, forward-facing mouths
- • Because they eat feed that is placed directly in front of them.
- • **Example:**
- • *Osteochilus thomassi*



50 Bottom feeders (dwellers)

- • **Bottom feeders (dwellers)** are fish that inhabit the lower level of the aquarium or feed off the bottom.
- • Their mouth may be turned down or “under slung”
- • And they may have barbs to help them locate food.

They eat bottom food such as rotten food.

- • **Example:**
- • Barbs, Marigal, Labeo calbasu, Cyprinus carpio, Cirrhina cirrhosus.
- • Some fish do not show a preference for the level of the aquarium.
- • **Example:**
- • Goldfish



51 Predatory fish

- Fish can be divided into the following categories based on the type of prey and swallowing, e.g.

1. Predatory fish

2. Grazers or Browsers

3. Parasites

4. Strainers

5. Suckers

• (1) **Predators**

- Fish that eat large animals as food are called predatory fish.
- They have acquired some general adaptations to take food.
- They have well-developed grasping and holding teeth, such as many sharks (Elasmobranchii), Barracuda (Sphyraena), Pike (Esox), and Gers (Lepisosteus).
- Their intestines tend to be smaller in size than herbivores.
- Many predatory fish such as bluegill (Pomatomus saltarix) and many deep sea fish actively hunt their prey.
- Other fish, such as the grouper (Epinephelus), often sit in wait till an animal passess and then durt out to grasp it.

- Angler fishes (Lophidae and Antennariidae) have developed an anterior ray of the first dorsal fin into a lure to attract their prey.
- The Southeast Asian archer fish (*Toxotes jaculata*) preys on insects by spitting on nearby trees.
- This fish has a well-developed aerial viewing system.
- Some predatory fishes hunt by sight.
- Other fish, especially many sharks (Squaliformes), nocturnal fish such as bullheads (*Ictalurus*) and Morays (*Muraenidae*), catch the prey by ensuring the position of the prey with the help of smell, taste, touch and lateral line organs.

Barracuda (*Sphyraena*)



Predators

• Pike



• Gers

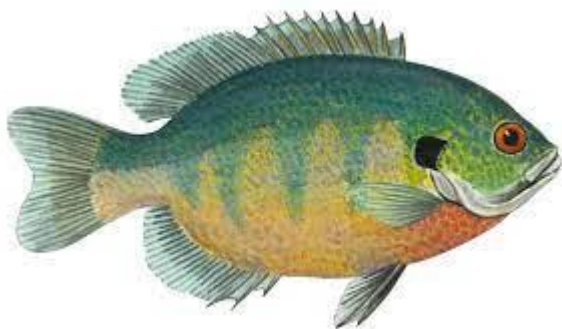


52 Grazers or Browsers Parasites

- 2. Grazers or Browsers
- In most cases, small fish eat food by biting.
- However, sometimes the fish graze alone or in small groups.
- This type of fish take many plankton or bottom animals as food. Bluegills (*Lepomis macrochirus*) often eat the larvae of dipteran insects from the bottom of lakes.
- Many small fish eat plankton-eating fish.
- Parrot fish (Scaridae) or butterfly fish (Chaetodontidae) graze on coral reefs.
- They take pieces of polyps or algae from the coral wall as food.
- Other fish suck on algae or rocks of the same shape if they accidentally fall into their mouths.
- **Parrot fish (Scaridae)**



- **Bluegills**



- **3. Parasites**

- It is perhaps the most unusual and highly evolved feeding habit among animals.
- In this case, one fish gets shelter and food from the other fish.
- Some parasitic fish, such as lamprey (Petromyzonidae) and hagfish (Myxiniidae), make holes in the sides of the host's body to absorb body fluids by sucking.
- Sea lamprey (Petromyzon marinus) of the western North Atlantic and adjacent continents live on the body of the whales as parasite and feed on host's body fluids by sucking.
- Deep sea eel (Simenchelys parasiticus) is also parasitic.
- Some deep-sea male angler (Ceratiidae) fish are mandatory parasites of female fish of the same species.
- In this case, after some time of development, the male finds a female and attaches by his mouth to her body.
- Female fish obligatorily responds by developing a fleshy papillae through which males can absorb nutrients. In this case, the males are relatively small.
- The embryonic nutrient absorption process is seen in the embryos of some baby fish.
- **lamprey (Petromyzonidae)**

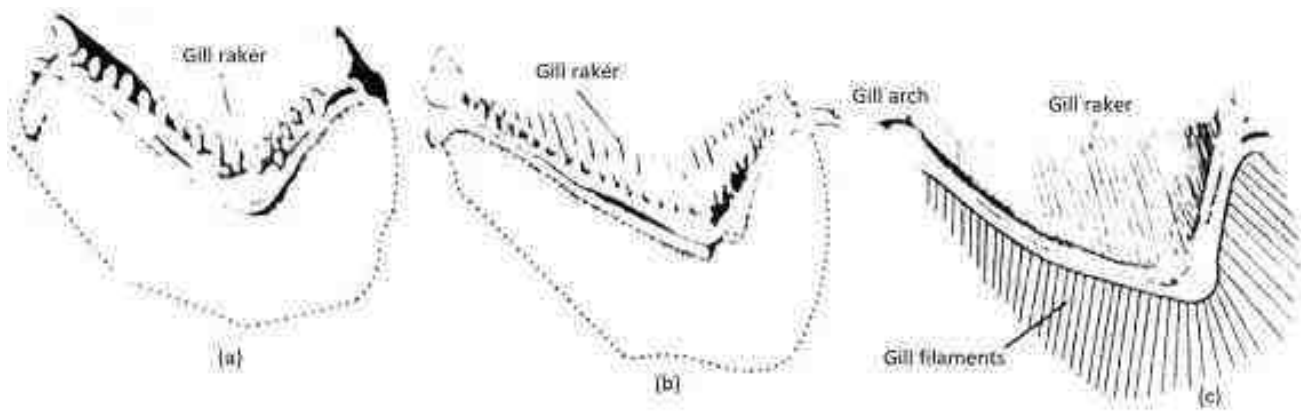


- hagfish (Myxiniidae)

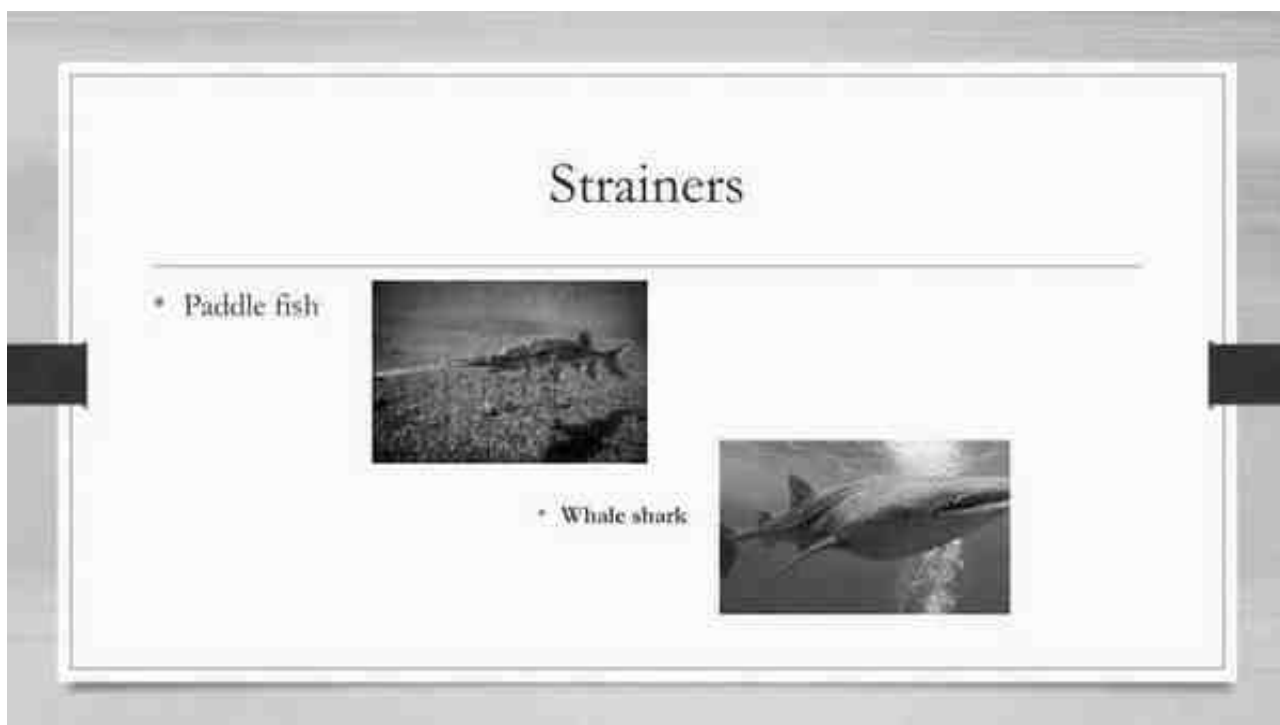


53 Strainers

- 4. Strainers
- In this case, the fish swallows the living creatures that live in the water.
- In this case, the food is selected as size.
- The gills of such fish are very large and are densely packed and form a sieve.
- Large flocks of many herring-like fish such as Gizzard Sads (*Dorosoma*) and Menhaden (*Brevortia tyranus*) swim across the Atlantic coast of the United States toward fertile plankton beds.
- An adult Menhaden is capable of straining as much as 1-2 gallons of water per minute by gill rakers.
- Figure: Relationship of feeding habits with Gill raker; In Figure (a) to (c) the filtering efficiency is gradually increased: (a) Round white fish (*Prosopium cylindraceum*) (b) Lake white fish (*Coregonus clupeaformis*) (c) Black fin sisco (*Coregonus nigripinnis*) [Source: Hubbs and Lagler 1959]



- This fish can hold a few cubic centimeters of plankton, especially diatoms and crustaceans, in this short time.
- Other large fish such as paddle fish (Polyodon), basking shark (Cetorhynchus), whale shark (Rhinocodon typus) have efficient adaptations in food selection or filtering.



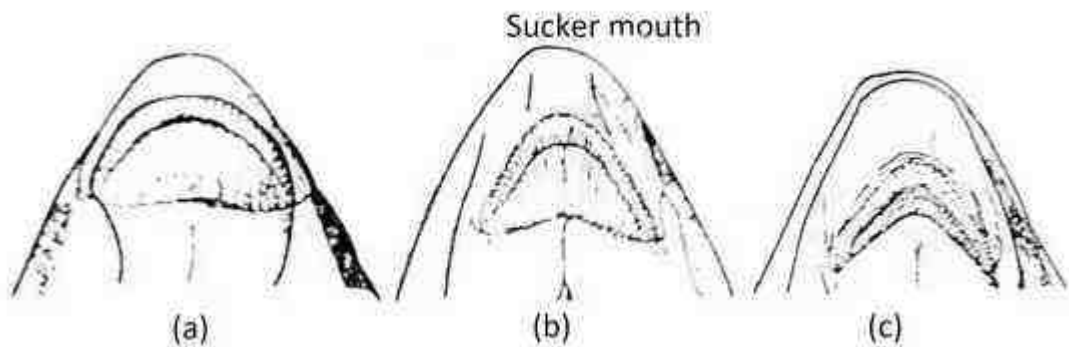
54 Suckers

- 5. Suckers
- In this case, the fish sucks food or food-carrying material inside the mouth.

Bottom-feeding fish such as sturgeon (Acipenseridae) and suckers

(Catostomidae) have similar feeding processes. Old World Minnows such as Fringelips, Labeo and Osteochilus have inferior face and sucking lips. Moreover, some carp (Cyprinidae) species of Southeast Asia have similar structures.

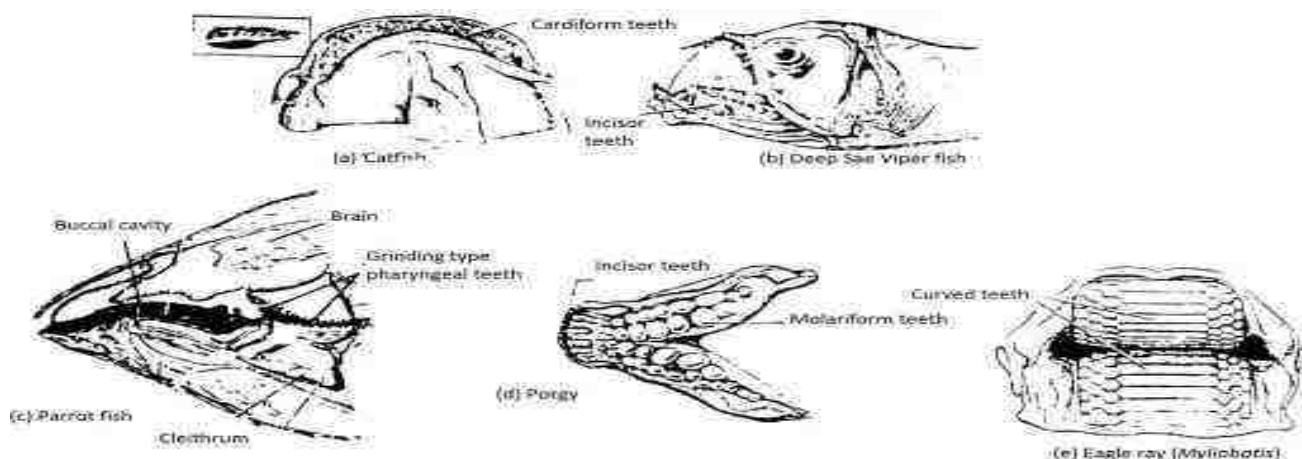
- **Figure: Differences in the development of sucking lips and mouth of three Red Horse Suckers (Myxostoma):** (a) Short head red horse (Myxostoma macrolepidotum) (b) Golden Red horse (M. erythrurum) (c) Silver red horse (M. anisurum) [Source: Hubbs and Lagler 1958]



- In parrot fish, the incisor-like teeth come together to form the incisor lip at the edge.
- This lip bites a piece of algae and brings it to the mouth separately.
- A series of pharyngeal teeth in the mouth break them down, exposing the cells and extracting the cell components with the help of digestive juices.
- Chewing teeth is also able to break down the coral into pieces.
- **Fingerlips**



- Animals of different types and sizes are needed for the food chain.
- Basic animal food ingredients are animal plankton or zooplankton.
- Eggs and larvae of many species, protozoa, microcrustacea and other microscopic invertebrates, fish eggs and larvae include it.
- Large invertebrates such as Annelida, snails, oysters (Mollusca), crustaceans and insects (Arthropoda), all species of vertebrates such as birds, mammals, reptiles, amphibians, fish are all preyed upon as fish food.
- Even small rats, snakes and tortoises can be found in the stomachs of pike (Esox), Lepisosteus or Amia.
- Figure: Fish teeth and positional differences (a) Upper jaw of Flathead Catfish (*Pyloditis olivaris*) (b) Deep sea viper fish (*Chauliodus sloani*) (c) Jaw and pharyngeal teeth in the sagittal section of Parrot fish (Scaridae) (d) Lower jaw of Porgy (Sparidae) (e) Curved teeth in the mouth of Eagle ray (*Myliobatis*)



- Sometimes ducklings and small birds are also seen in the belly of goosfish (Lophius).
- Moreover, frogs are also found in the stomachs of freshwater predatory fish.
- So frogs are used to make bait to catch game fish. Even some fish such as Barracuda (Sphyraena), some sharks, Piranha (Serrasalmus) fish attack humans.
- Bermuda angelfish (Holacanthus bermudensis) change their eating habits as the seasons change.
- They become completely vegetarian in winter and spring and become carnivorous in early summer and monsoon

55 Economic Importance of Fish..(i)

- Fish are aquatic, cold blooded and craniate vertebrates belonging to the super class Pisces under phylum Chordata.
- **Fishery** is a kind of industry which is concerned with the catching, processing or selling of fish, shellfish (molluscs, each has a shell in two halves, used for food, e.g., mussels, oysters, etc.) and crustaceans.



Economic Importance of Fish

- **(i) Fish as food:**

- The fish flesh is an excellent source of protein, has very little fat, carries a good amount of minerals and vitamins A and D and rich in iodine.

- Above all man can digest it easily.

- Some important edible fish of India are given in the Table

- 1. Rohu (*Labeo rohita*)
- 2. Calbasu (*L. calbasu*)
- 3. Catla (*Catla catla*)
- 4. Singhara (*Mystus seenghala*)
- 5. Mangur (*Clarias batrachus*)
- 6. Singhi (*Heteropneustes fossilis*)
- 7. Malli (*Wallago attu*)
- 8. Mirgala (*Cirrhinus mrigala*)



- **(ii) Fish for controlling diseases:**

- Diseases like malaria, yellow fever and other dreadful diseases that are spread through mosquitoes can be controlled.
- Larvivorous fish eat larva of mosquito.
- The important larvivorous fish are Gambusia, Panchax, Haplochitus, Trichogaster, etc.



56 Economic Importance of Fish..(ii)

- (iii) **Scientific value**

- Some fish like the lung fish are of zoological importance because of their discontinuous distribution and anatomical features.

- (iv) **Aesthetic value**

- A large number of fish are cultured in aquarium for their beauty and graceful movements.
- The important aquarium fish are Macropodus, Trichogaster, Carassinus (gold fish) and Pterophyllum (angel fish).

- (v) **Fishery Bye-products:**

- (a) Fish oil:

- It is extracted from the liver of the sharks, sawfishes, skates and rays and has medicinal value. These mainly include cod liver oil and shark liver oil.

(b) Fish Manure:

- The fish waste after the extraction of oil, is used as fertilizers,

(c) Fish Glue:

It is a sticky product, obtained from the skin of the cod and is used as gum.

- (d) Isinglass:
- It is a gelatinous substance, obtained from the air bladder of perches, Indian Salmons and cat fish used in the preparation of special cement and in the clarification of wine and beer.

Fish glue

Fish gelatin and fish glue are more or less same and can be prepared from fish skin and fish head.

If required, fish skin can be preserved by salting and drying before processing into glue however, fish head should be processed fresh.



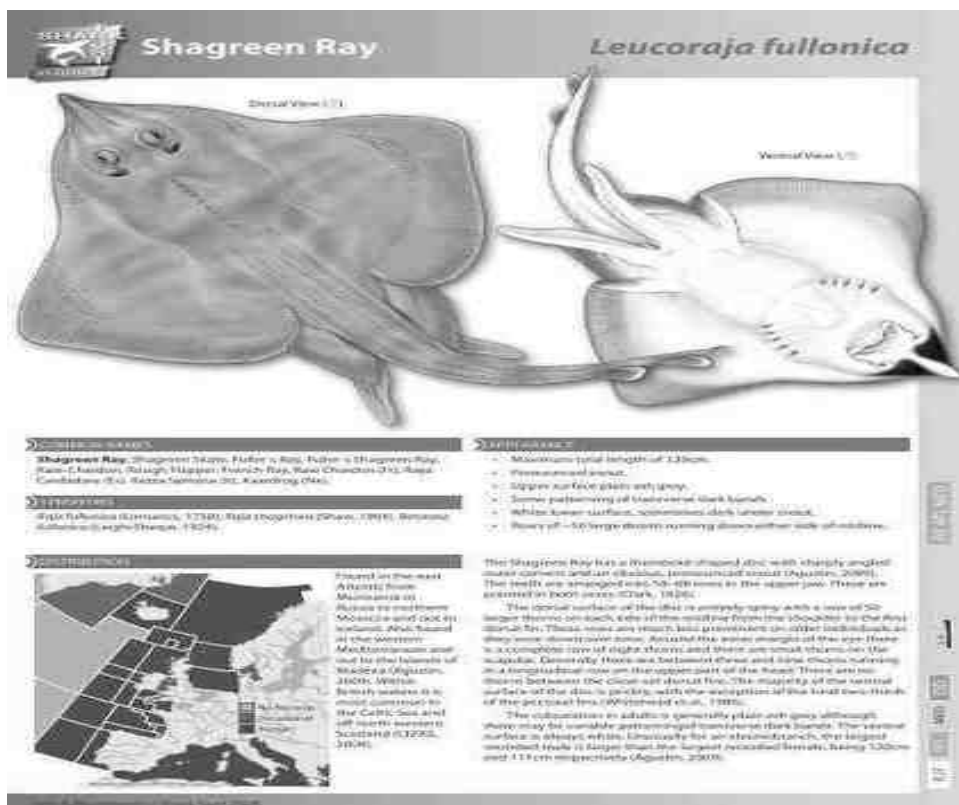
Economic Importance of Fish

- Fish most internationally traded commodity; About 40% global production enters international trade against 10% for meat
- Global trade in fish over \$ 102 billion in 2008
- Exports of fish & products exceed those of meat, dairy, cereals, sugar, coffee, oilseeds, etc.
- In many developing countries foreign exchange from fish exports finances other food imports



(e) Shagreen:

- The skin of sharks and rays, which has pointed and sharp placoid scales are used in polishing the wood and other materials.
- It is also used for covering the jewelry boxes and swords.
- (f) Leather:
 - A highly durable type of leather is prepared from the skin of sharks and rays



(g) Artificial pearls:

- The silvery boney scales of cyprinids (a type of fish) are used in the
- manufacture of artificial pearls especially in France.
- (vi) Employment:
- Development of fishing industry generates more employment opportunities.
- (vii) Source of Income:
- The fishing industry has brought a lot of income to the farmers in particular and the country in general. Now we can talk about “Blue Revolution” (fish production) on the same lines as ‘Green Revolution’ (for producing enough food for all).



57 Types of Fisheries; Inland or Fresh Water ...

- There are two main types of fisheries: Inland fisheries and marine fisheries.

- **Inland or Fresh Water Fisheries:**

- **Marine Fisheries:**

(i) **Inland or Fresh Water Fisheries:**

- Inland fishery deals with the fishery aspects of waters other than marine water.
- Potentially, the vast and varied inland fishery resources of India are one of the richest in the world.
- They pertain to two types of waters, namely, the fresh and the brackish.
- The former includes the country's great river systems, an extensive network of irrigation canals, reservoirs, lakes, tanks, ponds, etc.
- The estuaries, lagoons and mangrove swamps constitute the brackish type of water. In pisciculture (culture fisheries), which generally pertains to small water bodies, the fish seed has to be sown, tended, nursed, reared and finally harvested when grown to table size.
- In the case of capture fisheries, which pertain to the rivers, estuaries, large reservoirs, as well as big lakes, man has only to reap without having to sow some important edible fresh waterfishes of India are given in the table below.

<u>Names</u>	
Rohu (<i>Labeo rohita</i>)	Singhi (<i>Heteropneustes fossilis</i>)
Catla (<i>Catla catla</i>)	Malli (<i>Wallago attu</i>)
Mangur (<i>Clarias batrachus</i>)	Mirgala (<i>Cirrhinus mrigala</i>)
Singhara (<i>Mystus seenghala</i>)	Calbasu (<i>L. calbasu</i>)

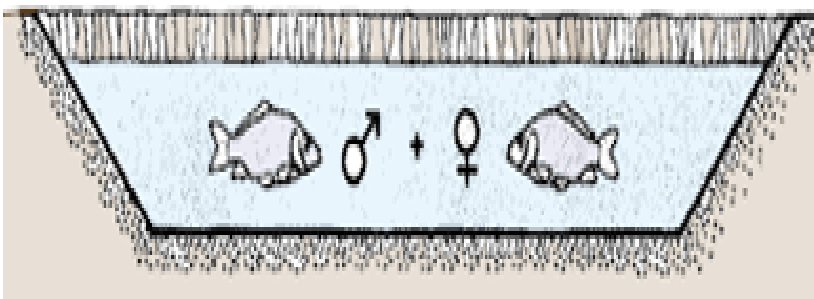
- **Types of Breeding:**

- According to the mode of breeding there are two categories, natural breeding and induced breeding.

- **(i) Natural Breeding**

- The natural bundhs are special types of ponds where natural water resource conditions are managed for the breeding of culturable fish.
- These bundhs are constructed in large low-lying areas to accumulate large quantity of rain water.
- These bundhs are having an outlet for the exit of excess rain water.

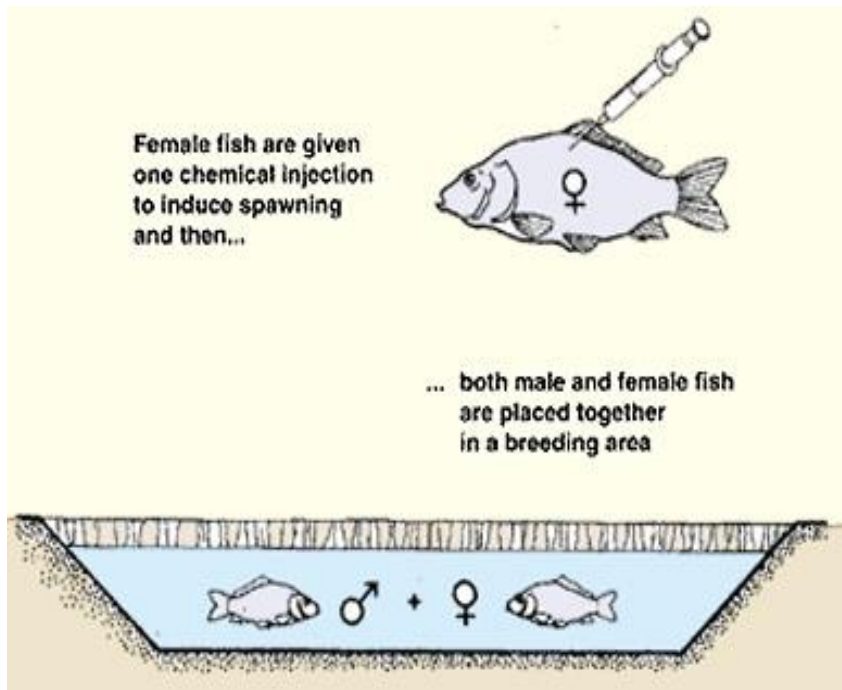
Male and female fish
are placed together
in a breeding area



- **(ii) Induced Breeding**

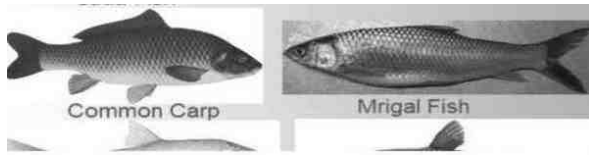
- In artificial method of fertilization ova from the females and the sperms from the males are taken out by artificial mechanical process and the eggs are got fertilized by the sperms.
- Different methods are used for induced breeding.
- Here induced breeding by hormones method is briefly described.

- The gonadotropin hormone (FSH and LH) secreted by pituitary gland influences the maturation of gonads and spawning in fishes.
- In India, Khan (1938) successfully induced *Cirrhinus mrigala* to spawn by injecting mammalian pituitary hormone.



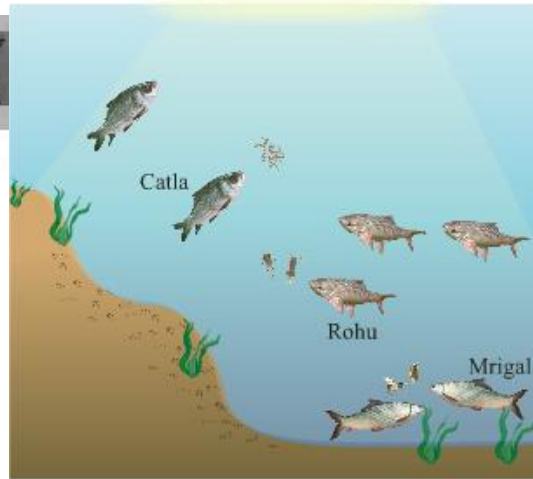
• (iii) Composite Fish Farming:

- It is found that if few selected species of fish are stocked together in proper proportion in a pond, total production of fish is increased many times.
- This mixed farming is called composite farming.
- It has some advantage-compatible species do not harm each other, all available areas are fully utilised, no competition among different species is found and fish may have beneficial effect on each other.
- Catla catla, Labeo-rohita and *Cirrhina mrigala* are surface feeder, column feeder and bottom feeder respectively and are used for composite farming.



★★★hey friend!!★★★

⇒ composite fish culture Composite fish culture is a technology developed by Indian Council of Agricultural Research.
 ⇒ It is a polyculture system where both local and imported fishes are cultured in a single fish pond.
 ⇒ They have different food habits and do not compete with each other for food. The food available in the pond will be utilized by these fishes.



Composite Fish Culture

58 Types of Fisheries; Marine Fisheries

• Marine Fisheries:

- Marine fisheries are conducted in all the oceans and seas of the world, including bays and estuaries .
- The capture and culture of aquatic organisms in salt water accounts for the bulk of the fishery products that reach world markets.
- Marine fishery deals with the fishery aspects of the sea water or ocean.

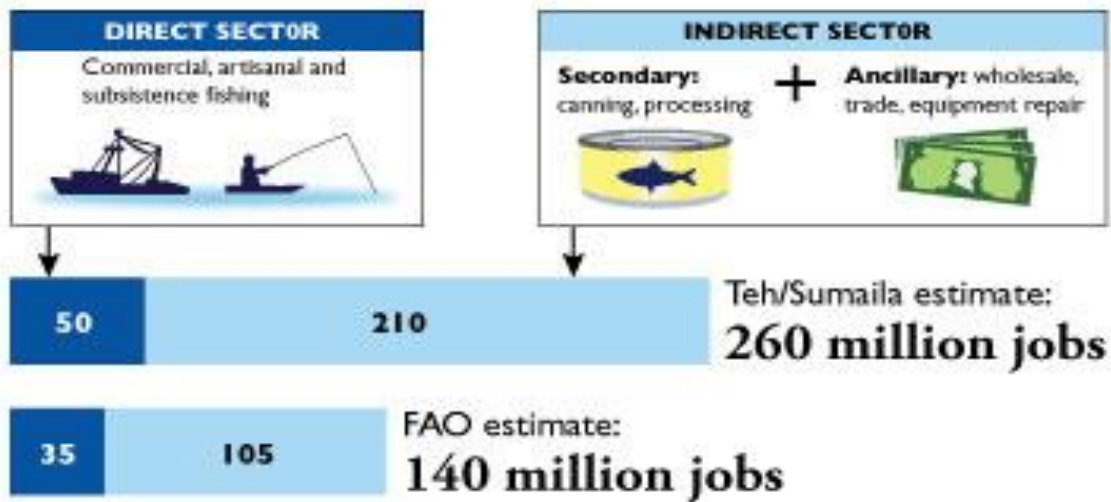
Bombay duck (Harpodon sp)
 Mackerel (Rastrelliger)
 Eel (Anguilla sp)
 Flying Fish (Exocoetus)
 Hilsa (Hilsa)
 Ribbon Fish (Trichiurus)

Pomfret (Stromateus)
 Tuna (Thunnus)
 Salmon (Aluitheronema)
 Seer Fish (Scomberomorus)
 Sardine (Sardinella)

- Hilsa migrates from the sea to the river for breeding. Dr. Hora studied the migration of Hilsa.

Marine fisheries jobs worldwide

The authors' estimates for global fisheries employment are 1.75 times higher than the Food & Agriculture Organization estimates.



- The world's marine fisheries belong to one vast network • Earth.com



59 Fish Diseases

- Fish Diseases Caused by Parasites and Pathogens:

- 1. Bacterial Diseases:

Two bacterial diseases are very important. ☰

(i) Abdominal dropsy of Carps is caused by
Aeromonas punctuata.

(ii) Furunculosis of Salmons and trout's is caused by
Aeromonas salmonicida.

Bacterial Disease:

- Reddened and frayed fins.
- Disintegration of the fins.
- Rapid breathing.
- Abdominal swelling or bloating.
- Loss of appetite.
- Lethargic body.



Fig: Fish affected by bacterial disease.

• 2. Viral Diseases:

- Economically most important is the 

viral haemorrhage septicaemia (VHS)

of rainbow trouts.

5. Viral diseases

1. Viral Hemorrhagic Septicaemia (VHS):

- This disease is caused by an unequal shaped fish virus with RNA.
- This disease occurs in salmon fishes. Transmission of the disease occurs through the water by flagellates.
- The symptoms are kidney swelling, reduced appetite, obvious distress, erratic spiral swimming, multiple haemorrhages in skeletal muscles, change in body colour, reddish fins.
- The only control measure is prevention.



3. Protozoan Diseases:

- Main protozoan diseases are caused by Costia, Myxobolus and Trypanosoma.

2. Protozoan diseases

1. Ichthyophthiriasis (white spot disease)

a) **Causative agent:-** *Ichthyophthirius multifiliis*

b) **Symptoms:-**

- ✓ nodular white spots fins, gills and skins.
- ✓ Affected fishes show irritation, erratic movement and restless with tendency to rub on the sides.

c) **Treatment:** therapeutic

- ✓ Hourly bath in 1:5000 formalin solution for 7 days.
- ✓ Bath in 2% sodium chloride solution for 7 days



• 4. Fungal Diseases:

- The gill rot (branchyomyces) of carps involves the attack of Saprolegnia on the gills of carps.

1. Fungal disease:

- i. **Saprolegniasis or cotton wool disease,**
 - a) **Causative agent:-** *Saprolegnia parasitica*
 - b) **Symptoms:-**
 - ✓ White to brown cotton like growth.
 - ✓ Consisting of colonies of mycellium with small to large patches on body.
 - ✓ Infect the fertilized egg- egg become white and fail to hatch.




• 5. Worm Diseases:

- Worms of four groups are parasites on fish. The flatworms (trematodes), tapeworms (cestodes), round worms (nematodes) and thorny-headed worms (acanthocephalans).

• 6. Common Ectoparasites:

Two ectoparasites of fish are most important, the fish lice (*Argulus*, *Lernaea* and *Ergasilus*) and the fish leech (*Piscicola*).

- Both parasites weaken fish by feeding on its blood.

PARASITIC

- ICH (AKA WHITE SPOT)
- HOLE IN THE HEAD
- ANCHOR WORM
- VELVET
- GILL FLUKES

VIRAL

- HEMORRHAGIC SEPTICEMIA
- LYMPHOCYSTIS

BACTERIAL

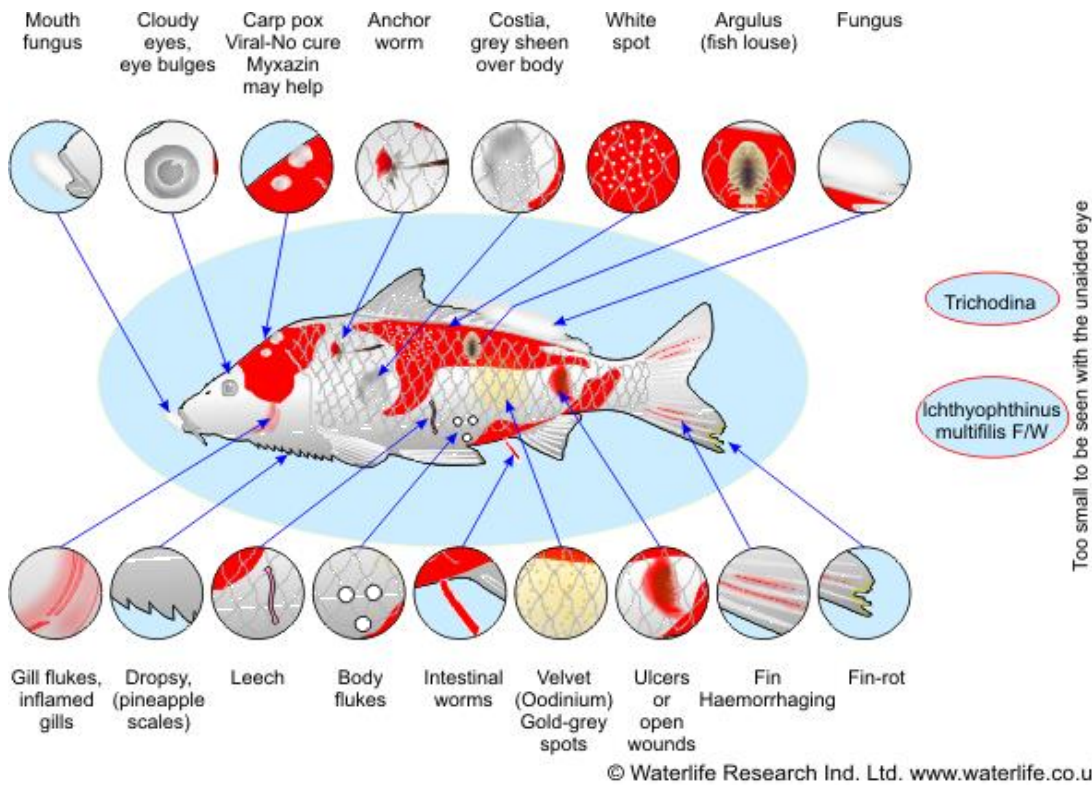
- FISH TUBERCULOSIS
- FIN OR TAIL ROT
- COLUMNARIS
- CLOUDY EYE

FUNGAL

- BODY FUNGUS
- COTTON FIN FUNGUS

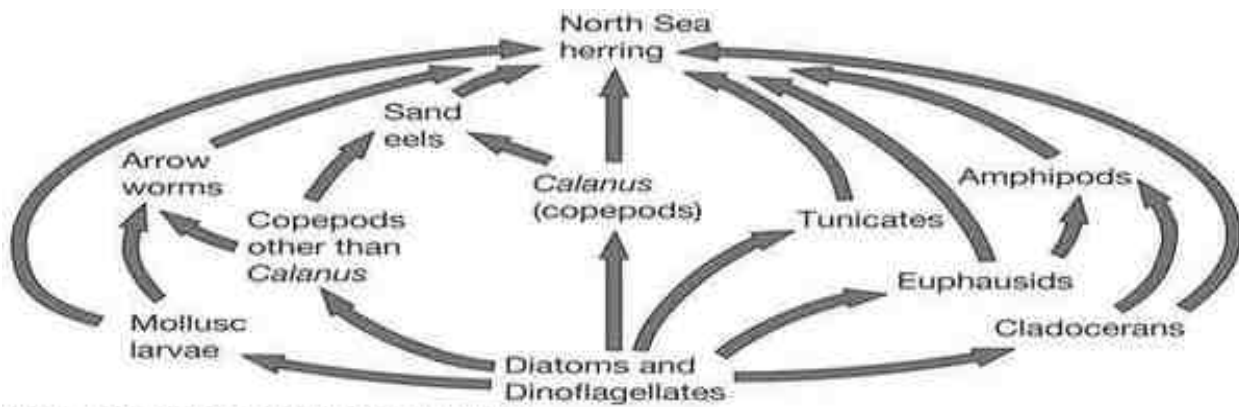
OTHER ISSUES

- SWIM BLADDER ISSUES
- DROPSY
- POP EYE
- ULCERS



60 -Food Webs and Marine Fisheries

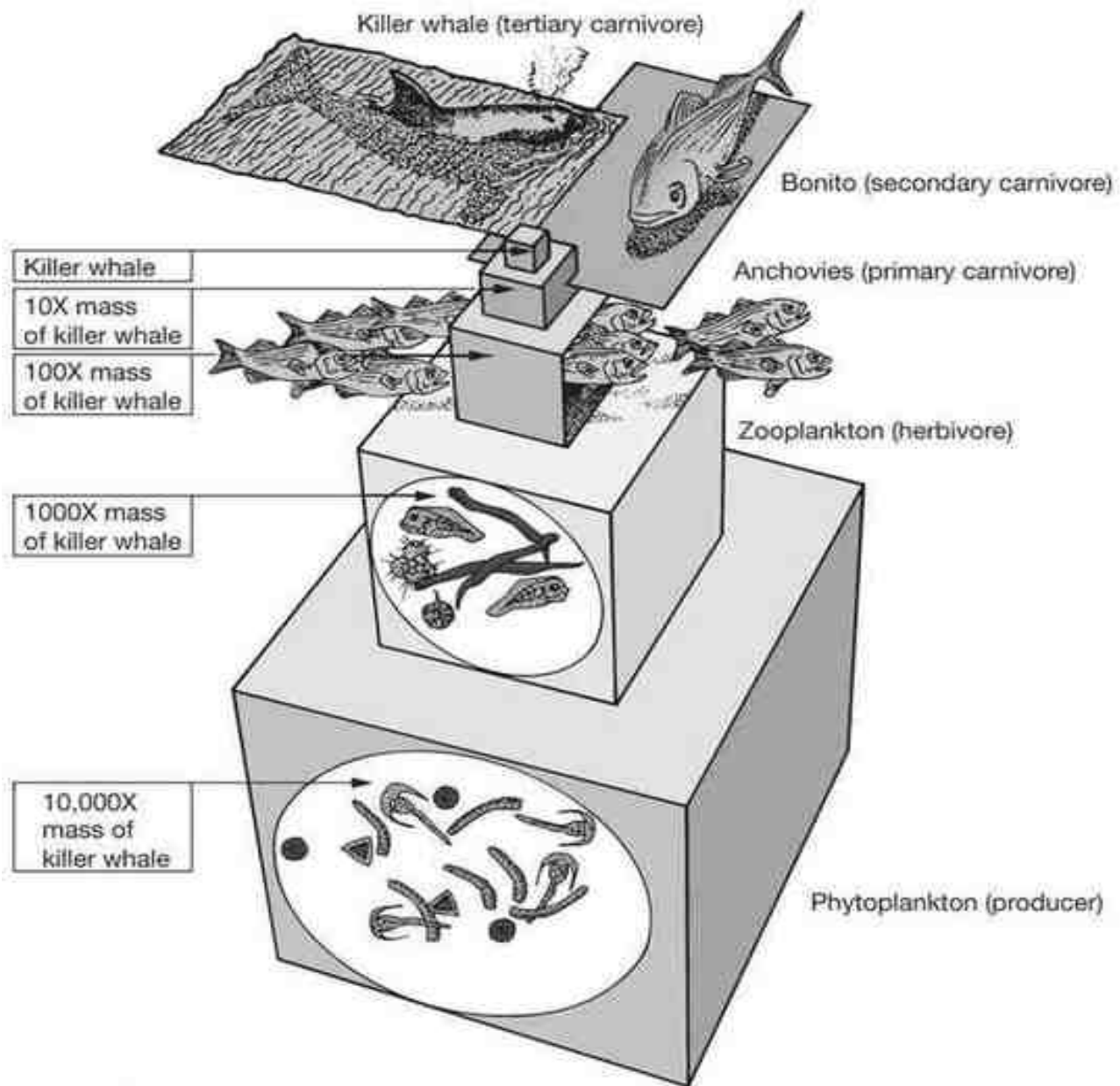
- Branching network of many consumers
- Consumers more likely to survive with alternative food sources



(b) Food web of North Sea herring containing many food chains.

Biomass Pyramid

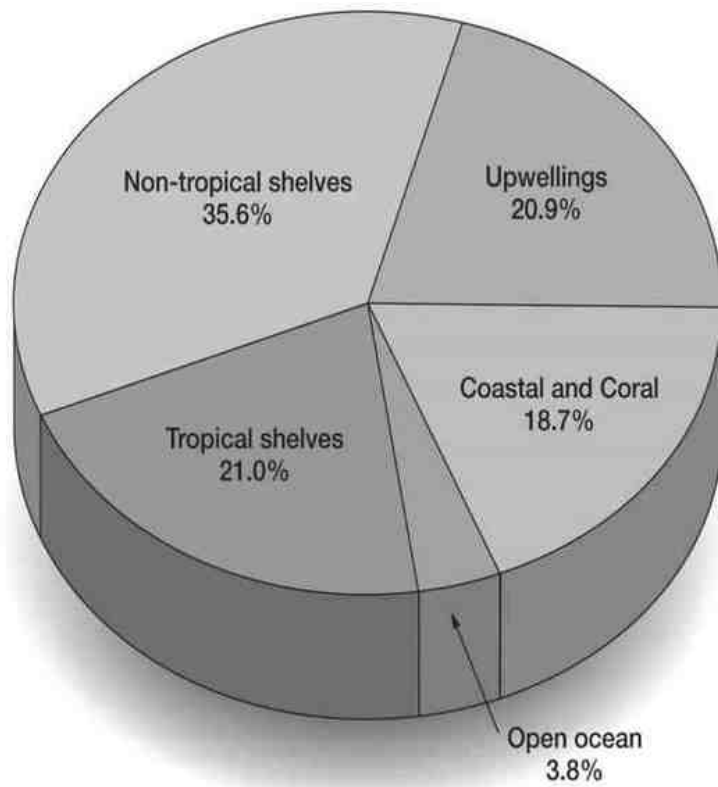
- The number of individuals and total biomass decreases at successive trophic levels.
- Organisms increase in size.



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Marine Fisheries

- Commercial fishing
- Most from continental shelves
- Over 20% from areas of upwelling that make up 0.1% of ocean surface area

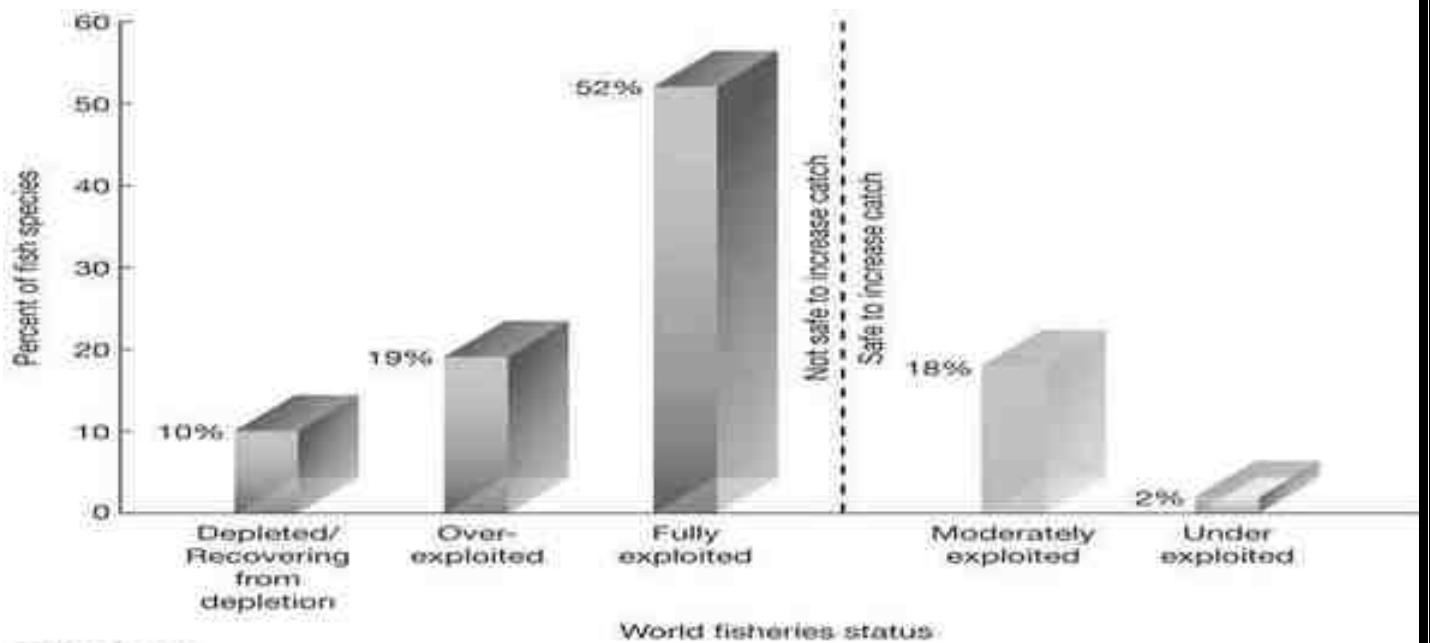


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Overfishing

- Fish from standing stock – the mass present in the ecosystem at any given time
- Overfishing – fish stock harvested too rapidly, juveniles not sexually mature to reproduce
- Reduction in Maximum Sustainable Yield (MSY)

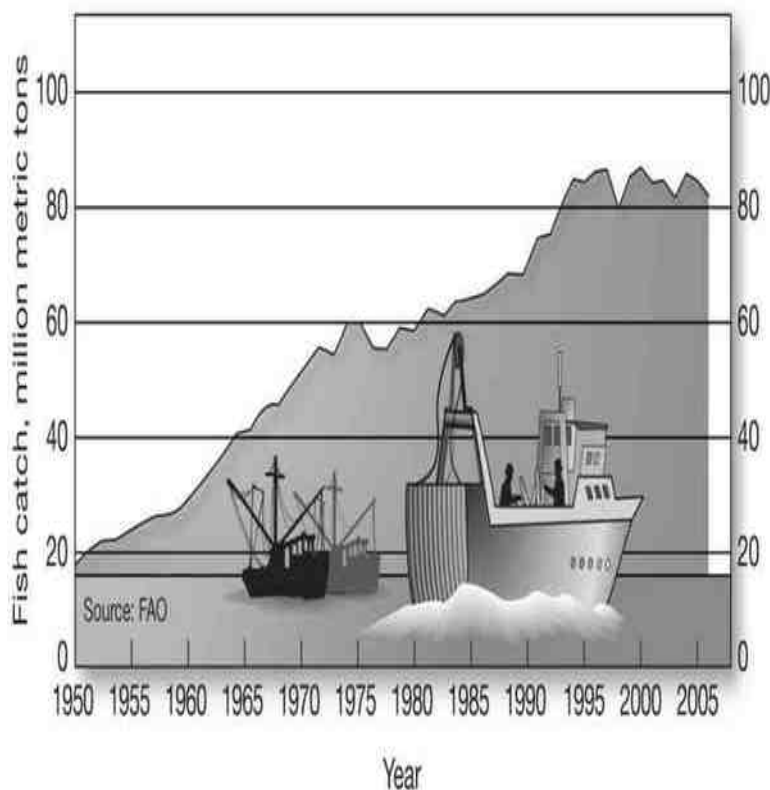
Exploitation Status of Marine Fish



61 -overfishing

Overfishing

- 80% of available fish stock fully exploited, overexploited, or depleted/recovering
- Large predatory fish reduced
- Increased fish production, decreased stocks



Incidental Catch or Bycatch

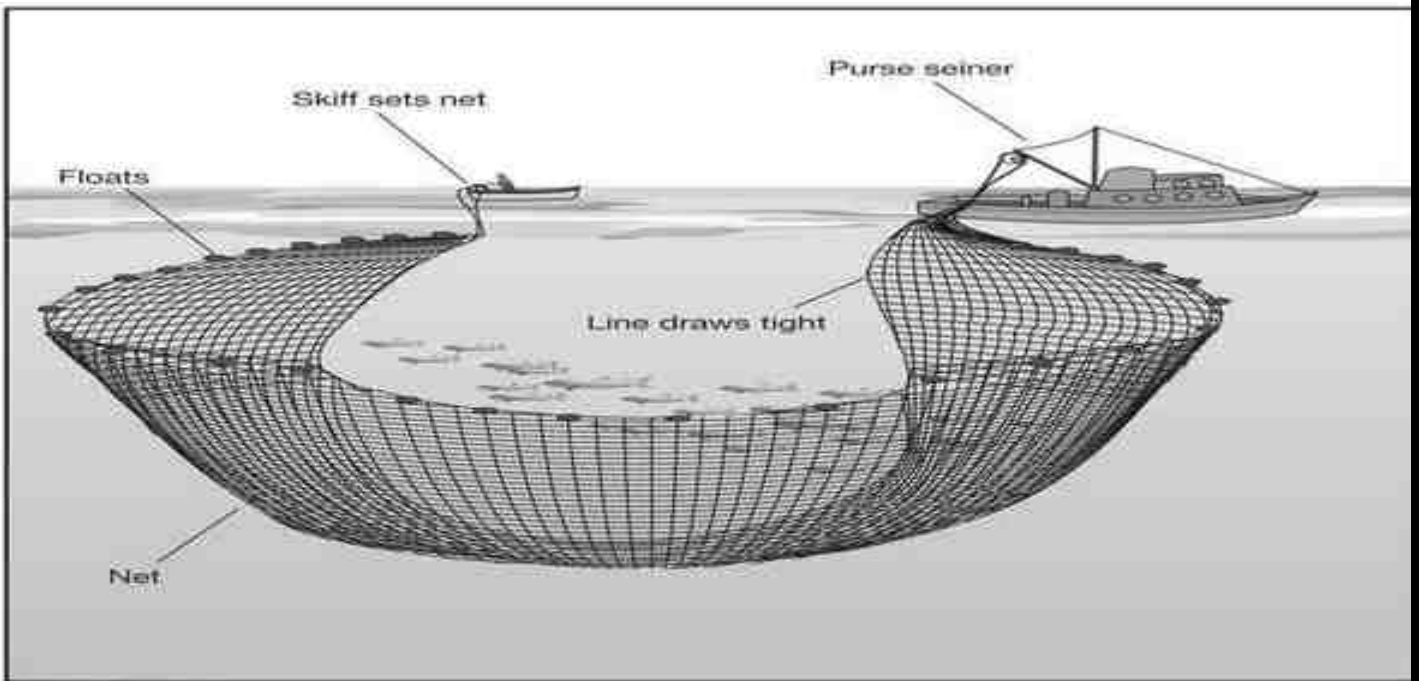
- Non-commercial species are taken incidentally by commercial fishers.
- Bycatch may be up to 8 times more than the intended catch.
 - Birds, turtles, dolphins, sharks

Tuna and Dolphins

- Tuna and dolphins swim together
- Caught in purse seine net
- Marine Mammals Protection Act addendum for dolphins
- Driftnets or gill nets banned in 1989



Purse Seine Net



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Fisheries Management

- Regulate fishing
- Conflicting interests
- Human employment
- Self-sustaining marine ecosystems
- International waters
- Enforcement difficult

62 -Fisheries Management

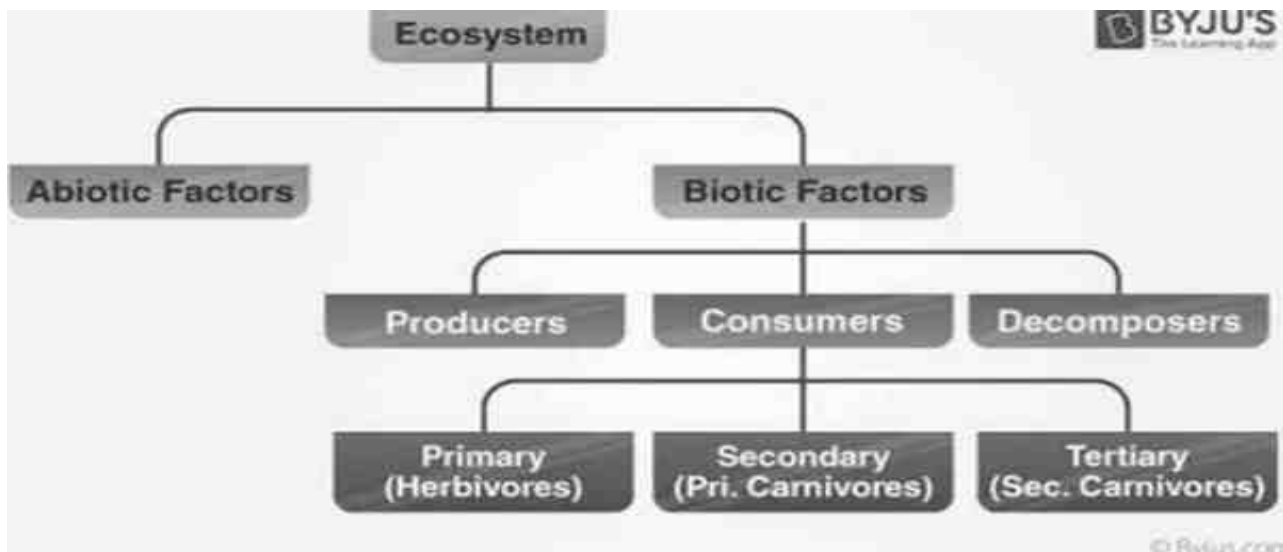
Fisheries Management

- Regulate fishing
- Conflicting interests
- Human employment
- Self-sustaining marine ecosystems
- International waters

- Enforcement difficult

63 -Ecology

- **Ecology** is derived from two words 'oikos' and 'logos'
- Oikos= house or dwelling place
- Logos=study of
- So. It can be defined as the study of living organisms with respect to their house or dwelling place.
- The structure of ecosystem can be split into two main components:
 - (i) Biotic Components
 - (ii) Abiotic components



Functions of Ecosystem

- The functions of the ecosystem are as follows:
- It regulates the essential ecological processes, supports life systems and renders stability.

- It is also responsible for the cycling of nutrients between biotic and abiotic components.
- It maintains a balance among the various trophic levels in the ecosystem.
- It cycles the minerals through the biosphere.
- The abiotic components help in the synthesis of organic components that involve the exchange of energy.
- So the functional units of an ecosystem or functional components that work together in an ecosystem are:

Productivity – It refers to the rate of biomass production.

Energy flow – It is the sequential process through which energy flows from one trophic level to another. The energy captured from the sun flows from producers to consumers and then to decomposers and finally back to the environment.

Decomposition – It is the process of breakdown of dead organic material. The topsoil is the major site for decomposition.

Nutrient cycling – In ecosystem nutrients are consumed and recycled back in various forms for the utilization by various organisms.

64 -Aquatic ecosystem: Freshwater ecosystem

Types of Ecosystems

- An ecosystem can be small as an ocean, spanning thousands of miles.

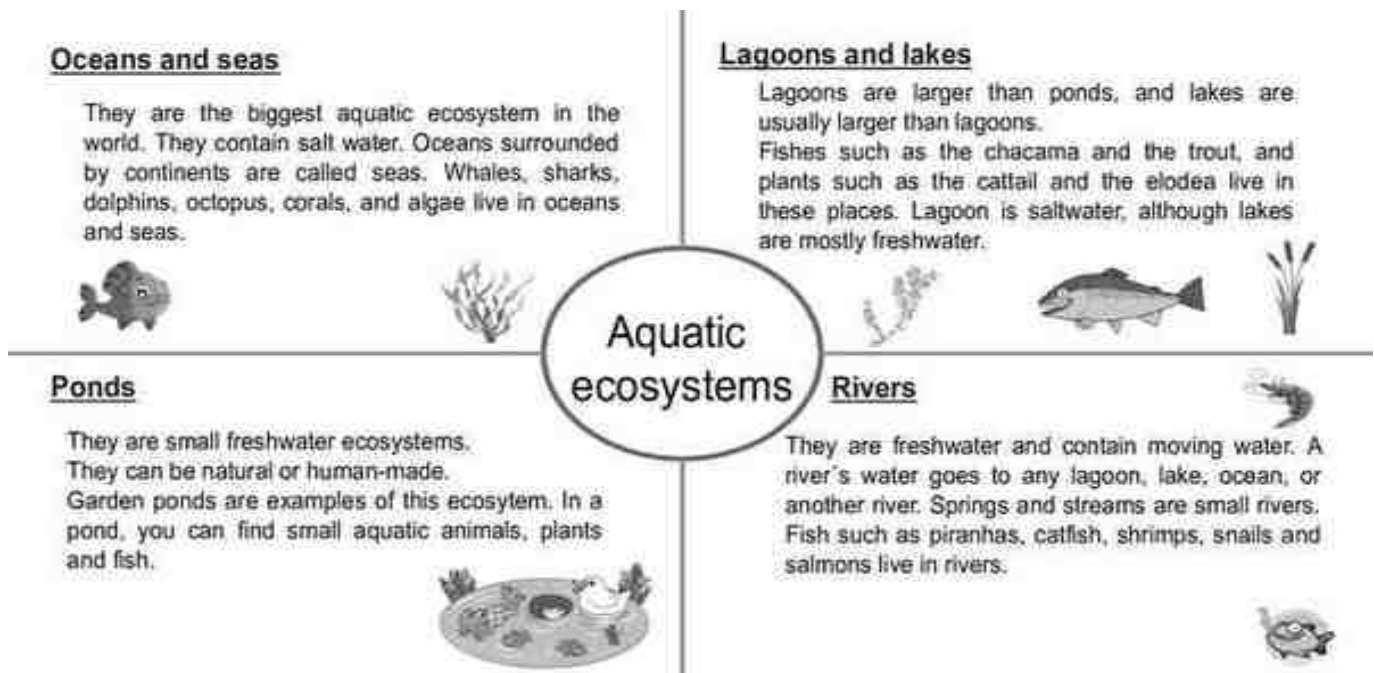
There are **two types** of ecosystems.

- (i) Aquatic Ecosystem
- (ii) Terrestrial ecosystem

Aquatic Ecosystem

Aquatic Ecosystem

- Aquatic ecosystems are ecosystems present in a body of water. These can be further divided into two types, namely:
 - (i) Freshwater Ecosystem
 - (ii) Marine Ecosystem
- Most of the Earth Surface (around 70%) is covered with water, but not all the water is freshwater. Only 3.5% is freshwater, and the rest 96.5% is saltwater in the form of oceans.



Freshwater Ecosystem

- **Freshwater Ecosystem**
- The freshwater ecosystem is an aquatic ecosystem that includes lakes, ponds, rivers, streams and wetlands. These have no salt content in contrast with the marine ecosystem.
- **Freshwater Ecosystem Characteristics**

- The freshwater ecosystem is a habitat for various plant and animal species. One of the major reasons is that it is quite rich in terms of nutrition and minerals.
- The freshwater ecosystem is less saline, unlike the marine ecosystem.
- The temperature in this ecosystem varies depending on some factors like location, season, and depth from the water surface.
- During summers, the temperature of the freshwater ecosystem generally ranges from 30-71 degrees Fahrenheit. Whereas during winters, the temperature ranges from 35-45 degrees Fahrenheit.
- The size and shape of freshwater ecosystems vary depending on location, an area covered, and depth of water bodies.
- The freshwater ecosystem contains sediments at the bottom. In gentle flowing freshwater bodies or still water bodies, the sediments remain in place.
- The freshwater ecosystem provides a suitable environment for various species of flora and fauna.

65 -Aquatic ecosystem: Types of Freshwater ecosystem

Types of Freshwater Ecosystem

- The freshwater ecosystem is mainly divided into three types based on its region – Lotic, lentic, and wetland freshwater ecosystem.

Lotic Freshwater Ecosystem

- In simple terms, the water bodies moving in one direction is known as a lotic freshwater ecosystem. Rivers and streams are common examples of lotic ecosystems.

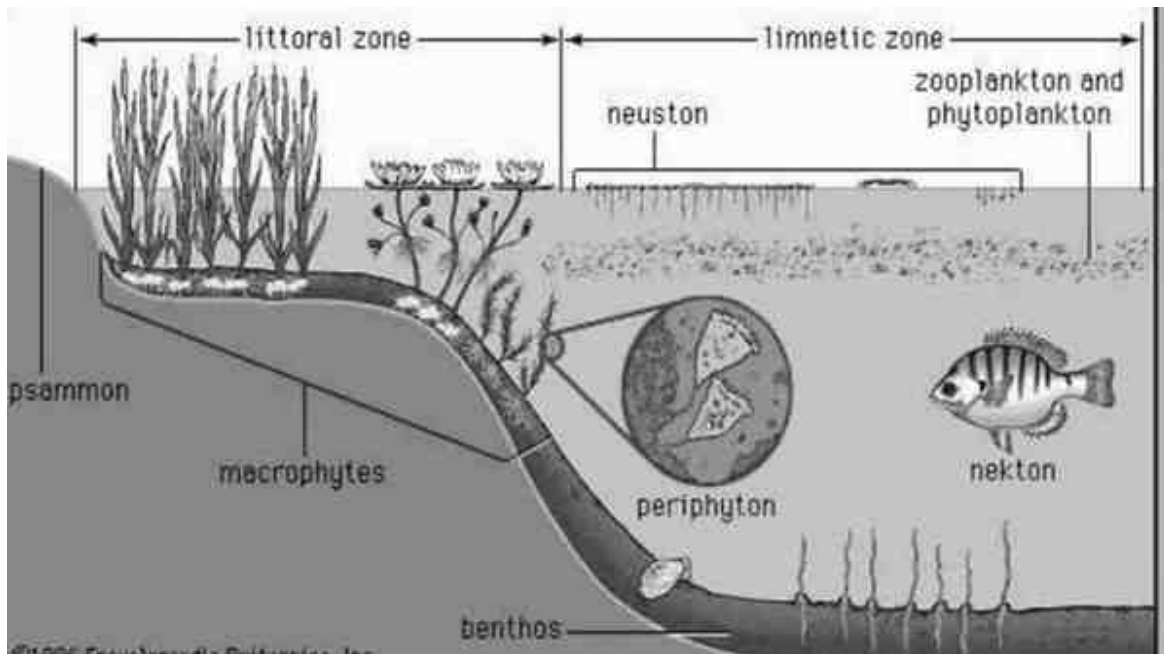
- There are many rivers and stream that flows from their origin and ultimately meets with other water channels or oceans at its mouth.
- Lotic freshwater travel through different locations from its source to mouth.

Lentic Freshwater Ecosystem

- An aquatic ecosystem within stagnant or still water like ponds and lakes is known as Lentic Freshwater Ecosystem.
- Lentic ecosystem found in various sizes ranging from a few square meters to thousands of square km.
- Some ponds last just for a few months as these are seasonal like sessile pools.
- On the other hand, lakes may exist for many years. Lentic ecosystem, i.e. Ponds and lakes, support a very limited number of species.

Wetland Freshwater Ecosystem

- Wetlands are still water bodies that support vascular plants. Marshes, swamps, and bogs are commonly known as wetland ecosystems.
- Wetlands are quite productive due to the proximity of water and soil.
- The plant species found in the wetlands are known as hydrophytes as they have adapted the moist and humid environment of the region.
- The common hydrophyte plants found in the wetland ecosystem include cattails, tamarack, pond lilies, sedges, black spruce, etc.
- As far as animal species are a concern, wetlands provide shelter to various amphibians, reptiles, birds, shrimp, shellfish, etc.



66 -Aquatic ecosystem: Marine ecosystem

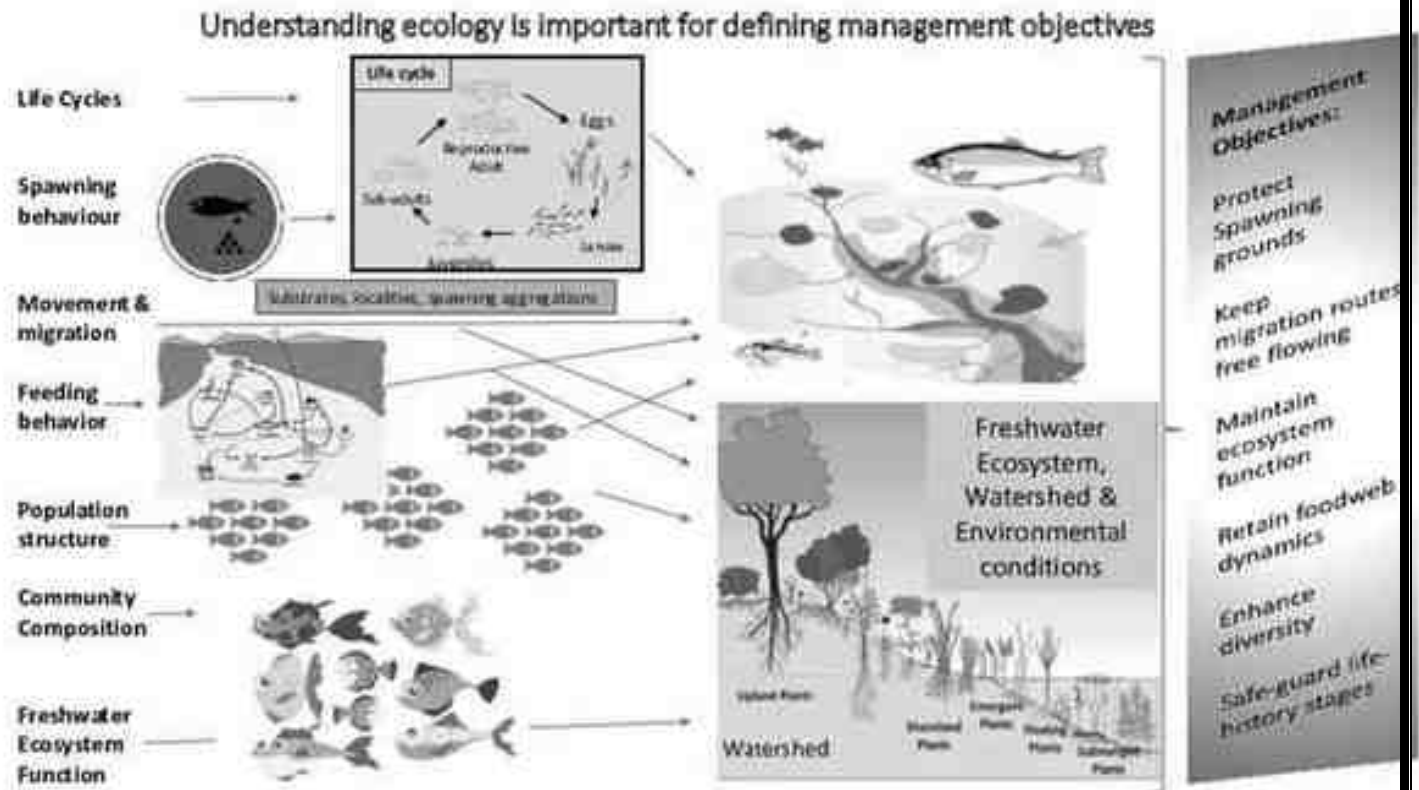
- The marine ecosystem includes seas and oceans.
- These have a more substantial salt content and greater biodiversity in comparison to the freshwater ecosystem.
- Fishes have a higher rate of endangerment than all other classes of vertebrates, due the varied and intensive human use of aquatic resources.
- Ecology of Fishes is a course focusing on the interactions between fishes and their environments.
- The course broadly covers physiology, life-history, predator-prey interactions and population and community level responses to biotic and abiotic factors in freshwater streams and lakes and marine habitats.
- We discuss adaptations for survival under different environmental constraints, basic fisheries concepts and concerns and fish conservation.



67 -Ecology of fishes

- The ecology of fishes is extremely varied due to the great diversity of species within the five fish classes.
- Habitats range from regions deep within the sea to lakes and streams high on mountaintops.
- Most fish are predators, but the nature of their prey and how they consume that prey varies.
- In this section we will consider general aspects of the ecology of each class of fish.
- Hagfish are deep-sea bottom dwellers.
- These fish are predators that feed on other fish by entering their bodies through an orifice, such as the mouth or anus, and consuming them from the inside.
- Small invertebrates also make up a large part of their diets.
- Because of their remote habitats, there is not a lot known about the ecology of hagfish.

- It is likely that their predatory role as well as their position as prey for other predatory fishes in the food chain is important in maintaining ecological balance.



Types of Fishes in Freshwater

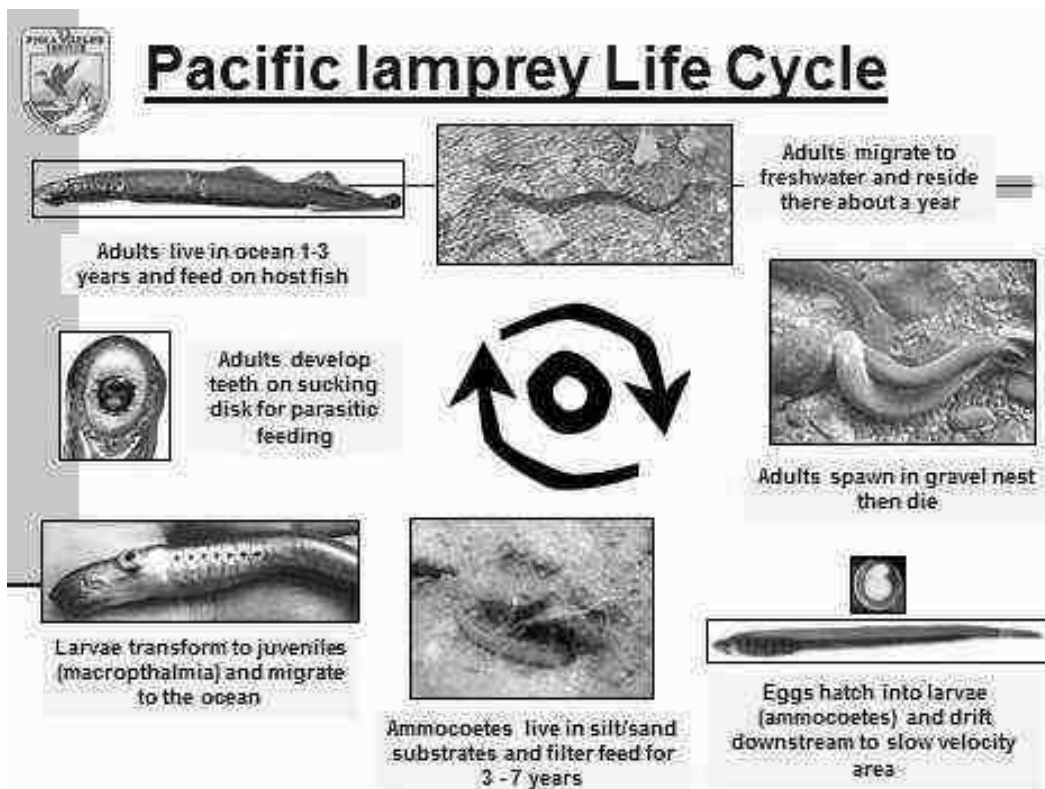
- Primary FW fishes:** families strictly confined to FW, cannot tolerate SW; have a long evolutionary history in FW
 - e.g., characins, minnows, catfishes, sunfishes
- Secondary FW fishes:** families generally restricted to FW but may occasionally tolerate SW; originally of marine origin
 - e.g., cichlids, poeciliids
- Freshwater representatives of marine families ("peripheral")**
 - e.g., sculpins, puffers, gobies, stingrays
- Diadromous fishes ("peripheral"):** migrate from SW to FW or vice versa at different stages in their life cycles
 - e.g. salmon, smelt, eels
- Euryhaline marine visitors**
 - e.g., sharks, snappers

- **Limnology** is the study of the structural and functional interrelationships of organisms of inland waters as they are affected by their dynamic physical, chemical, and biotic environments.
- **Freshwater ecology** is the study of the structural and functional interrelationships of organisms of fresh waters as they are affected by their dynamic physical, chemical, and biotic environments. Saline waters (e.g., > 0.3‰ or 3 g/liter–1) are excluded from this definition.
- **Freshwater biology** is the study of the biological characteristics and interactions of organisms of fresh waters. This study is largely restricted to the organisms themselves, such as their biology, life histories, populations, or, occasionally, communities.

68 -Ecological role of Lampreys

- Lampreys generally inhabit shallow coastal regions and freshwater environments.
- They feed on small invertebrates or larger fish species by attaching to the body wall and sucking their blood.
- There are both freshwater and marine species of lamprey.
- However, marine species must migrate to freshwater in order to spawn and for their young larvae to develop.
- Although there are native freshwater lamprey species found in North America, sea lampreys have been invading the Great Lakes over the past 100 years.

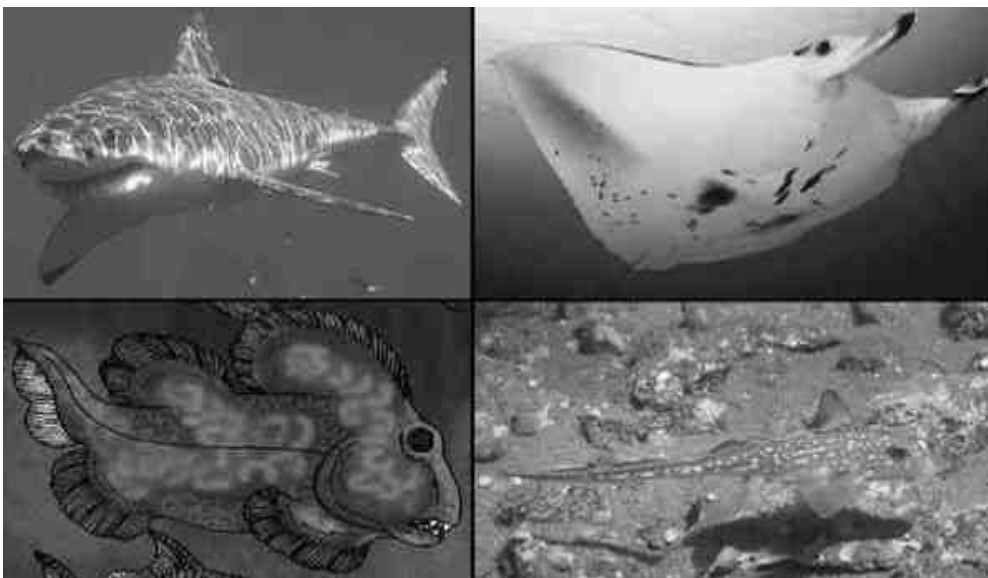
- This invasion was the result of man-made canals, built in the early 1900s, through which the sea lampreys were able to reach the lakes.
- They have caused a great deal of destruction to the fish industry by preying on economically important populations of trout and other fishes.
- Since they do not have natural predators in the Great Lakes, it has been a challenge for the U.S. and Canadian governments to control their populations.
- Methods such as chemically sterilizing males or using pheromones to disrupt their life cycles are currently being investigated.
- Although they are a nuisance in the Great Lakes of North America, there are many countries that value lampreys as a delicacy. Countries like Portugal, Spain, France, Sweden, Finland, South Korea, and the Baltic nations consume considerable amounts of lamprey, and populations have actually decreased in some of these regions due to overfishing.



69 -Ecological role of cartilaginous fish

- Cartilaginous fish species exhibit a wide range of habitats and feeding mechanisms.
- Most species of Chondrichthyes inhabit marine environments.
- Although some sharks are highly efficient predators that feed on fish and aquatic mammals, there are also some shark species, such as the whale shark, that filter feed and live entirely on a diet of plankton.
- Rays, skates, and chimaeras generally feed on crustaceans and mollusks.
- To accommodate this diet, their teeth are not sharp like a carnivorous shark's teeth, but are more like plates that can crush the tough shells of their prey.
- Rays, skates, chimaeras, and some shark species are bottom-dwellers that inhabit deep regions of the ocean.
- However, many shark species are pelagic, meaning that they spend much of their lives swimming throughout the open ocean (pelagic zone).
- The enormous number of Actinopterygii species (>20,000) covers a broad range of ecological habitats and modes of feeding.
- Roughly 40% of species inhabit freshwater environments, ranging from desert springs to high altitude streams.
- Ray-finned fishes include herbivores, carnivores, omnivores, zooplankton (for example, small crustaceans such as copepods and fish larvae) consumers, and detritus feeders, or those that feed on dead organic matter.
- Among the carnivores, there are a number of different hunting and feeding strategies.

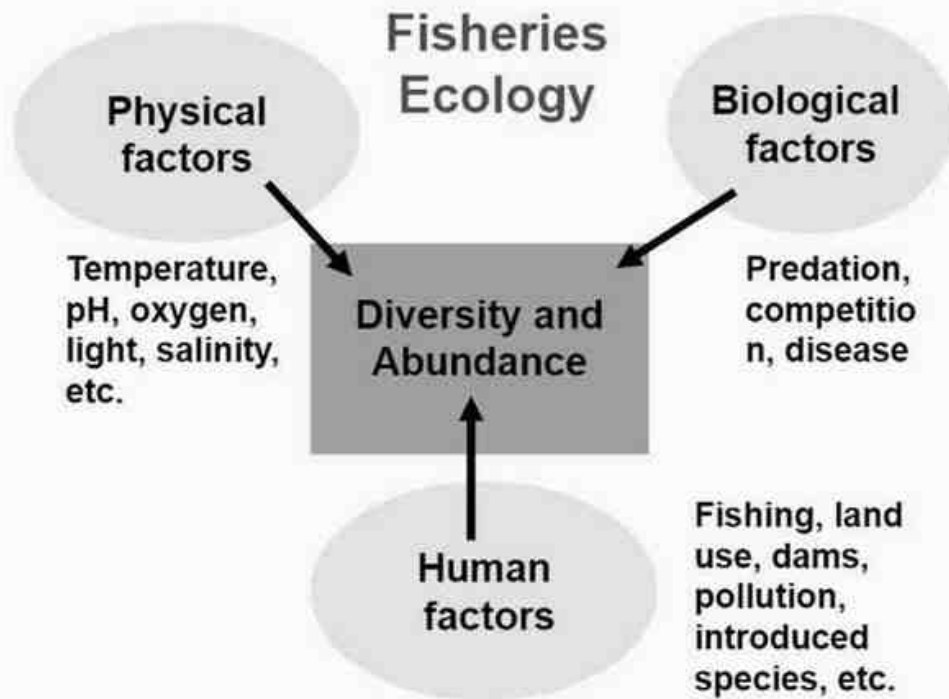
- These include fast-start predators such as pike and barracuda, ram feeders such as tunas and billfishes, and sit-in-wait predators such as scorpionfishes and sea basses.
- Fast-start predators wait in hiding for their prey to swim by and then lunge with a short burst of speed to attack. Ram feeders have bodies designed for high-speed swimming over long periods of time, so they chase down their prey. Sit-in-wait predators hardly move at all to obtain prey.
- They wait camouflaged or buried in sediment until prey is within close proximity.
- At that point they generate a large vacuum force to essentially suck in and inhale their prey.



70 -Physiological and Morphological Aspects of Ecology

- The habitats and diets of fish are varied.
- They live throughout the ocean and also in freshwater lakes, ponds, rivers, and streams. However, there is one fish, the mudskipper, that spends time on land.
- Many members of the class Actinopterygii are critically important components of the human diet and have been for thousands and thousands of years.

- Fish farms that breed large numbers of particularly popular species, such as salmon and trout, have become lucrative and integral parts of the economy.
- Many species of fish are also a source of recreation for humans; for example, activities such as sport fishing and aquarium keeping are widely popular.
- Unfortunately, human activities often threaten fish populations.
- There are currently over 1,100 species of fish that are at risk of extinction.
- The two leading causes of this problem are overfishing and habitat destruction as a result of pollution, dam building, and the introduction of exotic species that may take over a habitat.
- Conservation efforts are underway, but they must be balanced with the needs of human populations that are dependent on the very situations that are threatening fishes.
- For example, in many regions, such as Alaska, the fishing industry is a major source of employment, and the livelihoods of many people are dependent on commercial fisheries.



- **Sub-disciplines of Ecology**

- Landscape
- Nutrient cycling
- Physiological
- Behavioral
- Evolutionary
- Population
- Community

Physiological and Morphological Aspects of Ecology

- **Physiological and Morphological Aspects of Ecology**

- 1. Morphological Constraints
- 2. Behavioral regulations
- 3. Biological Rhythms
- 4. Temperature Units

- 5. Tolerance

- 6. Limitation

- **(1) Morphological Constraints**

- Some organisms are specialists and other are generalist in terms of morphology (shape). Careful examination of the mouth parts, fins and shape indicates the extent to which the species is adapted for particular kind of prey and movement, or is adapted to prey in a wider range of locomotion patterns.

- These attributes along with patterns of physiology, may determine the range of a species and its responses to changing conditions.

- **(2) Behavioral regulations**

- In addition to the physiological capacity to tolerate a range of conditions (e.g., temperature, salinity, oxygen etc.) mobile organisms often move to adjust their environment, searching for physiologically optimal condition in winter for warm springs, and are attracted to the attractive effluent from power plants. However areas that are optimal for some environmental features may b not be optimal for others and behavioral regulation may conflict with other needs such as feeding and reproduction.

- **(3) Biological Rhythms**

- We are strongly controlled by internal (endogenous) circadian rhythms affecting temperature, physiology and behavior etc.

- Physiology and behavior are strongly controlled by such rhythms, with periods of a year, a lunar month, a day or a tidal cycle. The reproductive biology and feeding patterns are intimately linked to such rhythms.

- Example include vertical feeding migrations from deep water towards the surface to feed on plankton, annual migrations from feeding to breeding grounds, synchrony of breeding on spring high tides and movement from the bottom to the middle of the water column on high and low tides.

Time and Temperature

For poikilotherms, physiological processes, including development of embryos, progress at a rate determined by temperatures. In many cases, the stage of development reflects a rough correspondence between time (number of days) and temperature (number of °C > 0).

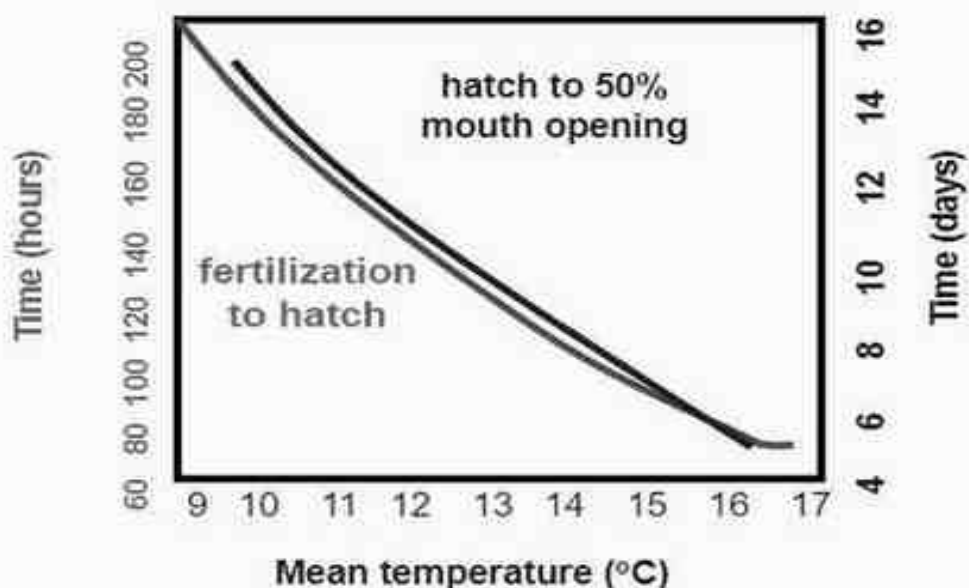
Thus, for example, coho salmon embryos develop from fertilization to hatching in about 500 temperature units (TUs). This might occur after 50 days at 10° or 100 days at 5°.

$$10^{\circ} \times 50 \text{ days} = 500 \text{ TUs}$$

$$5^{\circ} \times 100 \text{ days} = 500 \text{ TUs}$$

Effect of temperature on the development rates of European sea bass

(Jennings and Pawson 1991)



Limitation and Tolerance

Law of the Minimum:

“Under steady-state conditions the essential material available in amounts most closely approaching the critical minimum needed will tend to be the limiting one.”

For example:

In a lake, primary production may be limited by Phosphorous rather than by Nitrogen, and addition of Nitrogen may have no effect on production. At other times of the year light may be limiting.

Limitation and Tolerance

Law of Tolerance:

“The presence and success of an organism depend upon the completeness of a complex of conditions. Absence or failure of an organism can be controlled by the qualitative or quantitative deficiency or excess with respect to any one of several factors which may approach the limits of tolerance for that organism.”

For example:

The ability to exist and thrive may depend on such physical factors as dissolved oxygen, temperature, salinity, pH, etc.

“Steno” refers to species with narrow tolerances (e.g., stenothermal = narrow temperature tolerance); “eury” refers to those with wide tolerances (e.g., euryhaline = wide salinity tolerance).

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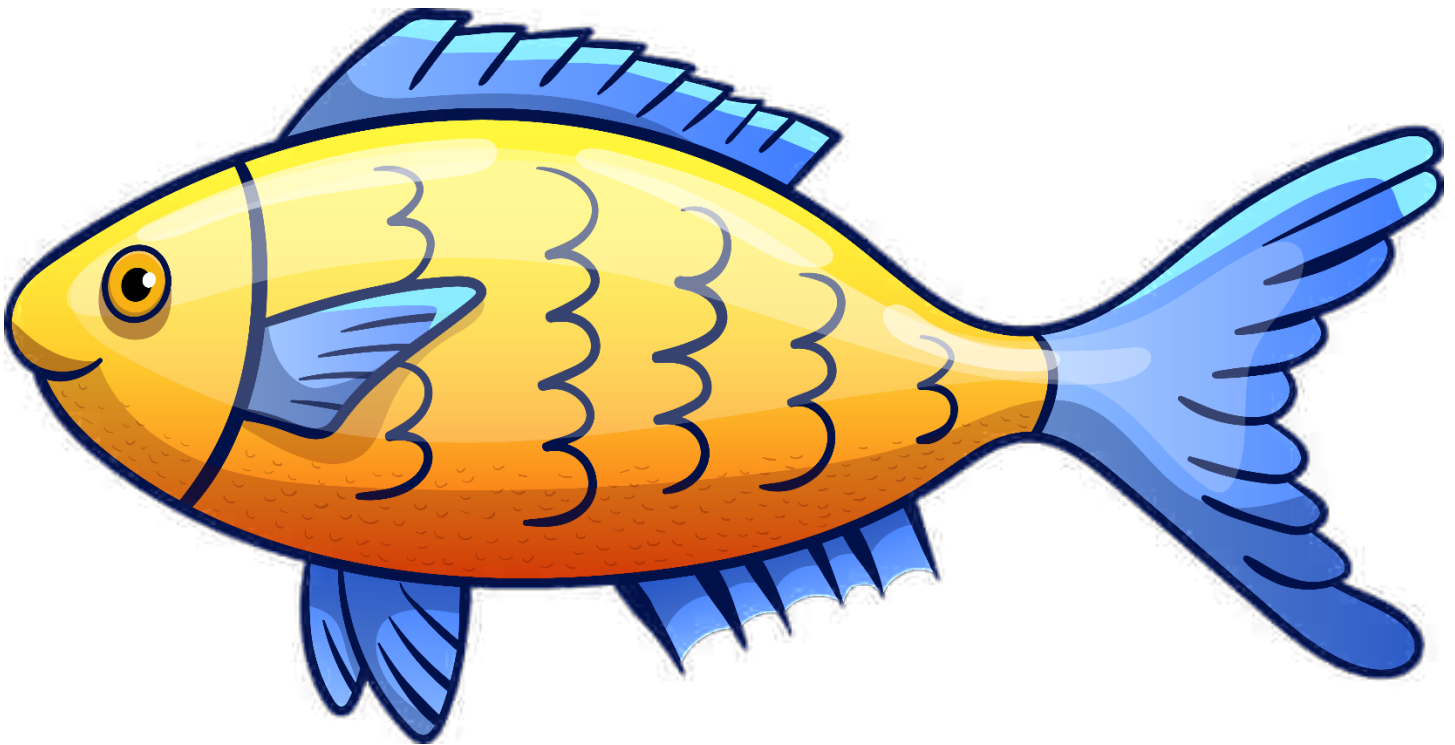
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