

Physiology of finfish and shellfish

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What is physiology?

- It is the branch of biology dealing with the functions and activities of living organisms and their parts, including all physical and chemical processes.

Fish physiology

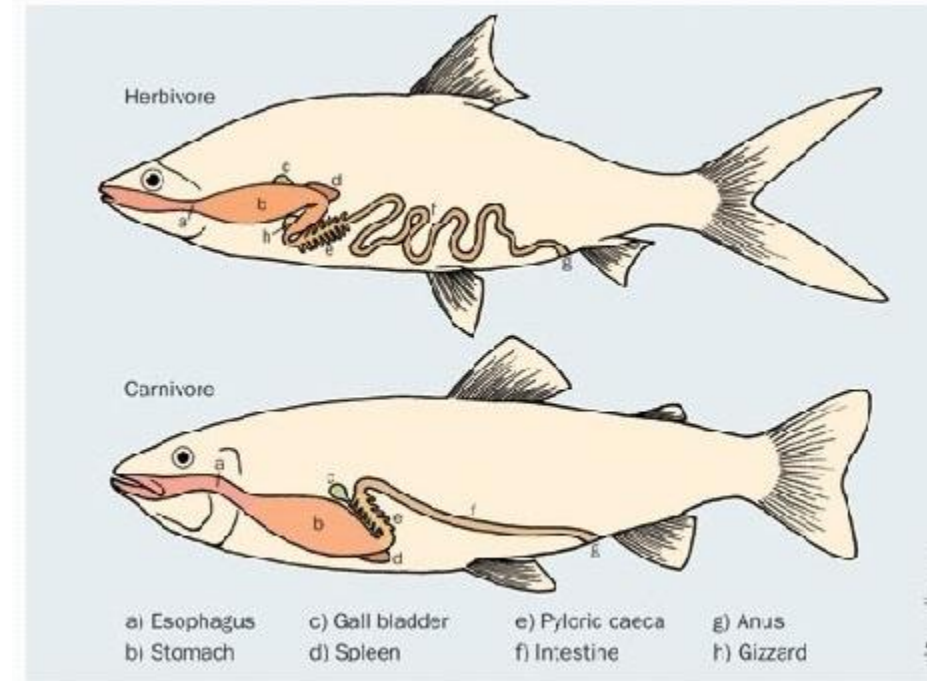
- ❖ It is the scientific study of how the component parts of fish function together in the living fish.
- ❖ It can be contrasted with fish anatomy, which is the study of the form or morphology of fishes.
- ❖ In practice, fish anatomy and physiology complement each other
- ❖ **Anatomy** dealing with the structure of a fish, its organs or component parts and how they are put together, such as might be observed on the dissecting table or under the microscope,
- ❖ **Physiology** dealing with how those components function together in the living fish.

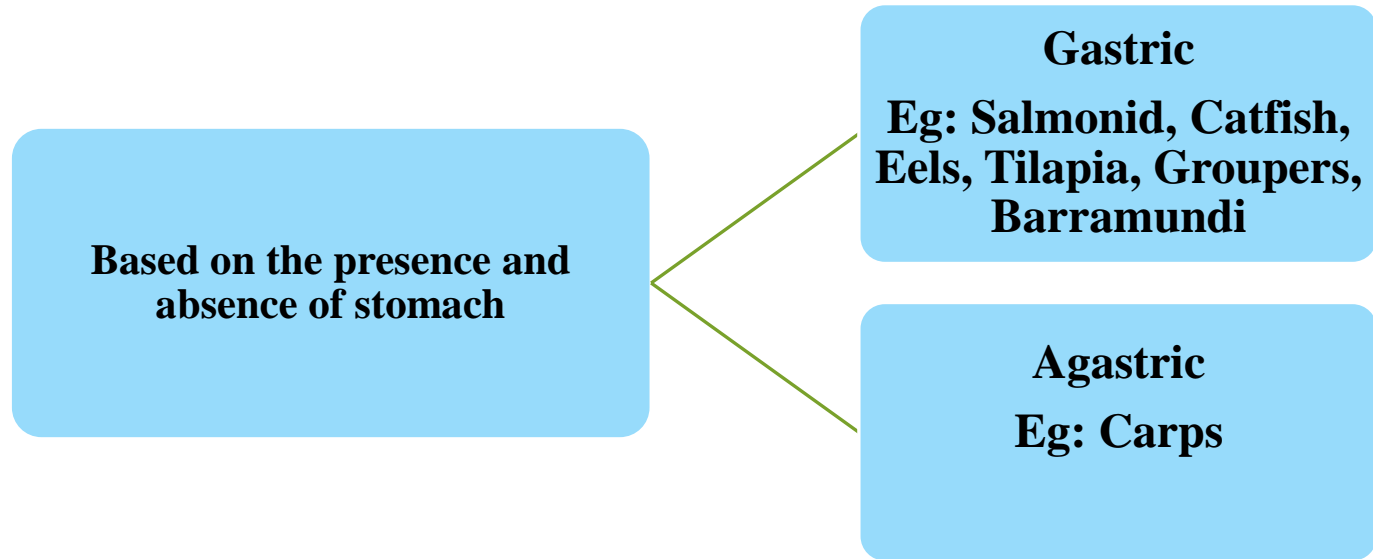
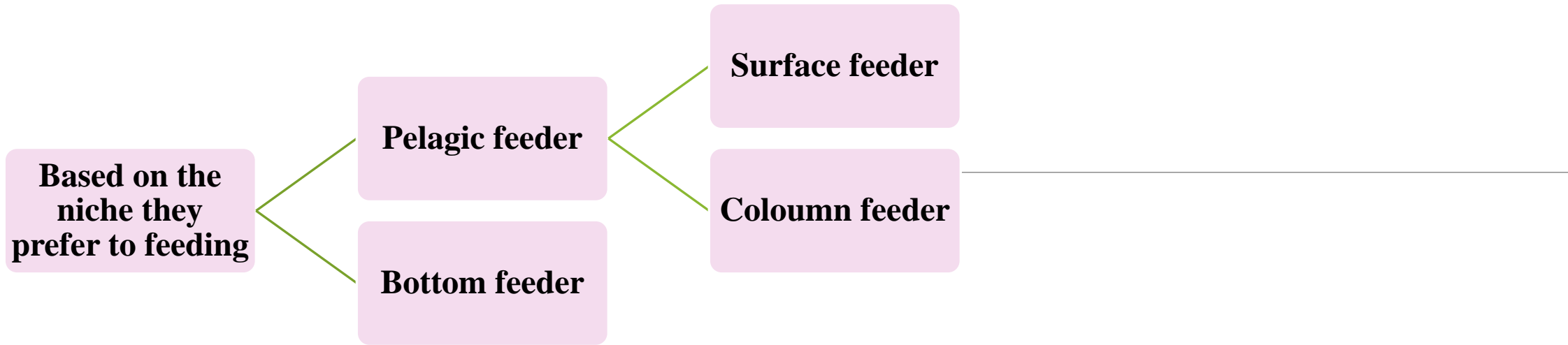
Digestive system physiology

- ❑ The function of the digestive system is **to digest and absorb food and then excrete the waste products with the help of the liver, gallbladder, pancreas, small intestine, large intestine, and rectum.**
- ❑ Each of these organs plays a specific role in the digestive system.

Classification based on feeding habit

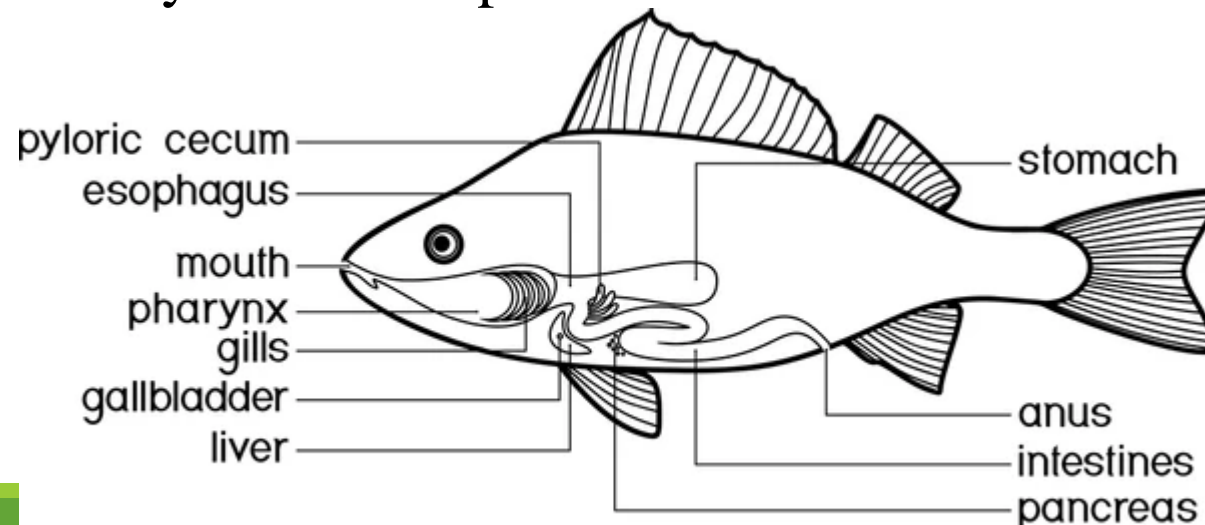
- Feeding and digestive system of fishes are diverse
- Based on the feeding habit
- **Herbivores:** Feed largely on plant materials
- **Omnivores:** Generally consume mixed diet
- **Carnivores:** Consume only animal matter
- **Detritivores:** Feed largely on detritus (mixture of sediments, decaying organic matter and bacteria)





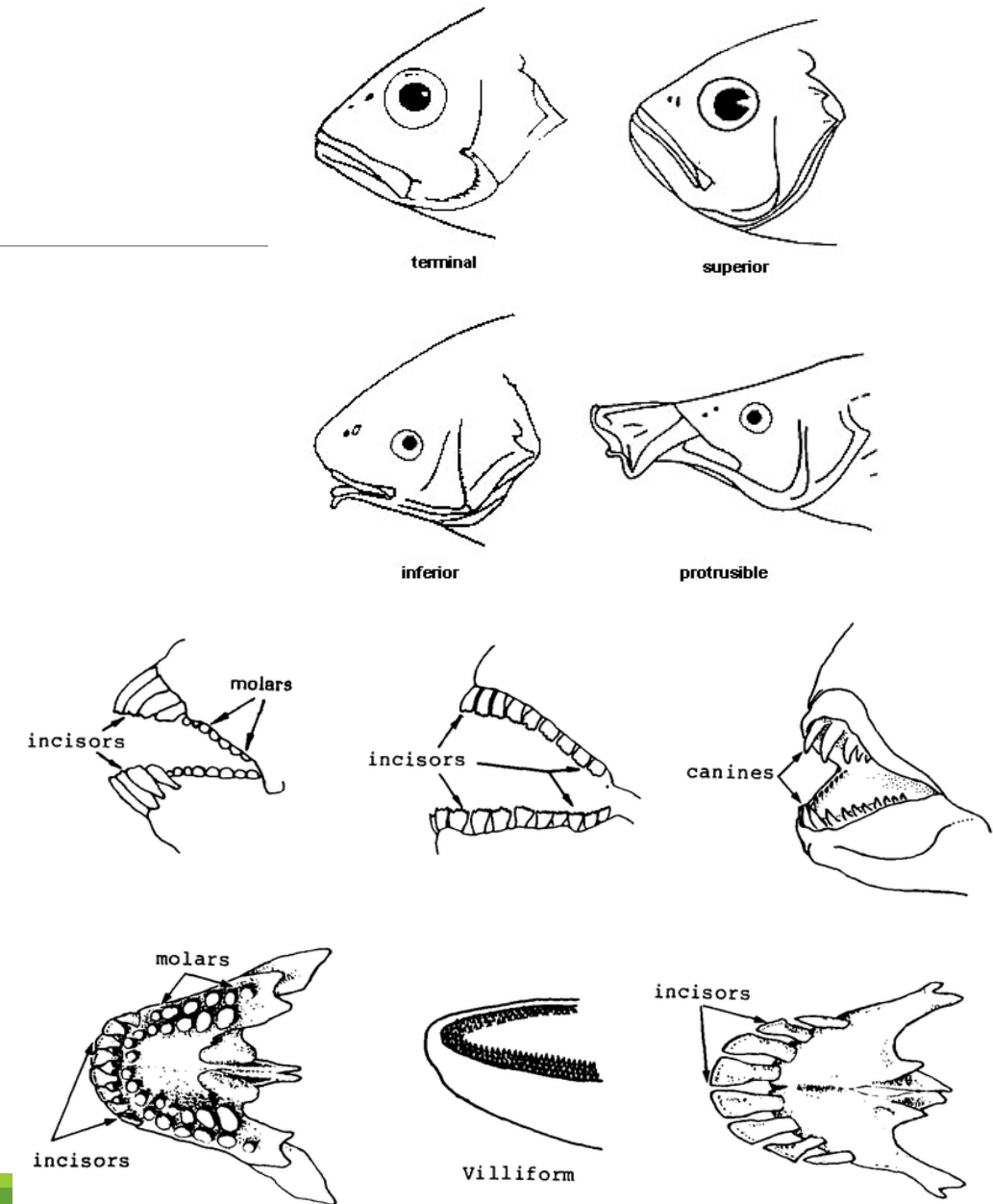
Digestive system of fish

- Digestive system is comprised of alimentary canal and associated digestive glands.
- Alimentary canal: mouth, buccopharynx, esophagus, stomach, pyloric caecae, intestine, vent (Anus)
- Digestive glands: liver, gall bladder, pancreas
- A fish's digestive system is adapted to their food habits

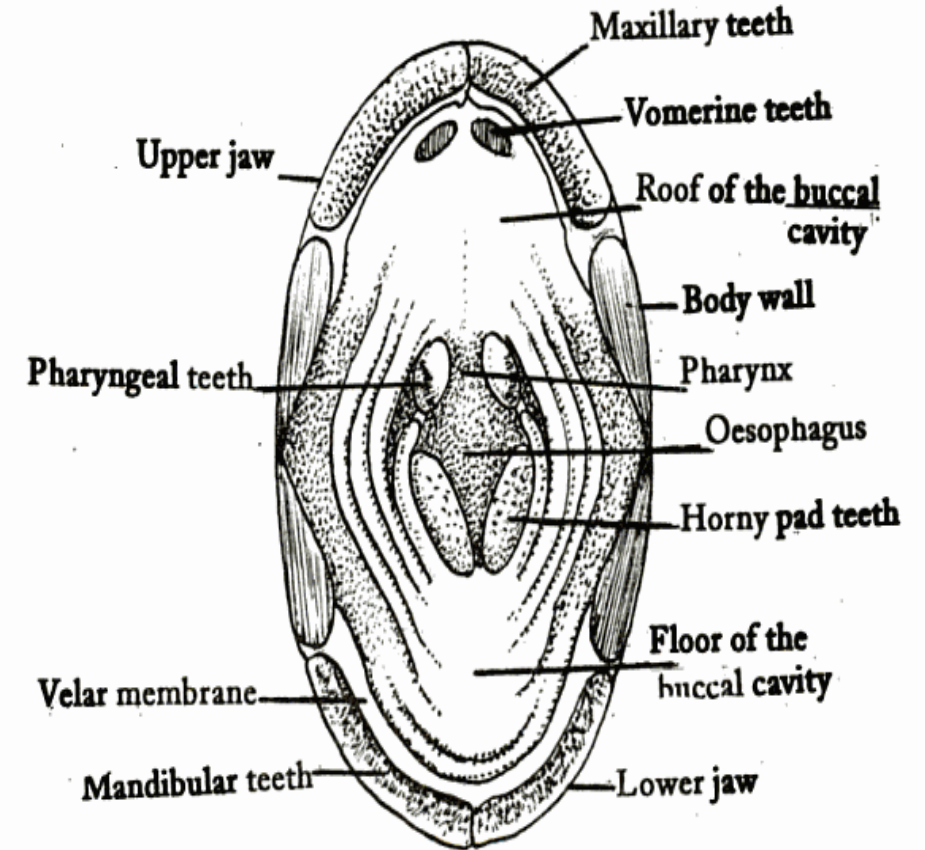


Mouth

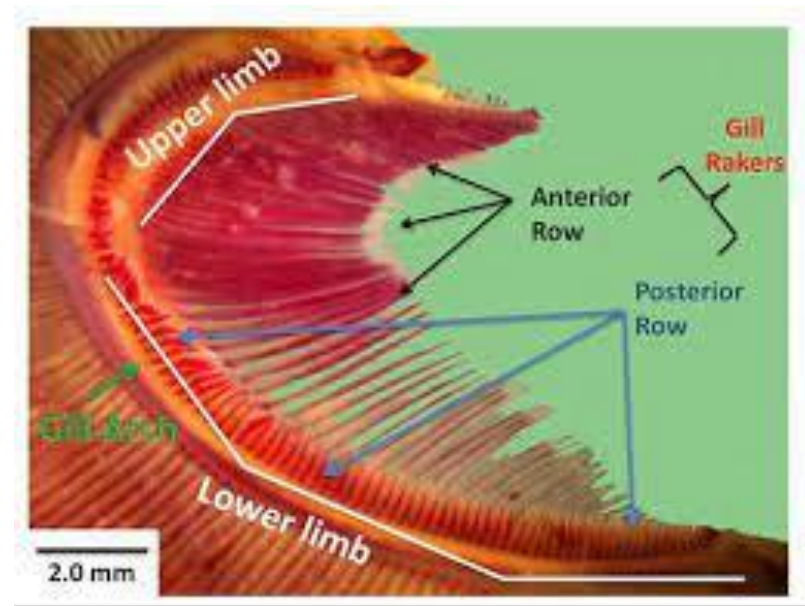
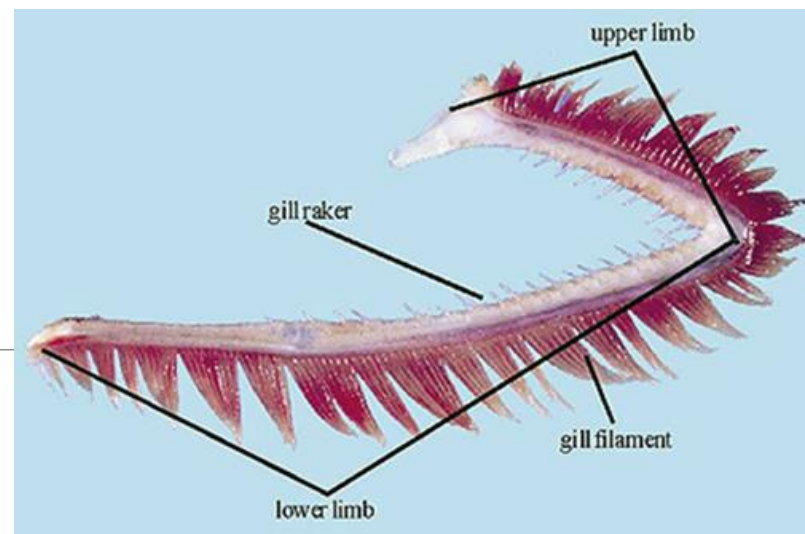
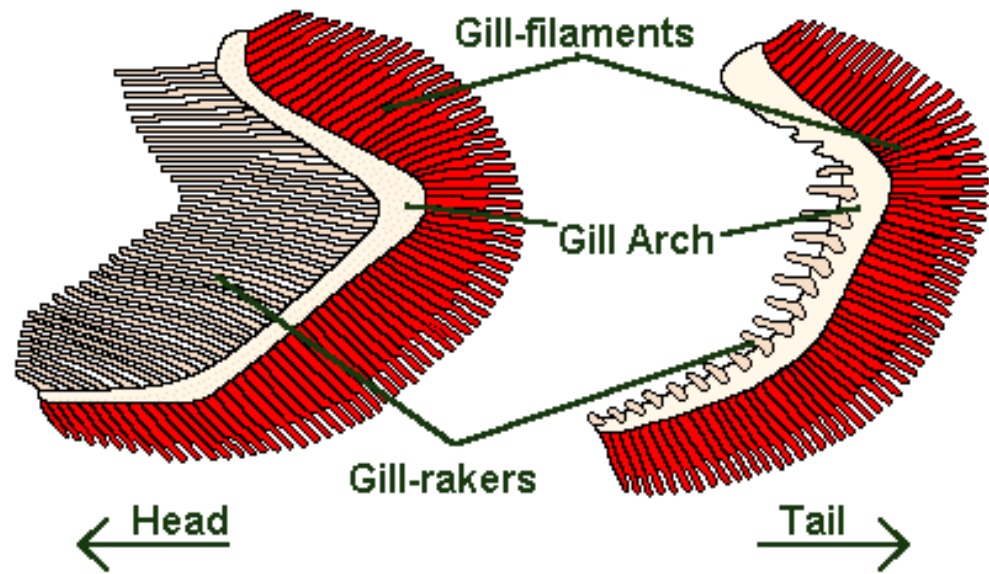
- ❖ It is the anterior most opening of body.
- ❖ Position, shape and size vary with food and feeding habits
- ❖ Mouth contains jaws having various types of teeth on it for retention, cutting and crushing of food viz. villiform, canine, incisor, premolar etc. according to the feeding habits.
- ❖ Mouth leads to buccopharynx.



- ❖ Agastric fishes-Do not have teeth on jaw
- ❖ Most stomach less cyprinids have pharyngeal teeth which are modified to varying degree depending on the nature of the diet
- ❖ These teeth helps in crushing and mastication of plant food particles
- ❖ Buccal teeth- food capturing and holding but do not assist in tearing of the prey , except in Piranha
- ❖ Filter feeders: Filtering apparatus composed of gill rakers of selected gill arches, which are modified to form fine sieve
- ❖ Most fishes do not have tongue except some carnivorous fishes
- ❖ The tongue supplements function of teeth in retention of prey, and may act as sensory organ



Diagrammatic Representation of Two Forms of Fish Gills



Buccopharynx:

- ❑ No clear demarcation between buccal cavity and pharynx - buccopharynx.
- ❑ True tongue is absent
- ❑ Some fishes immovable tongue like structures present (*Notopterus chitala*).
- ❑ Tongue - possess teeth for crushing/grinding of food
- ❑ e.g. pharyngeal teeth in carps, palatine teeth in marine catfishes and gills for filtering food and exchange of oxygen from water (4 pairs in bony fishes and usually 5 pairs in cartilaginous fishes, opening out through separate gill slits).
- ❑ Buccopharynx opens in to the oesophagus through a circular opening called gullet (esophagus).

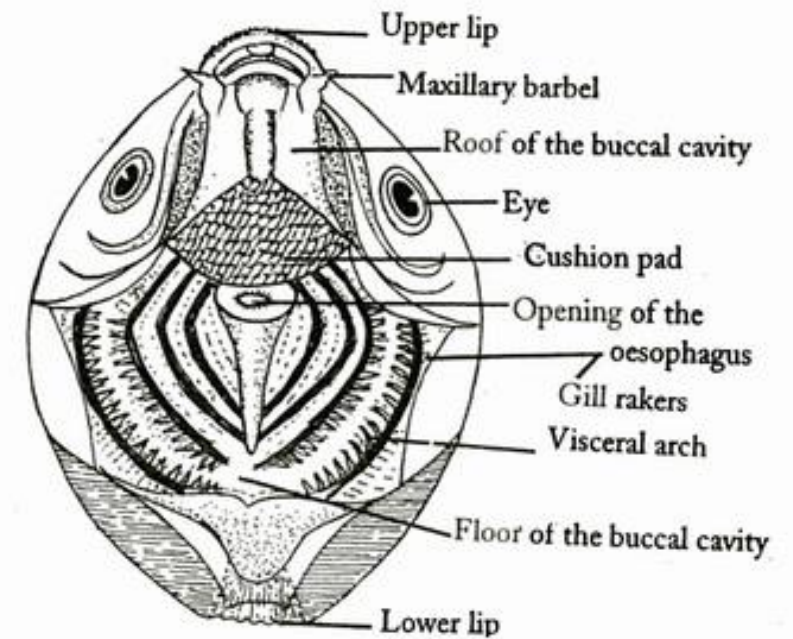
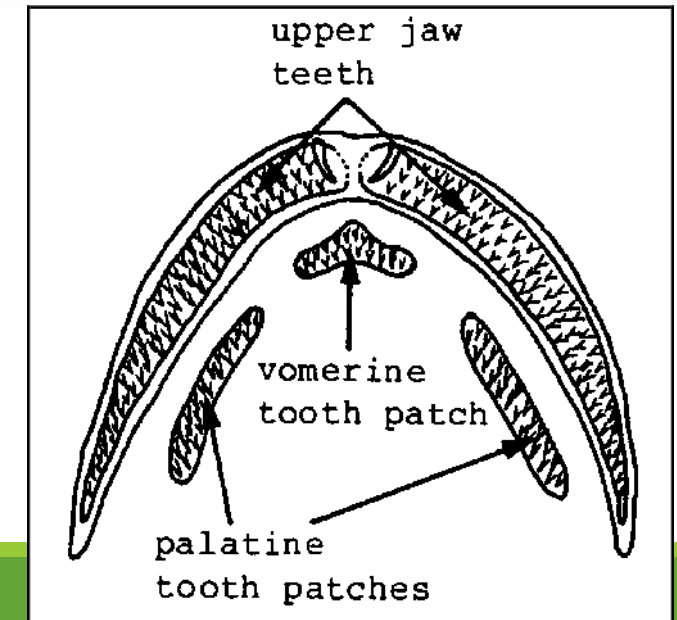


Fig. 13 : Buccal cavity of *Labeo rohita*



Oesophagus:

❖ Short, narrow and tube like distensible muscular structure which convey food into the stomach.

❖ This is the beginning of actual alimentary canal.

Stomach:

❖ A muscular bag (sac) like structure of alimentary canal where actual digestion takes place

❖ Most fishes true stomach is not present, it is just a bulbous expansion of the intestine.

❖ Size and shape of stomach vary in different species.

❖ It is much expandable / extensible

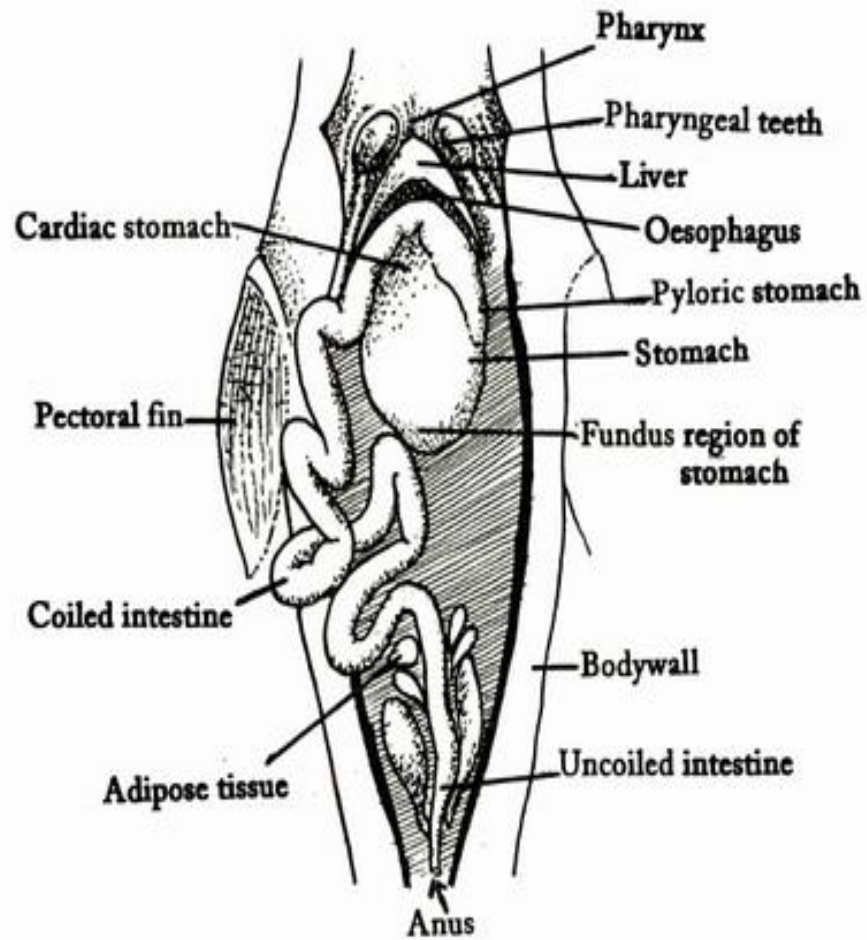


Fig. 10: Alimentary canal of *Wallago attu*

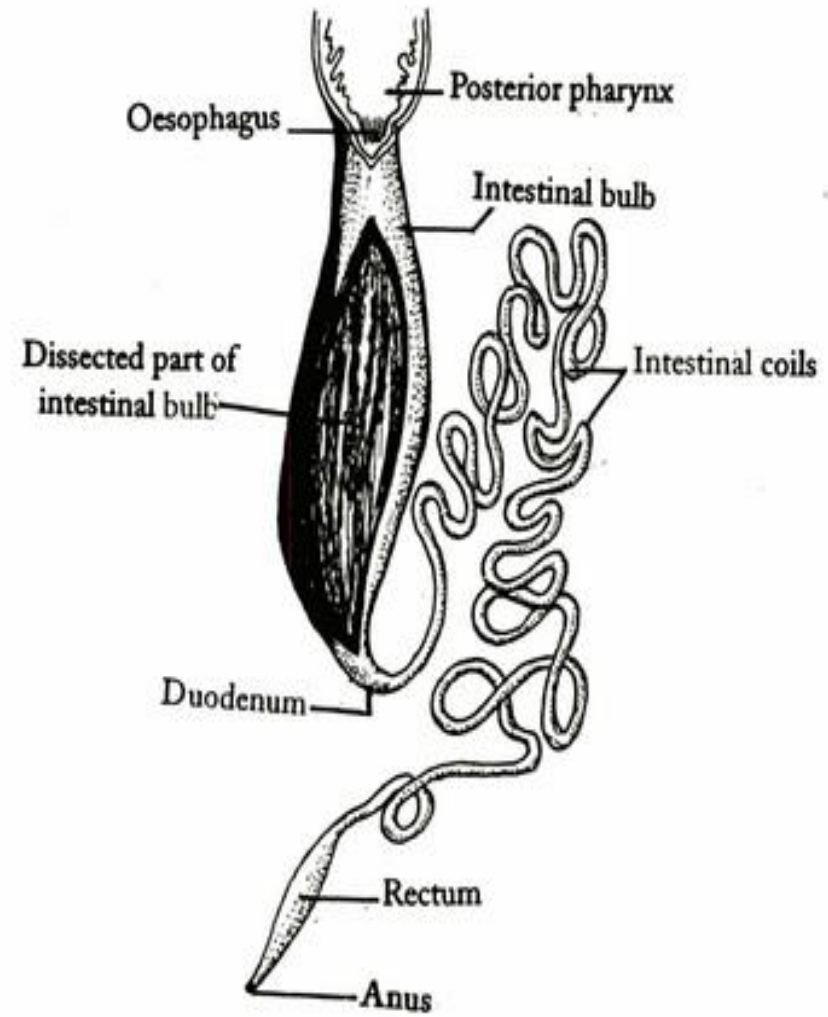


Fig. 14: *Labeo rotita*—Alimentary canal

Intestine:

- ❖ Tube like elastic structure, which terminates in to vent.
- ❖ Absorption of digested fish material takes place in this part.
- ❖ Posterior end of intestine is little broader in some fishes, which is known as rectum.

Vent/Anus:

- ❖ It is the posterior most opening of alimentary canal through which waste products are excreted out.

Pyloric caeca:

- ❖ Finger like projections present at the junctions of stomach and intestine
- ❖ Helps in digestion and increase the area for absorption of digested products.

Digestive glands and enzymes

Digestive glands:

Liver:

Yellowish brown gland

comprised of two lobes, which are further subdivided in to smaller lobes.

Secretes bile which helps in digestion (acts as digestive enzyme).

Stores glycogen as reserve food as well as vitamin A & D.

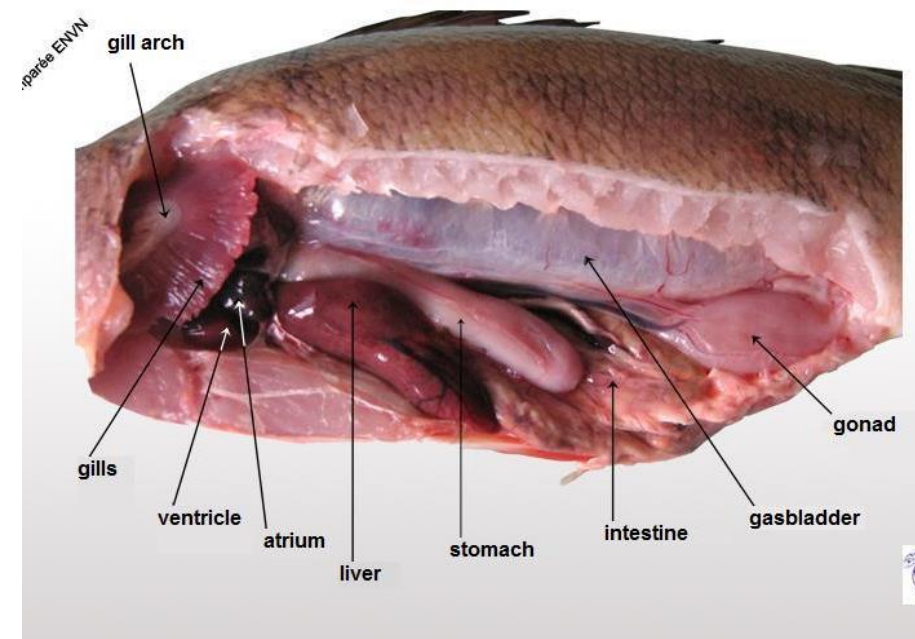
Destruction of old blood cells .

Gall bladder:

Narrow sac

Attached to right lobe of liver and stores bile .

Bile ducts from bladder open into intestine little behind pylorus.



Pancreas:

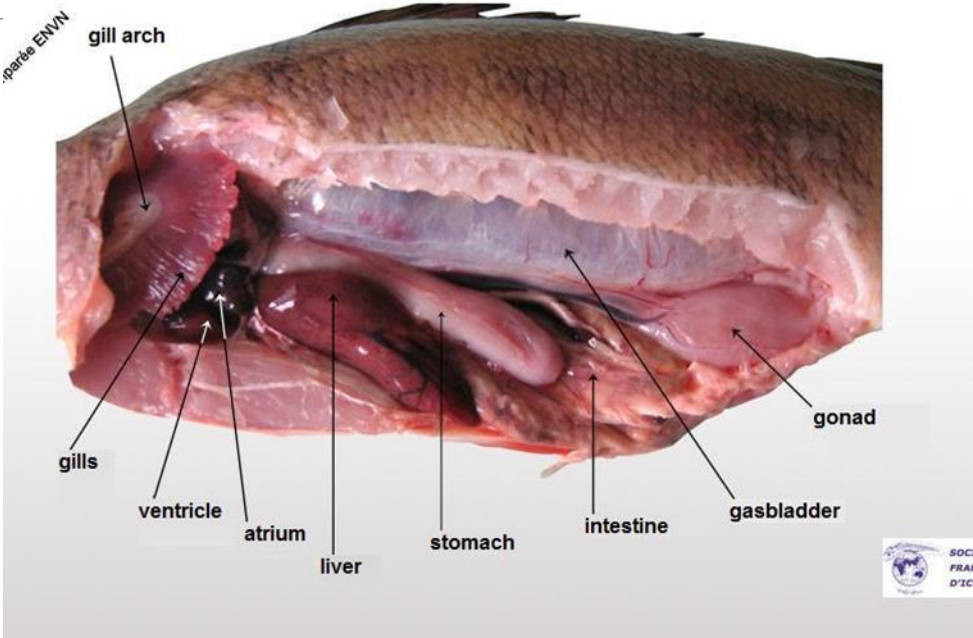
Diffused gland located in the mesenteric membrane surrounding the intestine and liver.

A part of it extends over the surface of stomach or concentrated in a compact organ (Mackerel)

Cartilaginous fishes it is relatively diffused.

In some fishes dispersed into liver forming hepatopancreas.

Pancreatic islets of langerhans - secretes insulin.



Gastro-intestinal Hormone In Fish Digestion

- ❑ Gastrointestinal hormones constitute a group of hormones produced from specialized endocrine cells of the stomach, pancreas and small intestine, which are secreted directly into the bloodstream
- ❑ The **gastrointestinal tract** is an organ system which takes in food, digests it to extract and absorb energy and nutrients, and expels the remaining waste as feces.
- ❑ The GIT of fish and other vertebrates are challenged with a diversity of functional demands caused by changes and differences in inputs and environmental conditions.

Major gastrointestinal hormones

Secretin

Cholecystokinin

Gastrin,

Gastric Inhibitory Peptide(GIP)

Vasoactive Intestinal Peptide(VIP) etc.

Secretin

Secreted by the lining of the duodenum (S cells in the intestine) in response to acid entering from the stomach

Secretin acts on the pancreas to increase the output of bicarbonate, which neutralizes the acid

It also increases the release of enzymes from the pancreas and reduce gastric secretion

Cholecystokinin

Released by the duodenum (I cells) in response to fats and acid

Cholecystokinin causes the gallbladder to squeeze bile into the duodenum

It stimulates the production of pancreatic enzymes, which pass into the duodenum through the pancreatic duct.

Gastrin

Secreted mainly by cells in the stomach, G cells in Gastric antrum (the wider part of the pylorus, which is the narrower part of the stomach) in response to eating food (especially protein)

Gastrin causes the stomach to produce more acid and stimulates contraction of muscle in the wall of part of the stomach, ileum, and colon

This contraction propels food through the digestive tract.

Gastric inhibitory peptide

Secreted by the lining of the duodenum (K cells)

Reduce gastric acid secretion and intestinal motility

Stimulates insulin release

Vasoactive intestinal peptide (VIP)

VIP is widely distributed throughout the central and peripheral nervous systems

Secreted from enteric nerve

Increase water and electrolyte secretion from pancreas and gut

It simulates smooth-muscle relaxation, both in the alimentary tract and in the systemic vasculature

Pancreas secrete two important hormone

Insulin: secreted from beta cell

Glucagon: secreted by alpha cell

Somatostatin is present in the stomach and pancreas of fishes.

They are called paracrine substances

It differs from hormone because it diffuses locally to the target cell instead of releasing into blood

It inhibits the release of insulin and glucagon from the pancreas.

Bile:

Produced by liver and stored in the gall bladder

Bile contains bile salts, cholesterol, phospholipids, bile pigments, organic ions, glycoproteins and inorganic ions

Bile emulsifies fat, maintain optimum internal pH for lipase activity, activates lipase and helps in excretion of toxins, heavy metals and different pesticides

Digestion

Process in which action of enzymes of digestive fluids and gut epithelial cells, proteins, polysaccharides, lipids and nucleic acids are degraded into small molecules that can be absorbed and assimilated

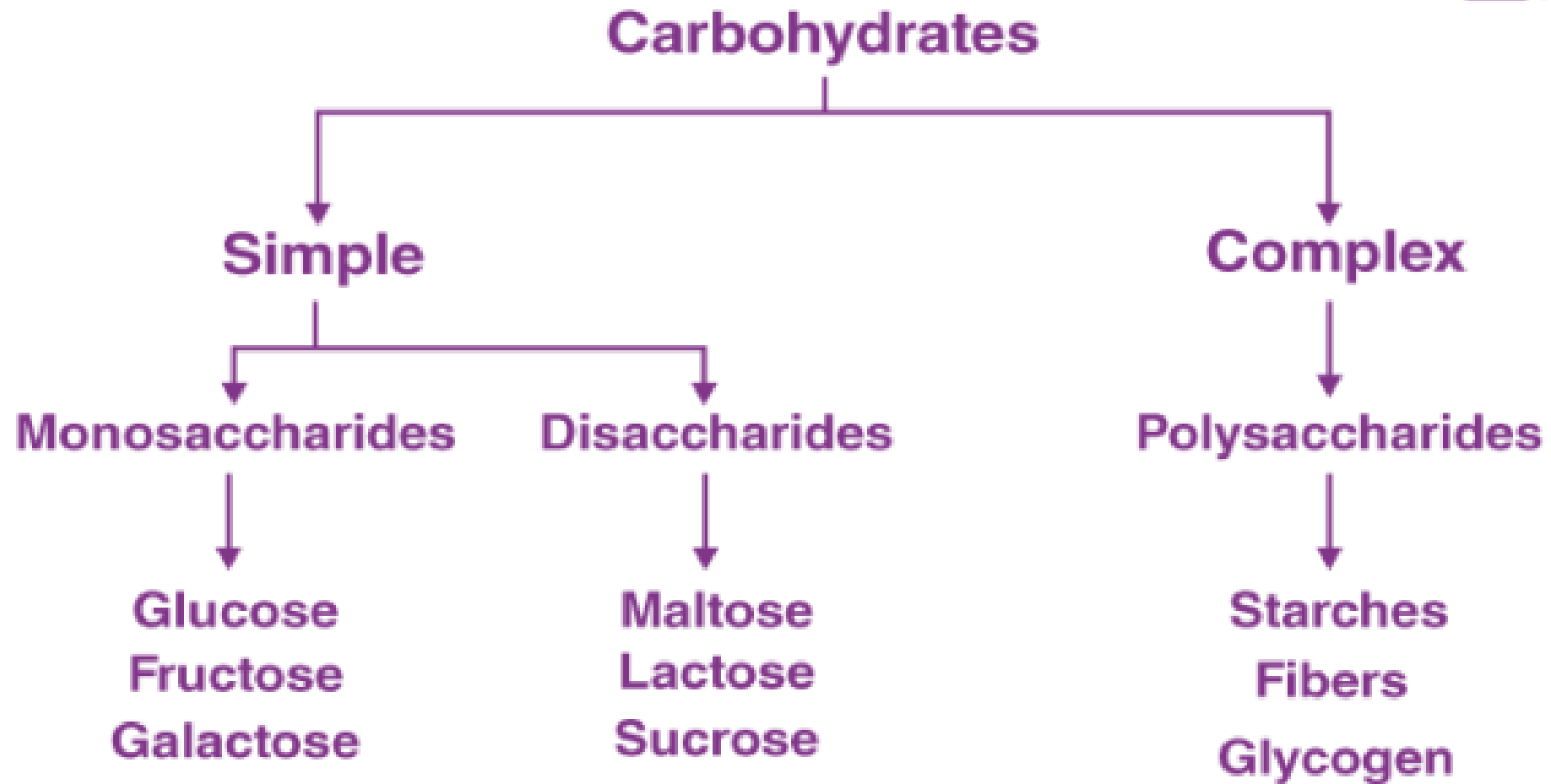
Digestion of carbohydrate

Carbohydrate

The term carbohydrates was originally derived from a large group of Organic compounds occurring in foods and living tissues including sugars, Starch and cellulose

It contain hydrogen and oxygen in the same ratio as a water (CH_2O) and typically can be broken down to reduce energy in the animal body

Monosaccharides do not need hydrolysis before absorption and this can be absorbed after digestion



The enzymes which break down the carbohydrates in the gut of fishes are

1. Amylase
2. Lactase
3. Sacchases/sucrase
4. Cellulase

Process of Carbohydrate digestion

Mouth: CH₂O digested to some extent in the mouth by amylase

Stomach:

Starch (Amylase) Maltose (Maltase) Glucose

Upper part of intestine  

Sucrose (sucrase) Glucose + Fructose

Maltose (Maltase)  Glucose + Glucose

Lactose (Lactase)  Glucose + Galactose



Digestion of proteins

Proteins are large biomolecules, or macromolecules, consisting of one or more long chains of amino acid residues

Protein is an important component of every cell in the body

Proteins is an important building blocks of bones, muscles, cartilage, skin and blood.

Enzymes that's required for the digestion of Protein

1. Pepsin (Stomach of carnivores fishes)
2. Trypsin (Intestine [alkaline medium], Pancreas intestinalcaecae)
3. Chymotrypsin
4. Erypsin (Collection of peptidases are known as erypsin, found in intestine)

Digestion of proteins

Protein digestion begins starts in fish mouth

The fishes which possess stomach are generally carnivorous & secrete pepsin enzyme from gastric mucosa

The pepsin is protease enzyme, it can break down protein

The stomach produces HCl, which is needed to activate protein digestion

The pancreas release trypsin, digestive enzyme, into the small intestine

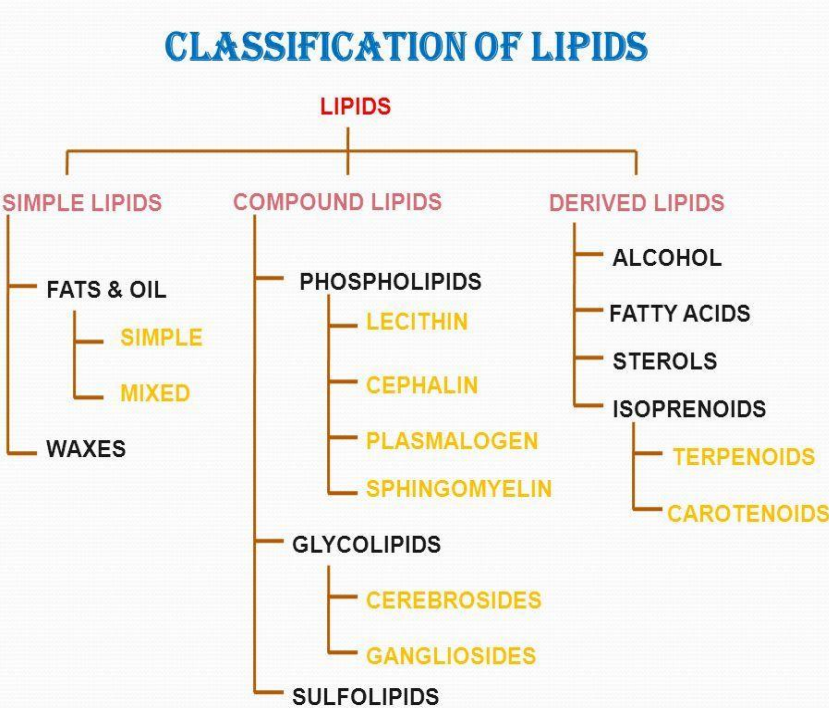
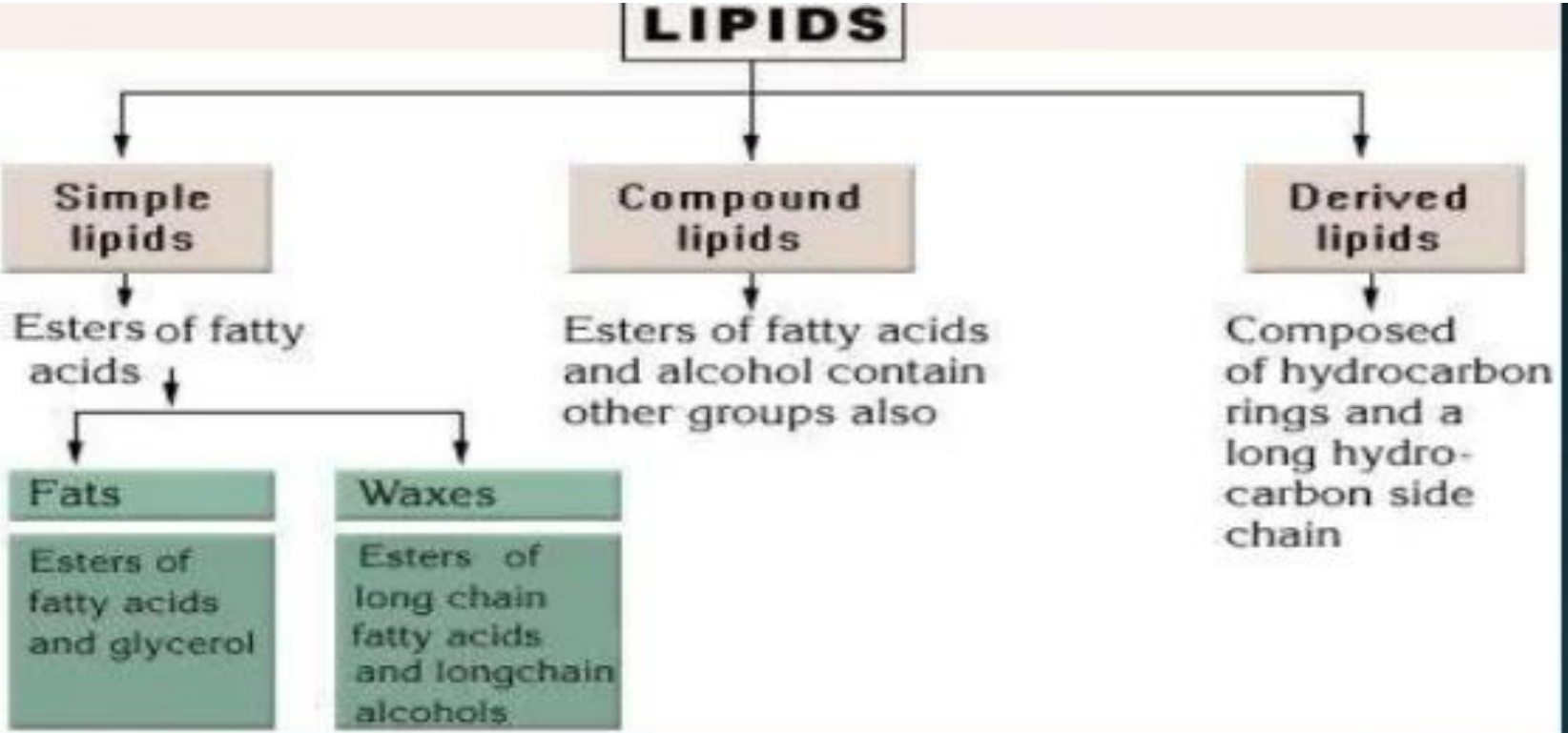
The protein molecules are reduced in size until they can pass through the intestinal wall

Once the protein molecules are reduced to their smallest component parts, they are ready to enter bloodstream.

Digestion of Lipid

A lipid is a biomolecule that is soluble in nonpolar solvents

Non-polar solvents are typically hydrocarbons used to dissolve others neutrally occurring hydrocarbon lipid molecules that do not dissolve in water, including fatty acids, waxes sterols, fat-soluble vitamins.



For the digestion of Lipids lipases enzyme is required.

Lipases enzyme is secreted as

- Lingual lipases
- Pancreatic lipases
- Enteric lipases

Digestion of Lipid

- ❖ Pancreatic lipases is a powerful lipolytic enzyme
- ❖ It's digests triglycerides into monoglycerides
- ❖ Lipase can break them into the smaller parts that can enter the intestinal vili for digestion
- ❖ However, lipid digestibility varies between species & developmental stage, feeding rate, water temperature lipid source & its melting point.

Absorption of Fish

Absorption is the process by which one thing absorbs or is absorbed by another

Absorption efficiencies are about 97% for the protein fraction, and 91% for the total food consumed; they do not vary appreciably among the individuals of different body weights.

How Nutrients can enter absorptive cells?

Nutrients can enter (or exit) absorptive cells following a concentration gradient by simple diffusion or via the paracellular route.

Absorption of nutrients occur at a faster rate in tissues from the proximal intestinal regions compared to more distal regions in most but not all fish species.

Types of Absorption:

Protein/Peptide/Amino Acid Absorption

Lipid Absorption

Carbohydrate Absorption

Pigment Absorption

Synthesis and Absorption of Vitamins

- Minerals Absorption

- Phosphorus Absorption

- Calcium Absorption

- Magnesium Absorption

- Iodide Absorption

- Iron Absorption

DIGESTIVE PHYSIOLOGY- SHELLFISH

Digestive system

- The digestive tract is responsible for the nutritional function.
- This function, includes ingestion, transit of nutriment, mechanical digestion, chemical and biochemical hydrolysis, cellular absorption and transfer of excreta, occurs in the digestion tract.

- Digestive system of prawn consists of two parts

1. Alimentary canal

2. Digestive glands

Alimentary canal

This is tube like structure which opens at both the end

The anterior opening is **mouth** and posterior opening is **anus**

The remaining part has irregular shape and size

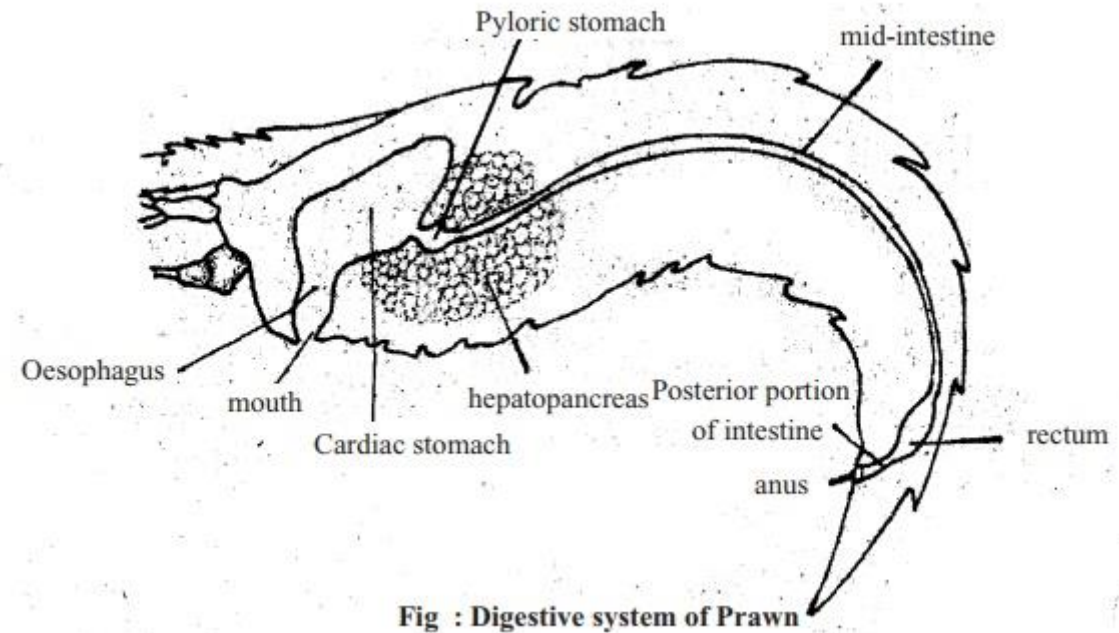
The alimentary canal of prawn is divided into three parts. Namely,

- A) For gut or alimentary canal
- B) Mid gut or mid alimentary canal
- C) Hind gut or posterior alimentary canal

a) For gut or anterior alimentary canal

Divided into four parts

1. Mouth opening
2. Buccal cavity
3. Oesophagus
4. Stomach



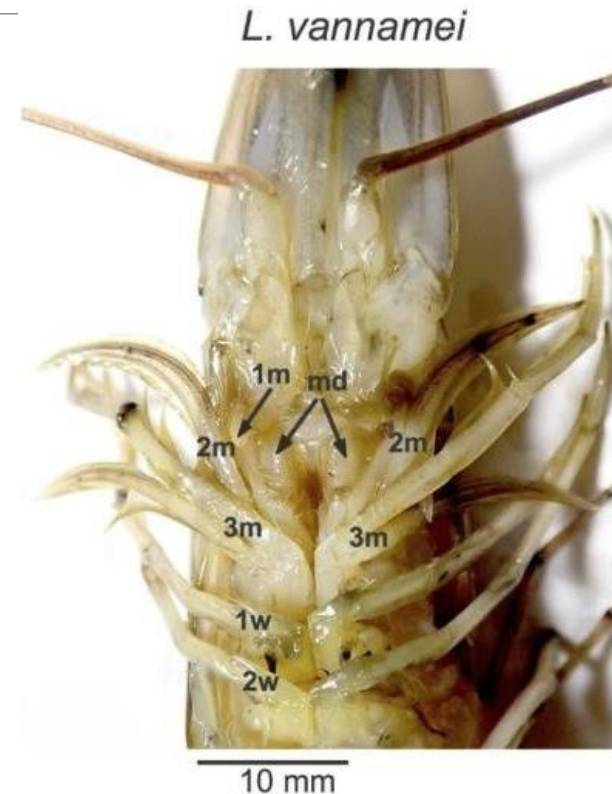
1. Mouth opening

It is a broad opening on the ventral side of the head situated at the junction of 3rd and 4th cephalic segments

Through this opening food enters

It is bordered anteriorly by shield like labrum (upper mouth), posteriorly by two lobed labium (lower lip) and laterally by the incisor processes of the mandibles (jaws).

Where the food crushed here



2. Buccal cavity

This short cavity is situated between the mouth and oesophagus

It has an irregularly folded lining of cuticle

3. Oesophagus

At the back of buccal cavity a short and wide oesophagus is present, from where the food passes to the stomach

- It is relatively short and straight
- The wall of oesophagus is made up of chitin-protein complexes
- The cross section is generally X-shaped

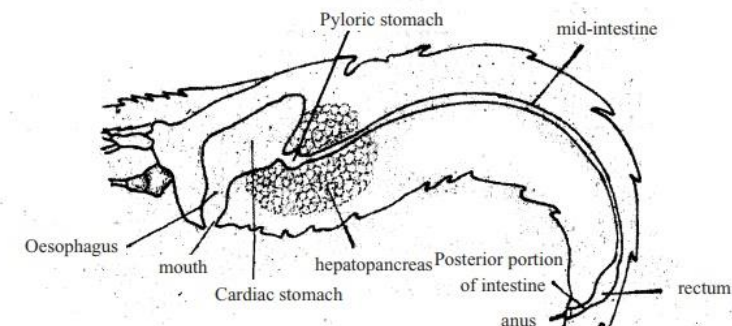


Fig : Digestive system of Prawn

4. Stomach

- ❑ Big sac like organ behind the oesophagus
- ❑ This is the largest and widest part in cephalothorax region and covered with hepatopancreas.
- ❑ During larval development, hard structures (bristles, spines and brushes) are present on the internal walls of the stomach, which results in the same way as teeth do in vertebrates

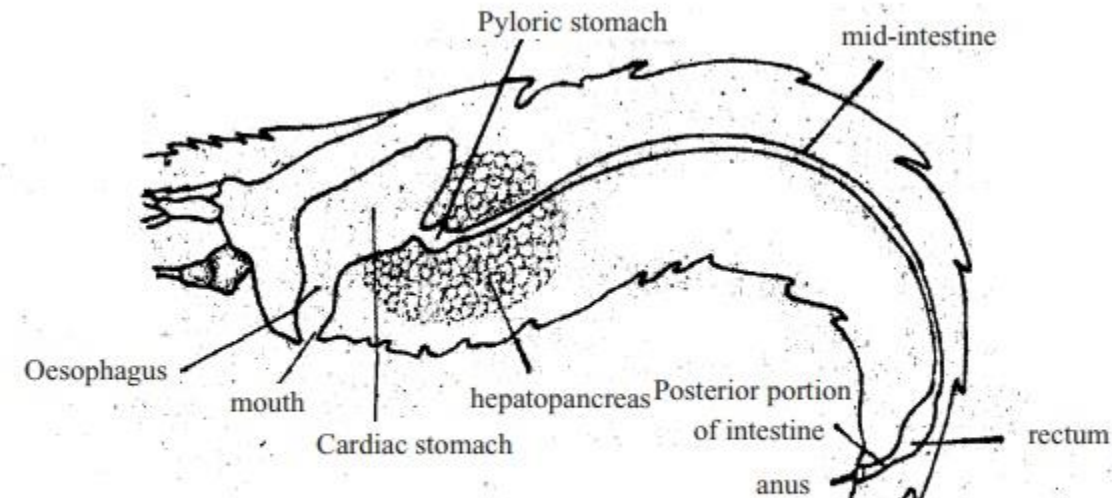


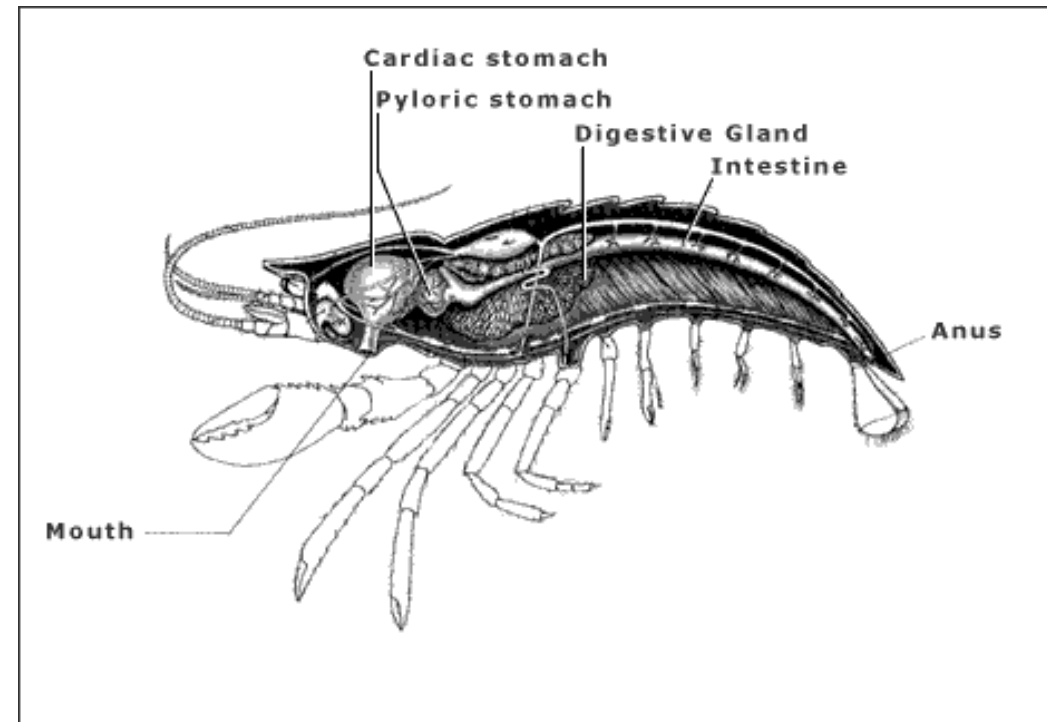
Fig : Digestive system of Prawn

Stomach has two parts

- a) cardiac stomach and
- b) Pyloric stomach
- These two parts are separated by marked valve.
- The cross section of the cardiac chamber is X-shaped

B) Mid gut or mid alimentary canal

- This is straight, long narrow and tubular portion of the alimentary canal
- It is extended along the mid dorsal line upto the 6th abdominal segment
- Its function is to absorb digested food and undigested food passes to the rectum through mid gut
- Its lumen is wide at the anterior end but reduced posteriorly due to the presence of longitudinal folds



C) Posterior alimentary canal or hind gut

- ❖ Behind the mid gut a small tube extended upto anus.
- ❖ It has following portions
 1. Rectum: small sac-like, first portion of the posterior alimentary canal
 2. Narrow tubular posterior portion: it is located behind the rectum.
- ❖ At its posterior end anal opening is present
- ❖ The undigested waste materials are stored here
- ❖ The faecal wastes eliminated through the anus

2. Digestive glands

- ❖ Glands associated with the food digestion are termed as digestive glands
- ❖ In prawn or shrimp it occurs singly as hepatopancreas
- ❖ Which is orange colored massive organ and occupies most of the regions of Cephalothorax
- ❖ It is a large gland surrounding the stomach
- ❖ This gland functions like the liver, pancreas and small intestine of higher animals
- ❖ They secrete enzymes take part in digestion.

