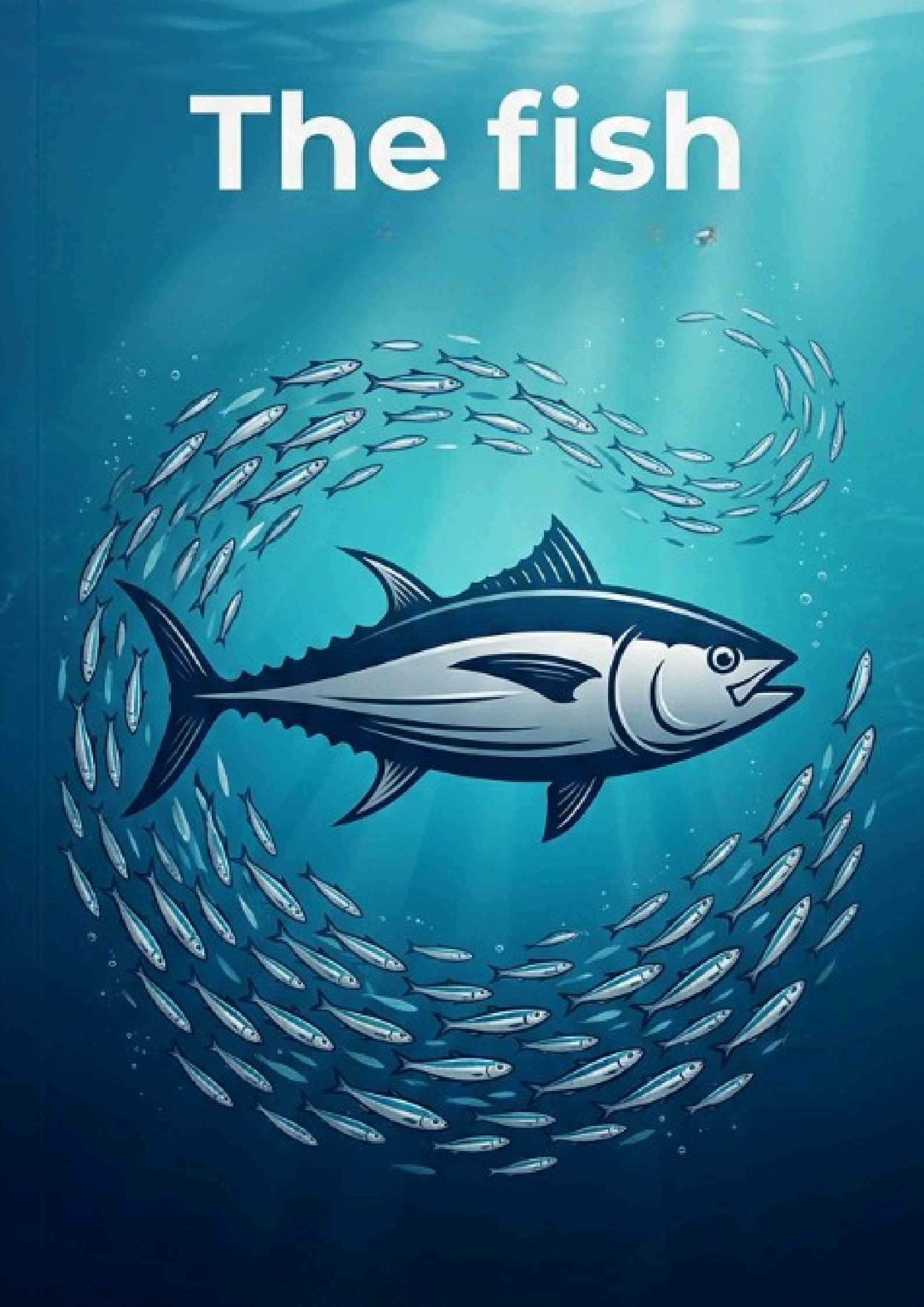
The fish



Bony fish

These are vertebrates living in aquatic environments, characterized by scales covering their skin. They possess fins for locomotion and gills specialized for respiration.

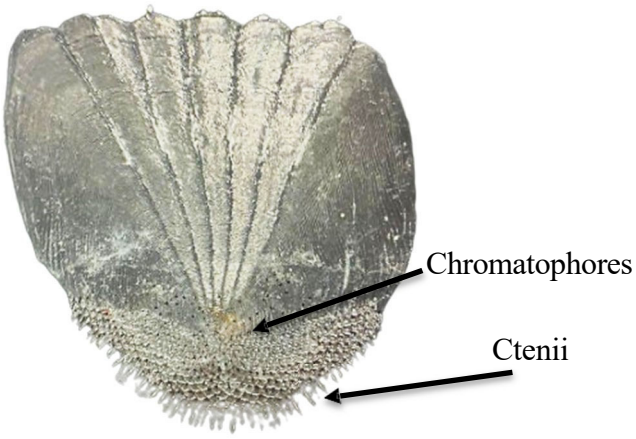
I) Morphology

1.1) The skin

In cartilaginous fish, the skin is characterized by a highly rough texture. It forms a discontinuous covering made up of placoid-type scales, deeply embedded in the dermis.

In bony fish, the body is protected by overlapping scales, known as elasmobranchs. These are embedded in the dermis up to their midpoint and exhibit continuous but irregular peripheral growth, influenced by seasonal variations.

This same layer also contains cells that secrete a mucus covering the entire body, enabling more efficient movement.



Ctenoid scale

Cycloid scale

1.2) The fins

Fish share the common feature of having fins that serve different purposes. There are two types of fins: **paired fins** and **unpaired fins.**

- Pair fins

We distinguish between the **ventral or pelvic** fins and the **pectoral** fins; these are involved in changing direction and braking, and they play a secondary role in maintaining stability in fish.

Note

In rays, the pectoral fins develop into wings and are involved in propulsion and stabilization.

- Unpaired fins

The fins are classified as: **dorsal**, **anal,** and **caudal**.

The caudal fin is responsible for propulsion in most bony fish; this fin has two lobes, upper and lower.

In bony fish, the two lobes are **symmetrical,** and the caudal fin is called **homocercal.**

In cartilaginous fish, the two lobes are **asymmetrical,** and the caudal fin is known as a **heterocercal fin**.

The shape of the caudal fin is a **good indicator of the fish's speed**.

The other unpaired fins include the dorsal fin, which helps maintain the fish's **balance** in conjunction with the anal fin (in some fish, it also helps prevent **rolling**).

Note

Some fish have a **fatty fin** at the base of the **caudal peduncle,** known as the **adipose fin**; the role of this fin is to help **stabilize the fish**.

II) Anatomy

2.1) The skeleton

In fish, the skeleton is of the axial type; it comprises

2.2) The vertebral column

It is made up of several vertebrae and ribs. The head skeleton comprises the skull and gill arches in bony fish; the endoskeleton enables steady growth; it is rigid and serves as an attachment point for various muscle groups, thereby enabling efficient movement.

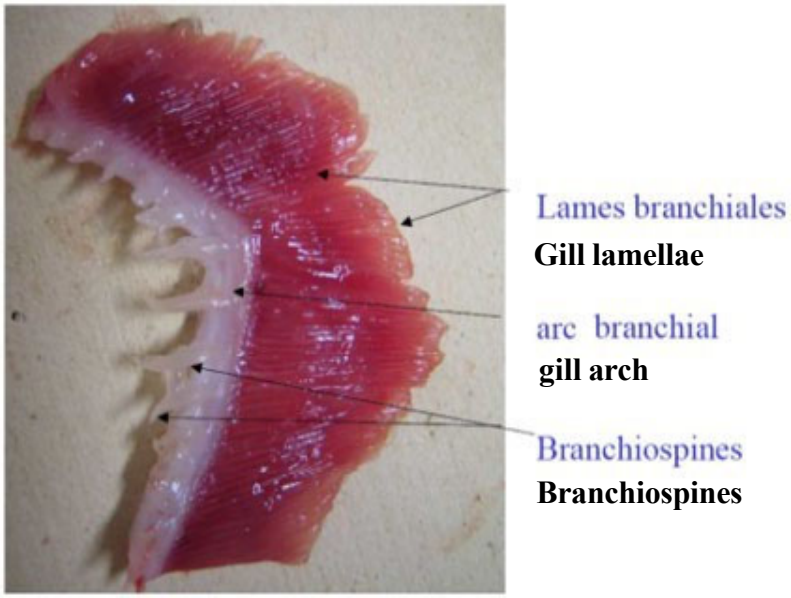
2.3) The nervous system

The brain has two large lobes: these are the olfactory lobes, which are connected to the olfactory pits in sharks and to the nostrils in bony fish.

The cerebral hemispheres are small in comparison to those of vertebrates.

2.4) The respiratory system

It consists mainly of gills, which comprise a skeleton, the gill arch, bearing thin, highly vascularised lamellae on its outer surface. Water enters through the mouth and exits via the gills in bony fish and via the gill slits in cartilaginous fish. The gill arch bears spines called branchiospines at the front; these can be very long, especially near the gill slits, forming a veritable filter.



2.5) The digestive system

The digestive system of fish is as varied as their diet. From front to back, the digestive system comprises:
The mouth and teeth.
The pharynx and esophagus. The
stomach, intestine, and anus.

a) The oesophagus

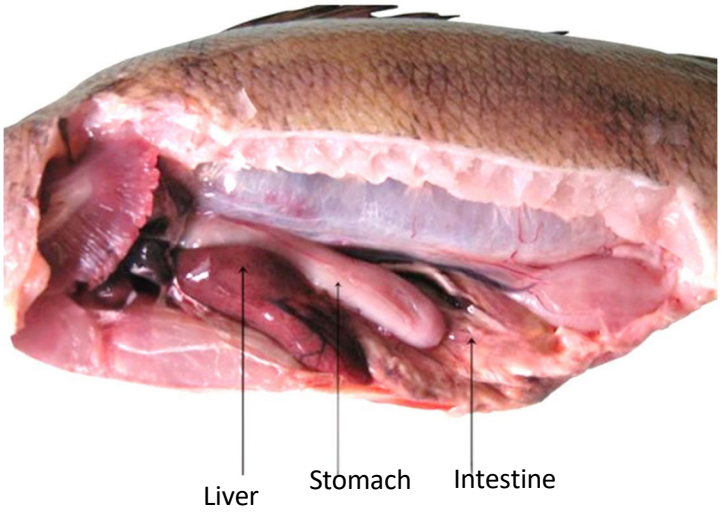
This is a passageway to the stomach; its walls are thinner or thicker depending on each species' diet.

b) The intestine

It is generally the longest segment of the digestive tract. It carries out the bulk of the digestive process through its own secretions and those of the associated glands: the liver and the pancreas.
Pyloric caeca can be observed in many species. These are elongated anatomical extensions that compensate for the small size of the digestive tract by increasing the surface area of the intestinal mucosa and thus the capacity for nutrient absorption.

c) The liver and pancreas

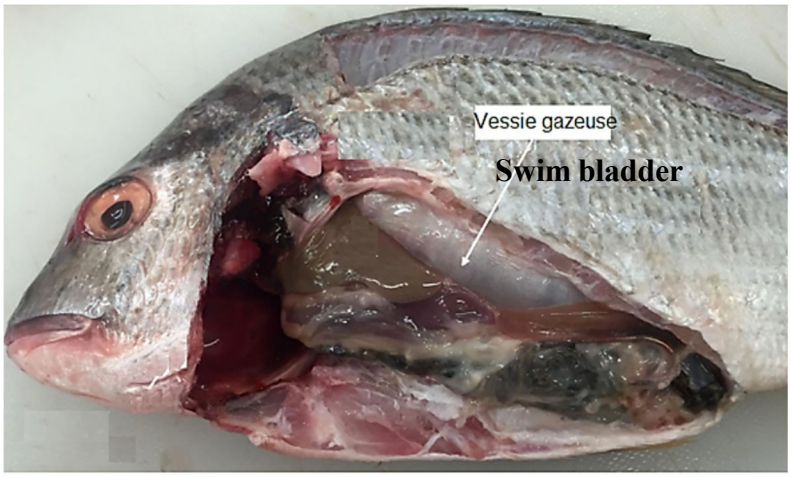
These are two large brown glands situated behind the heart. The liver is voluminous and the pancreas diffuse.



Note

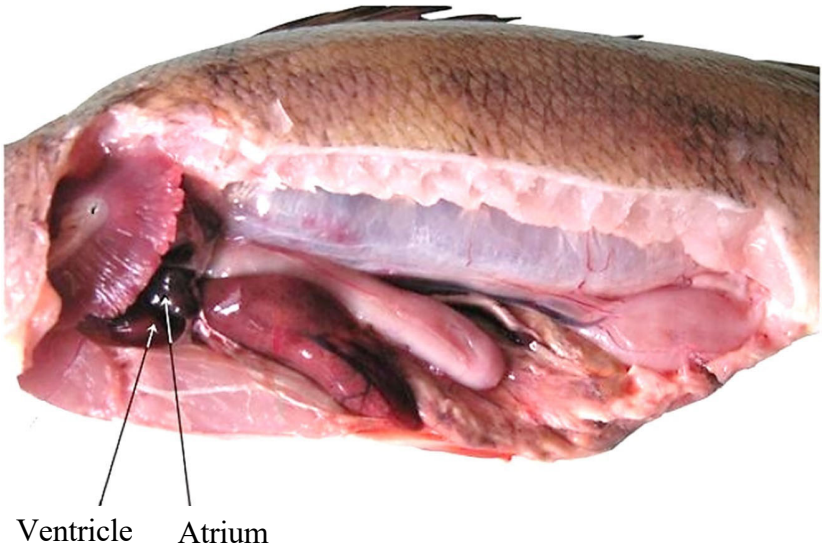
In many species, there is a **swim bladder**, a thin-walled sac connected to the esophagus by a canal known as **the pneumatic canal**.

The swim bladder fills and empties with a gas mixture consisting mainly of oxygen and nitrogen, allowing fish to **withstand varying water pressures as they swim up or down.**



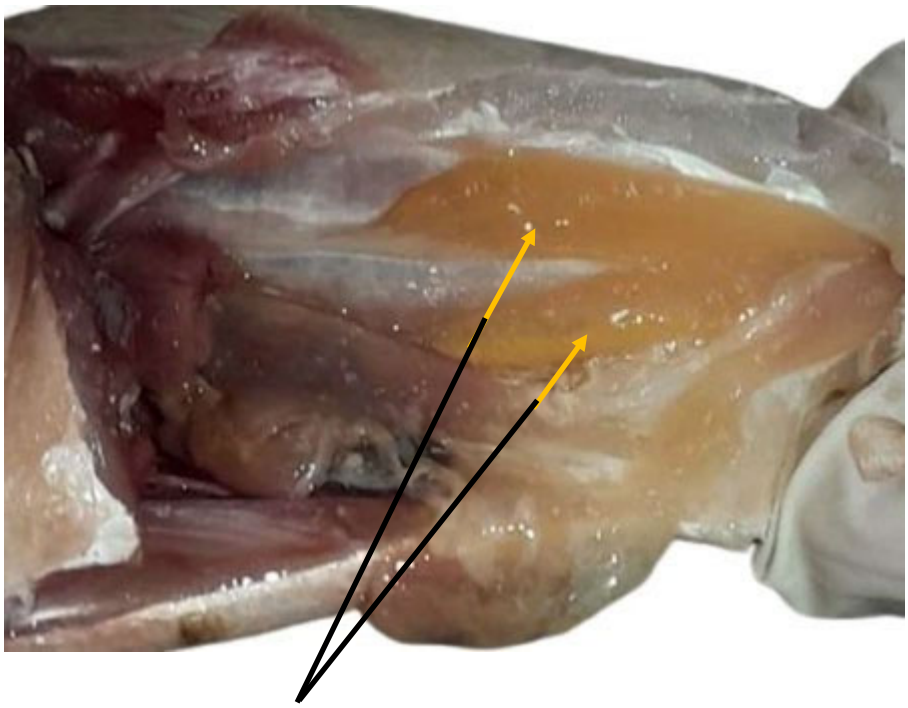
2.6) <u>The circulatory system</u>

The heart is simple. Blood is pumped by the heart into the afferent branchial arteries, which supply the various gills. Blood leaves the gills via the efferent branchial arteries, which distribute it to the organs.



2.7) The reproductive system

In bony fish, the testes are two elongated organs connected by a vas deferens that opens into the genital pore.
In females, the oviducts merge into a single duct and lead to the genital pore.



Gonads:
White in **males,** **Orange** in **females**

2.8) The excretory system

It consists mainly of the kidneys, which appear as two small, elongated, dark red masses situated against the dorsal wall of the abdominal cavity.
Urine consists of water and salts and is excreted via the urinary pore.

III) Biology

3.1) Breathing

In many bony fish, respiratory movements can be easily observed. The mouth and gill covers work alternately. First, opening the mouth allows water to enter; then, opening the gill cover simultaneously with closing the mouth allows the water to exit through the gills.

A system of one-way valves is provided by buccal valves, which prevent water from flowing back out through the mouth and propel it towards the gills.

Water movements involve a set of muscles that, through their contractions, create pressure differences between the oral-pharyngeal cavity and the opercular cavity.

The oxygen-rich water passes over the gills, where the oxygen is absorbed by the blood vessels in the gill filaments and then distributed throughout the body.

Next, the CO_2-laden water is expelled through the gills.

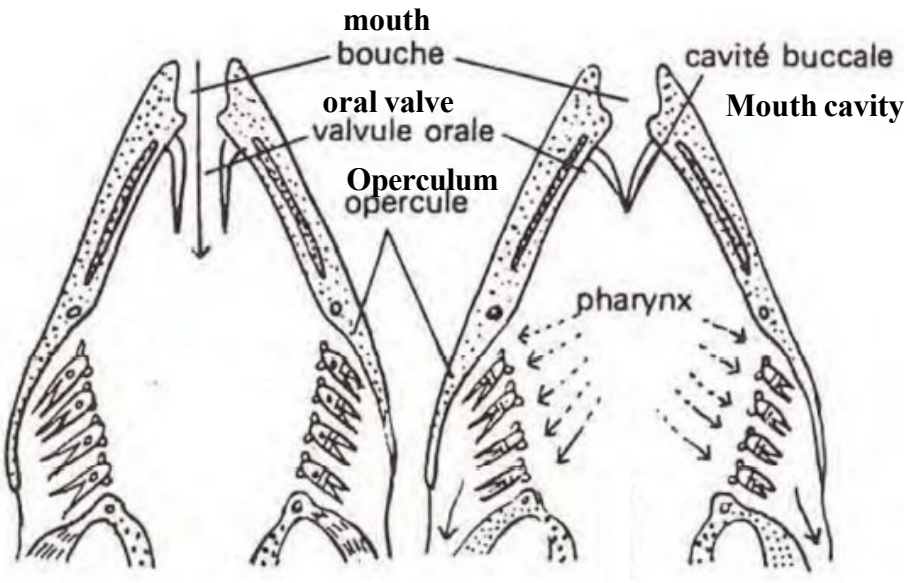


Schéma montrant les deux temps de la respiration

Diagram showing the two phases of breathing

Notes

- In some fish, especially those kept in aquariums, additional systems allow them to use air when gas exchange with the water is insufficient. This is known as bimodal respiration.
- The gills have a thin membrane that separates the blood from the external environment.
- The respiratory rate in fish increases when they are exerting themselves or when oxygen levels decrease.

3.2) Digestion

A fish's diet tells us about its behavior. A fish's tongue is not very mobile; it is used to move nutrients along. Food sources are very varied. Fish can therefore feed on plants, algae, plankton, plant debris, mollusks, surface-dwelling insects, crustaceans, and larger fish. In most cases, a fish's diet is not limited to a single food category, but may include several.

The position of the jaws in relation to one another helps answer several questions: What does the fish eat? Where is its food located, and in what position does the animal feed? We distinguish between:

- The superior position:

The lower jaw is prominent. (Applies to surface-dwelling fish).

- The terminal position:

Both jaws are the same size. (Applies to fish found in both freshwater and saltwater).

- The lower position:

The lower jaw is shorter than the upper jaw. (Bottom-dwelling fish).

The digestive tract is adapted to various types of diet; indeed, this can be observed by comparing the length of the intestine to the body. This length increases as we move from carnivorous to omnivorous and then herbivorous diets.
This criterion is indicative, as other characteristics, such as mouth and dentition adaptation, must also be considered.

In most fish, the mouth is often lined with teeth pointing backward. The morphology, arrangement, and function of the teeth are important criteria for determining taxonomic groups.

- **We distinguish based on the number:**
- Polydonty:

Presence of numerous teeth on the jaws.

- Oligodonty:

A reduced number of teeth in the jaws

- **We distinguish between the following types:**
  - Homodontia: The teeth are similar.
  - Heterodonty: The presence of several types of teeth.

There is a significant difference in the shape and size of teeth among different fish species; some have sharp, conical teeth called **canines**, which are very effective at seizing and piercing prey.

Species with canines hold onto their prey until it stops struggling before swallowing it. Other species have sharp teeth called **incisors;** these are located at the front of the mouth (sometimes saw-like and sometimes fused to form parrot-like beaks).

There are also **molar-like** teeth adapted for crushing crustaceans, mollusks, and other organisms with hard shells.

Teeth may also be **conical;** they are used to hold prey and to extract small organisms from plants. They (the teeth) may have one, two, or three cusps, in which case they are referred to as monocuspid, bicuspid, or tricuspid. They are used to dig up plants. Other teeth, which are **spatula**-shaped, are used to scrape plants.

Notes

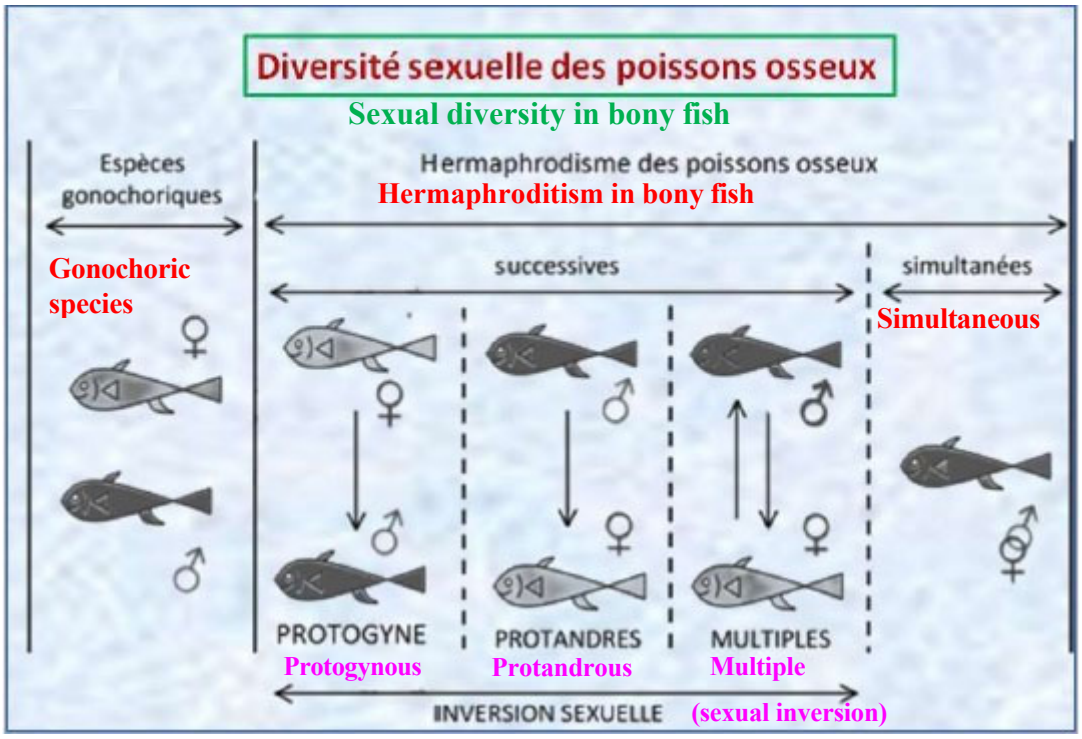
- Many fish have teeth at the entrance to their throats; these are **pharyngeal teeth,** which can take various forms depending on the species: pointed, molar-like, or rudimentary.
- Teeth may be arranged in a single row or in several rows.
- Some species may have teeth along the edges of the mouth (at the level of the premaxilla and maxilla).
- Many planktonic fish lack teeth; their gill rakers trap the microscopic organisms that serve as their food.

- The sea lamprey is a **parasitic fish**; its mouth is lined with rows of sharp teeth, and it attaches itself to the body of another fish, sucking its blood and bodily fluids.

- The esophagus and stomach can expand considerably when the prey is large.
- In predatory fish, the stomach is often large and the intestine shorter than the body.
- In fish with a mixed diet, the stomach is smaller than the intestine.
- In herbivorous fish, the intestine is longer than the body.
- In omnivorous fish, the stomach is small, and the intestine is quite large.
- The esophagus and stomach can stretch when the prey is large.

- It is rare but possible for a fish to choke when swallowing large prey
- Fish exhibit remarkable differences in their feeding habits.
- Predators tear their prey apart using well-developed teeth
- Other species, known as filter-feeders, feed on tiny organisms extracted from the water using their gills.
- Other fish are suckers; they have fleshy lips that stretch
- Fish feed more readily during the warmer months than during the colder months
- Some fish lack a stomach but use grinding teeth to crush food, making it more easily digestible.
- Some migratory species stop feeding during their journeys, their digestive tract narrowing to allow the reproductive organs to fill the abdomen.

3.3) Reproduction



When the sex cells mature, **the reproductive instinct** manifests itself. The fish move to **locations favorable** for the development of their offspring. Fish are **gonochoric**; some are **hermaphroditic,** and in this case, we distinguish between:

- **Protogynous** fish

These are individuals who transition from a female stage to a male stage. Example: the common sculpin.

- **Protandrous** fish

These are individuals who transition from male to female. Example: the gilthead seabream. In most bony fish, fertilization is external. In fish, the sperm is called **milt**; it is used to fertilize the eggs after they are laid in the water. These are **oviparous** animals.

In many bony fish species, the male displays a
'nuptial display', characterized by bright, vivid coloring. Spawning occurs when the water reaches the optimal temperature for each species.

The fate of the eggs varies by species. We distinguish between:

- Pelagic eggs that float on the surface.

- Eggs that water currents can carry.
- The eggs have adhesive filaments that allow them to attach to various surfaces.

3.4) Growth

This is defined as a change in size (length and weight) over time. From an energy perspective, it corresponds to a change in the number of calories stored in certain tissues (reproductive tissue). Most fish continue to grow throughout their lives, but this varies depending on the animal's life stage. Growth is rapid during the early years and gradually slows, so that in very old individuals the annual increase in size is very small.

Growth is a good indicator of the health of individuals and populations.

Rapid growth indicates abundant food and favorable conditions, whereas slow growth is likely to indicate the opposite.

The growth rate of fish varies greatly; it depends on several environmental factors, the most important of which are:

- **Temperature**

Growth can be rapid during the warmer months, when food is plentiful, and slow in winter.

- **The amount of dissolved oxygen in the water**

Each fish has a minimum oxygen level below which its metabolism is disrupted.

Some species can tolerate fairly low oxygen levels (catfish). Rising temperatures can affect oxygen levels.

- **The quantity and quality of food**
- **Age and stage of maturity**

Fish generally grow very rapidly during the first few months of their lives; until they reach maturity, a large amount of energy is devoted to weight gain.

The rate of growth also depends on other factors, including:

- **Ammonia.**
- **The photoperiod.**
- **The degree of intraspecific and interspecific competition**.

Note

High densities slow down growth.

Growth can be determined in two ways:

- **Rearing in a controlled environment**

Length and weight are measured at regular intervals.

- **Tagging**

Fish are tagged or marked, then released after their length and weight are recorded. The fish are recaptured after a period of time and measured again.

IV) The sense organs in bony fish

4.1) The Vision

In fish, the eyes are lateral, lack eyelids, are often bulging, and are independent of one another, which helps to widen the animal's field of vision.

The fixed gaze of fish stems from the fact that their pupils cannot contract; however, this allows them to maintain a wide field of vision.

The position of the eyes can vary among species (protruding eyes, eyes on the same side).

Bony fish have good color vision, but shapes are poorly interpreted; this depends on the depth at which each species usually lives.

4.2) Sense of smell

Odors are molecules dissolved in water; fish perceive them thanks to a highly developed sense of smell due to the presence of receptors concentrated in the olfactory sacs located in the nostrils.

Fish have nostrils with an inlet and an outlet separated by a skin bridge, allowing for efficient fluid circulation.

The different odors detected by fish can trigger various reactions, such as pursuing a mate, recognizing a predator, and navigating during migrations.

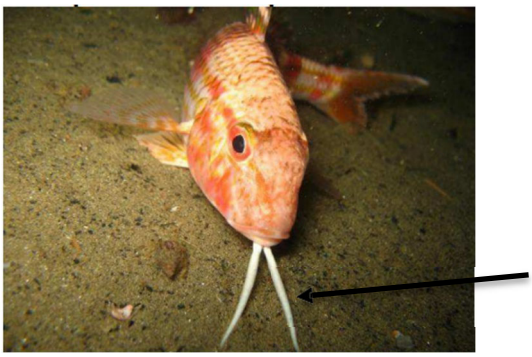
4.1) Sense of taste

Fish can identify tastes thanks to specialized cells: taste buds, which are widely distributed on the tongue and in the mouth, as well as on the head.

4.2) The sense of touch

Fish have numerous nerve endings on their skin. This is how they sense any friction, which can cause them to flee.

These nerve endings are found in large numbers on specialized organs: **the barbels.**



Barbel

Note

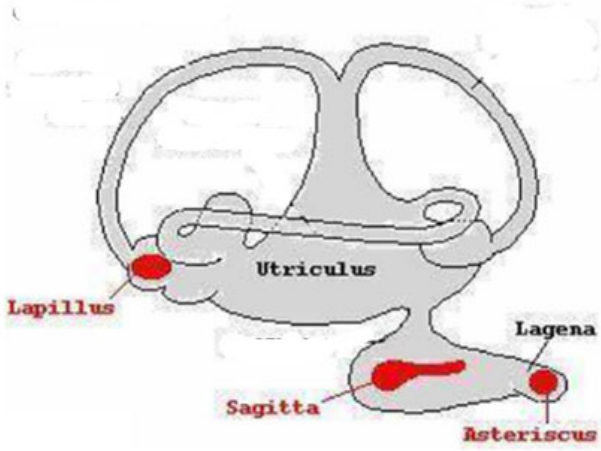
In some species, the sense of touch is provided by **organs other** than the skin.

Example: in the gurnard, the three free lower rays of the pectoral fins act as the sense of touch.

4.3) The internal ears and the lateral line

Fish have internal ears located on either side of the skull behind the eyes. These primarily serve the function of balance and, secondarily, the perception of some vibrations.
The inner ear canals contain small bony structures called otoliths, which are suspended in a fluid known as endolymph.
When the fish is moving, and under the influence of gravity and vibrations, the otoliths continuously provide the animal with information about its environment and its position in space.
The lateral line is a line, often running in pairs, found on either side of the fish's flanks.

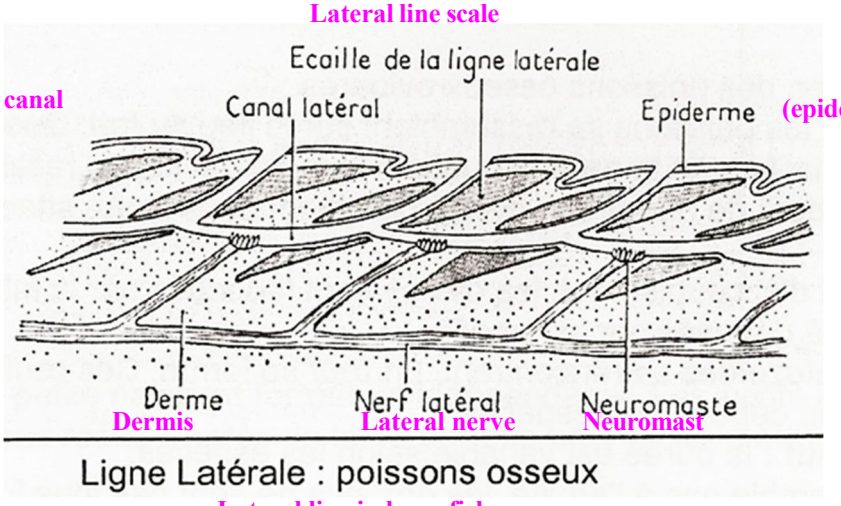
In bony fish, it extends from the rear of the operculum to the base of the caudal fin. It takes different forms depending on the species; it is a variable feature and may be absent in some species.



The lateral line is formed by a series of channels open to the outside; these channels contain receptor cells known as neuromast cells. These cells constantly inform the fish of the vibrations around it, which other fish or predators generally produce in motion.

The information transmitted to the brain is analyzed, enabling the fish to determine the direction, shape, and distance of an object.

Lateral line scale



Lateral canal

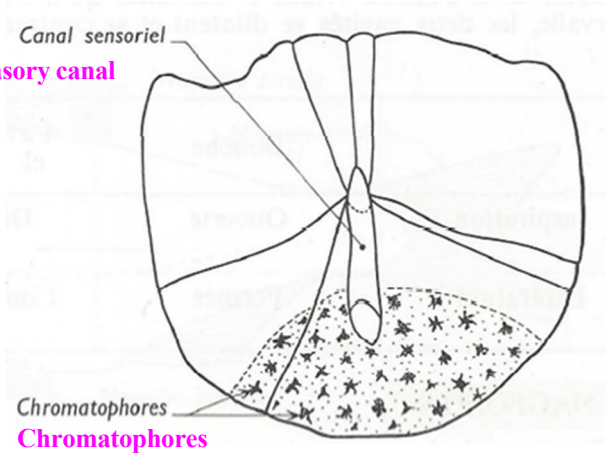
(epidermis)

Dermis

Lateral nerve

Neuromast

Lateral line in bony fish



Sensory canal

Chromatophores

Ecaille de la ligne latérale

Lateral line scale

BONY FISH MORPHOLOGY

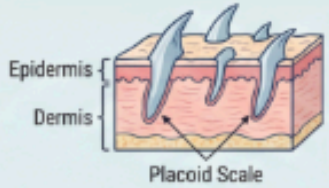
A Guide for Veterinary Medicine Students

Bony fish are vertebrates living in aquatic environments, characterized by scales covering their skin. They possess fins for locomotion and gills specialized for respiration.

1.1 THE SKIN

Cartilaginous Fish Skin

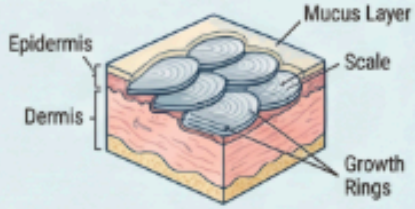
Highly rough texture. Discontinuous covering made of placoid-type scales, deeply embedded in the dermis.

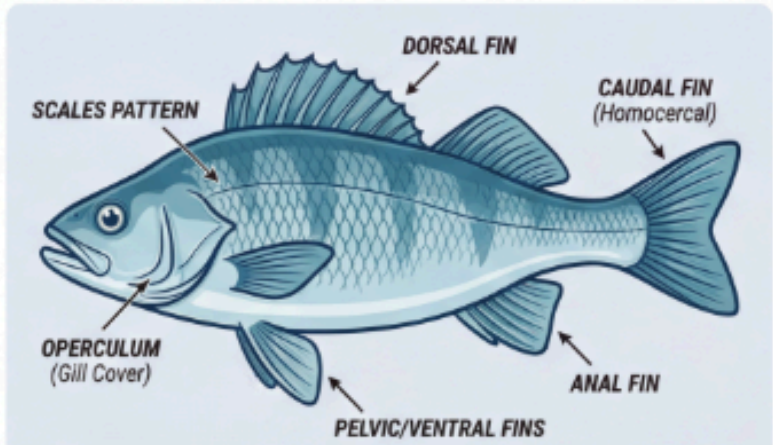


Bony Fish Skin

Body protected by overlapping scales (elasmobranchs). Embedded in dermis up to midpoint.

Peripheral growth is continuous but irregular, influenced by seasonal variations. Dermis also contains mucus-secreting cells covering the body for efficient movement.





1.2 THE FINS

PAIRED FINS

- **Pectoral fins** — located near the head/chest area
- **Ventral / Pelvic fins** — located on the belly

Function: Direction change, braking, and secondary stability.

UNPAIRED FINS

- **Dorsal fin** — maintains balance, prevents rolling
- **Anal fin** — works with dorsal fin for stability
- **Caudal fin** — primary propulsion

Caudal Fin Types

BONY FISH — Homocercal

CARTILAGINOUS FISH — Heterocercal

The shape of the caudal fin is a good indicator of the fish's speed.

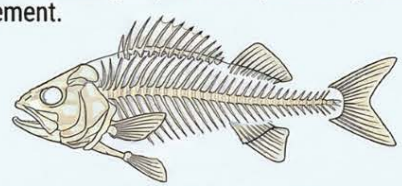
II) ANATOMY

2.1) The skeleton

In fish, the skeleton is of the axial type; it comprises

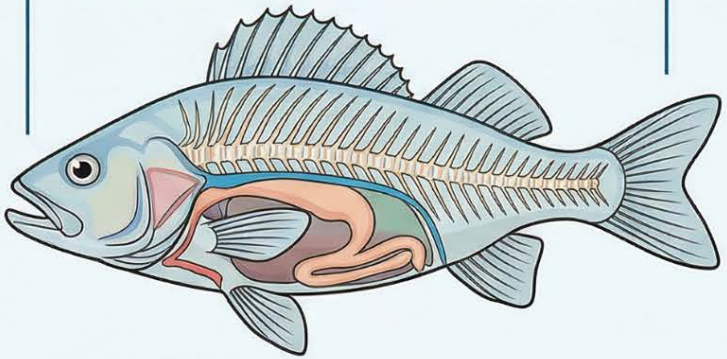
2.1.1) The vertebral column

It is made up of **several vertebrae and ribs**. The head skeleton comprises the skull and gill arches in bony fish; the endoskeleton enables steady growth; it is rigid and serves as an attachment point for various muscle groups, thereby enabling efficient movement.



2.2) The nervous system

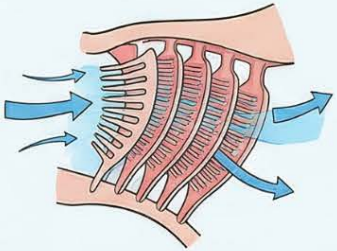
The **brain has two large lobes**: these are the olfactory lobes, which are connected to the olfactory pits in sharks and to the nostrils in bony fish.



2.3) The respiratory system

It consists mainly of **gills**, which comprise a **skeleton**, the **gill arch**, bearing thin, highly vascularised lamellae on its outer surface.

Water enters through the mouth and exits via the **gills** in bony fish and via the **gill slits** in **cartilaginous** fish. The gill arch bears **spines** called **branchiospines** at the front.



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The digestive system of fish is as varied as their diet.
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- The **mouth** and **teeth**.
- The **pharynx** and **esophagus**.
- The **stomach**, **intestine**, and **anus**.

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In bony fish, the **testes** are two elongated organs connected by a **vas deferens that opens into the genital pore**.
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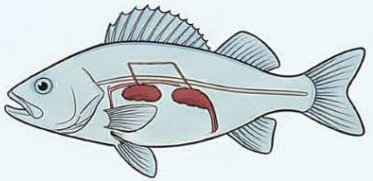
2.7) The excretory system

It consists mainly of the **kidneys**, which appear as two small, elongated, dark red masses situated against the dorsal wall of the abdominal cavity.



Glossary

Term	*Definition*
Branchiospines	***Spines located at the front of the gill arch; these can be very long, especially near the gill slits, forming a veritable filter.***
Homocercal fin	*A caudal fin where the two lobes are symmetrical, as called in bony fish.*
Heterocercal fin	***A caudal fin where the two lobes are asymmetrical, as known in cartilaginous fish.***
Heterodonty	*The presence of several types of teeth.*
Homodontia	***The teeth are similar.***
Oligodonty	*A reduced number of teeth in the jaws.*
Lateral line	***A line formed by a series of channels open to the outside; these channels contain receptor cells known as neuromast cells.***
Pharyngeal teeth	*Teeth at the entrance to the throats, which can take various forms depending on the species: pointed, molar-like, or rudimentary*
Protandrous fish	***Individuals who transition from male to female.***
Protogynous fish	*Individuals who transition from a female stage to a male stage.*
Pyloric caeca	***Elongated anatomical extensions that compensate for the small size of the digestive tract by increasing the surface area of the intestinal mucosa.***
Swim bladder	*A thin-walled sac connected to the esophagus by a canal known as the pneumatic canal, allowing fish to withstand varying water pressures as they swim up or down.*