Digestive System of Finfishes

Fish Digestion: Anatomy

- Two major groups: w/stomach, w/out
- w/out stomach: cyprinids (carps)
- w/stomach: cold-water salmonids, warm-water catfish, tilapia, eels, grouper
- All “pure” predators have a stomach and teeth

- **Relative gut length (RGL):** gut : body length
- high RGL = species consuming detritus, algae (high proportion of indigestible matter)

Relative Gut Length

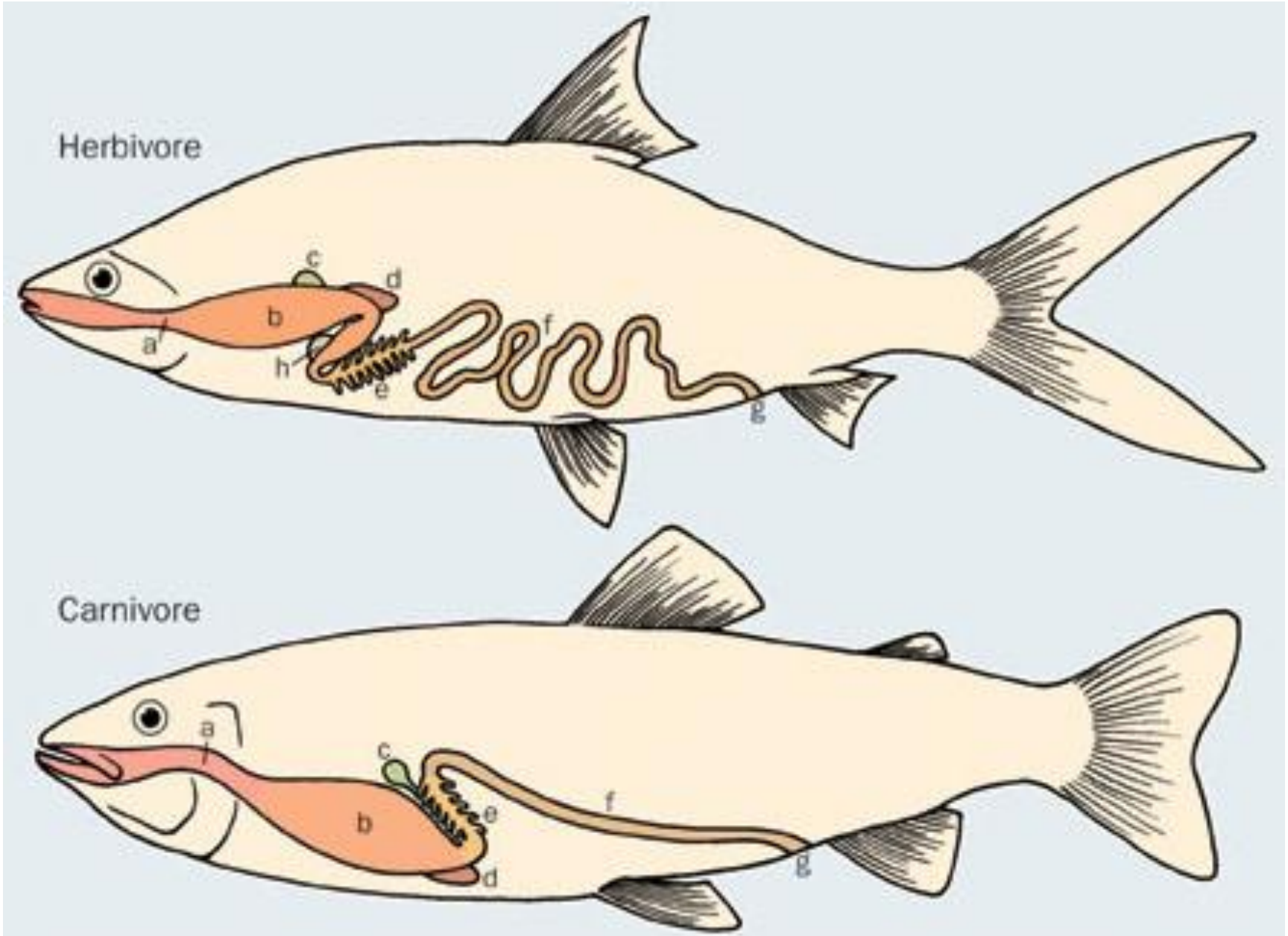
Species	Feeding	RGL
Labeo horie	Algae, detritus	15.5
Garra dembensis	Algae, inverts	4.5
Barbus sharpei	Plants	2.8-3.1
Chelethiops elongatus	Zooplankton	0.7
Chela bacaila	Carnivorous	0.9

Alimentary Canal

Fishes alimentary canal consist of mouth, oesophagus (throat), and areas for the absorption of food components (fore and midgut) and compaction of indigestible waste material (hindgut)

The structure of alimentary canal varies in different species of fishes, and is generally adapted in relation to the food and feeding habits.

The variations are seen in the position of the mouth, architecture of buccopharynx, relative length of the gut, presence or absence of the stomach and pyloric caeca.



a) Esophagus
b) Stomach
c) Gall bladder
d) Spleen
e) Pyloric caeca
f) Intestine
g) Anus
h) Gizzard

Gut and its Subdivisions

- The gut is a tubular structure beginning at the mouth and ending at the anus. It is commonly divided into four parts.
- The most anterior part, **the head gut** is most often considered in terms of its two components, the oral (buccal) and gill (branchial or pharyngeal) cavities.
- The **foregut** begins at the posterior edge of the gills and includes oesophagus, stomach and pylorus.
- The **midgut** includes the intestine posterior to the pylorus, often with no distinct demarcation posteriorly between it and the hindgut. The midgut is always the longest portion of the gut and may be coiled into complicated loops when longer than the visceral cavity
- The beginning of the **hindgut** is marked by an increase in diameter of the gut. The posterior end of the hindgut is the anus.

Alimentary Canal of Cartilaginous Fish (*Scoliodon*)

- It has a crescentic **mouth** on ventral side of the snout.
- **The buccal cavity** is lined by a thick and rough mucous membrane. A large number of dermal denticles are present in the mucous membrane, which become enlarged to form the pointed teeth on the jaws.
- **Teeth** are arranged in several row, one behind the other, of which only one row is functional at a time. When teeth of the first row lost, other migrate to take their place. Teeth of the *Scoliodon* are not used for mastication.
- **Tongue:** Simple and non muscular without any gland.

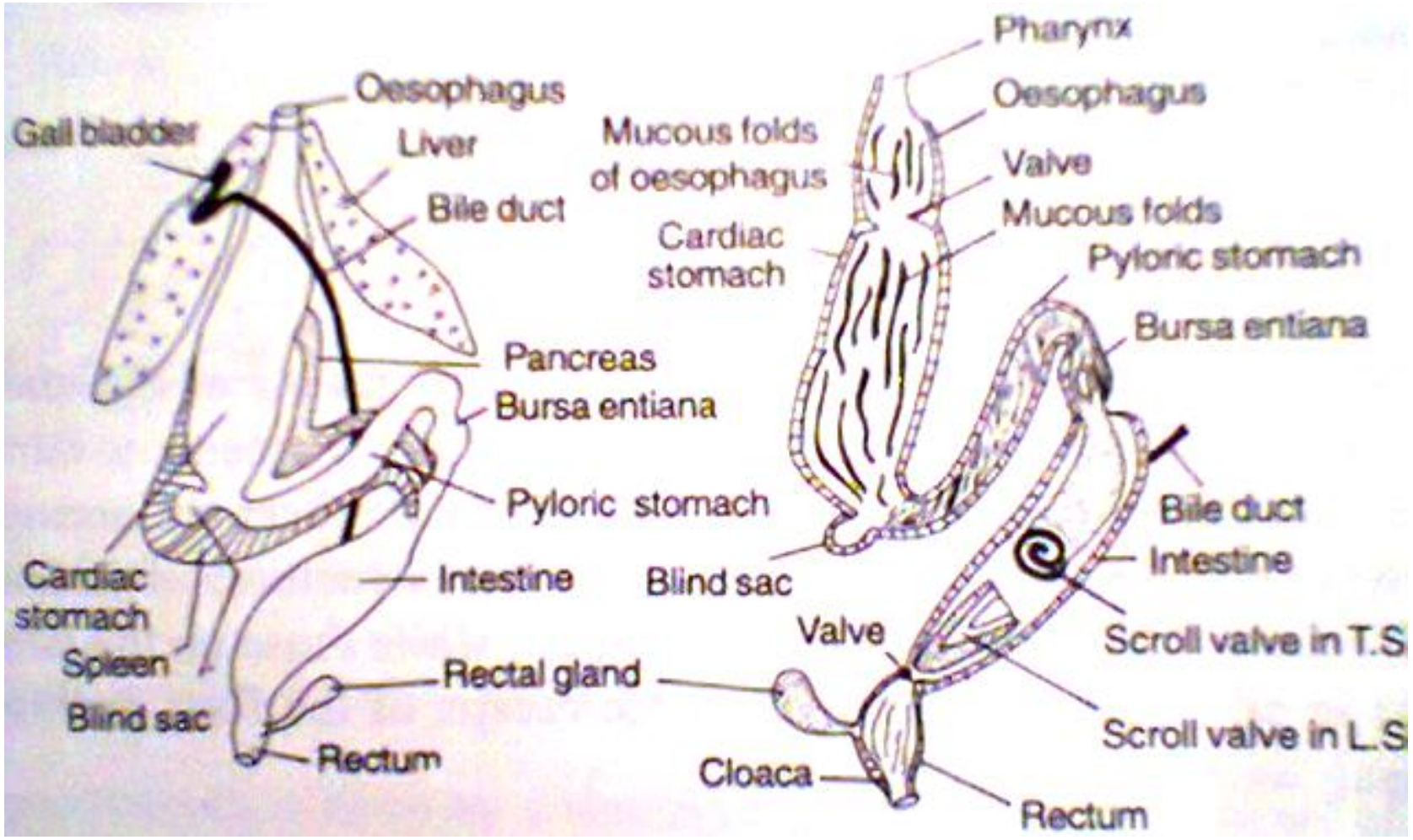
- **Pharynx:** The buccal cavity leads into the pharynx, which is perforated on each by the opening of gill pouches. Mucous lining of the pharynx is also rough due to the presence of dermal denticles in it.

- **Oesophagus:** pharynx opens into a short muscular oesophagus whose internal lining is raised into longitudinal folds.

- **Stomach:** oesophagus is followed by muscular stomach which is J shaped with a long limb (**cardiac**) and a shorter limb (**pyloric**). A small **blind sac** as an outgrowth at the junction of the cardiac and pyloric stomach is present. Pyloric stomach opens into muscular chamber called **Bursa entiana**. The opening is guarded by valve composed of circular muscle fiber.

- **Intestine**: Bursa entiana opens into the short intestine which is wide tube open posteriorly into rectum intestine have characteristic **scroll valve** which has 2½ turns in anticlockwise. This scroll valve check the rapid passage of food through intestine and increase its absorptive surface.
- **Rectum:** intestine is followed by rectum. One small rectal gland also opens into the rectum.

Alimentary Canal of *Scoliodon*

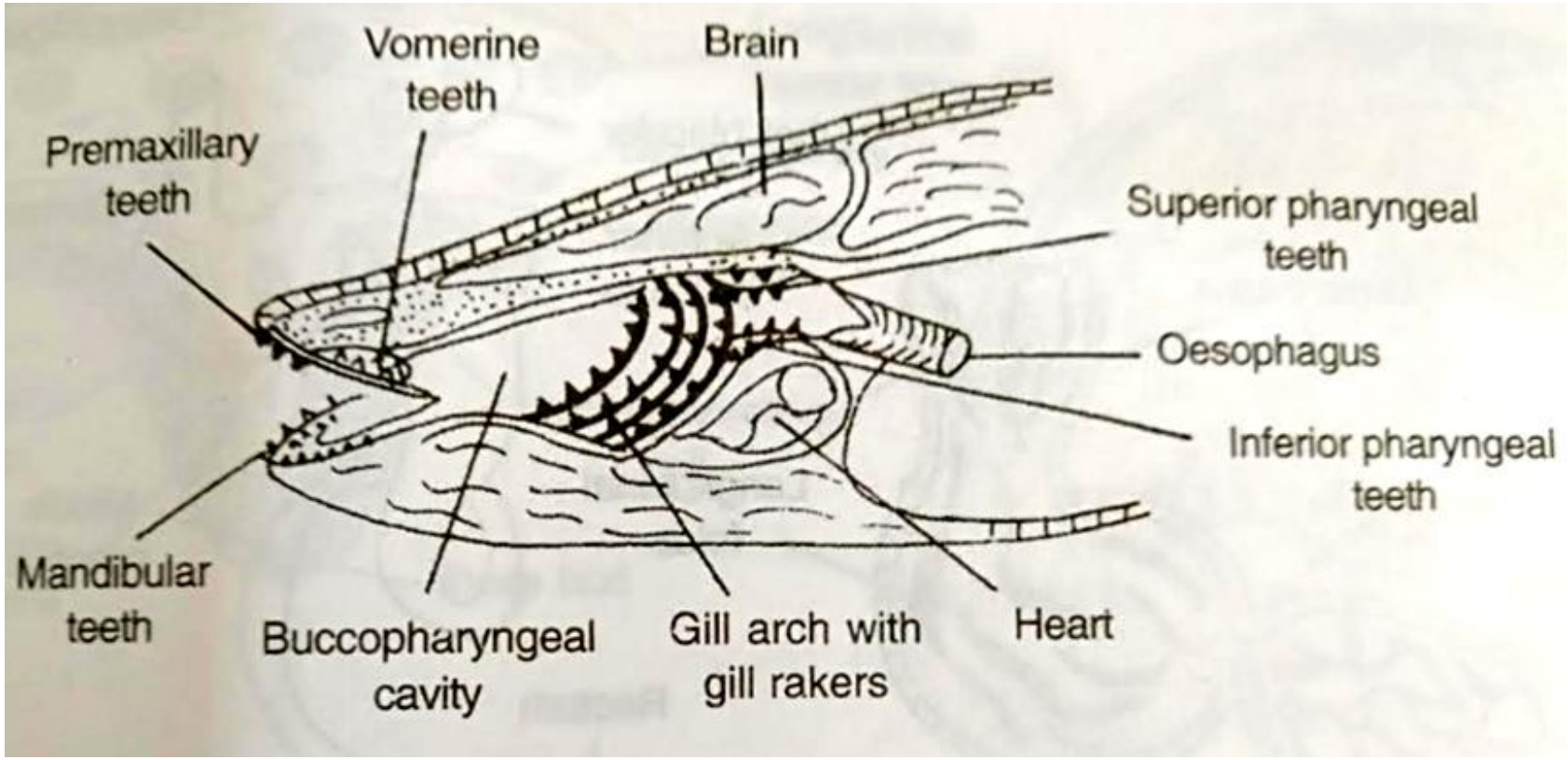


Alimentary Canal of Teleost

- Alimentary canal of *C. batrachus* or *M. seengala* can be consider as a typical example of teleost alimentary canal.
- **Mouth:** Lies at the anterior end of the snout and open behind into the buccal cavity. Barbels surrounding the mouth are used for the searching the food.
- **Teeth:** Numerous fine pointed teeth i.e. Maxillary, vomerine (behind upper lip) and mandibular (behind lower lip) are present. Rest of the buccophayrngeal cavity is lined with soft mucous membrane.
- **Pharynx:** The buccal cavity leads into the pharynx, which is perforated ventro-laterally by means of oblique gill slits. Gill rakers are present in one or two rows on each gill arch and are hard and pointed structure. Gill rakers of the 1^{st} arch are longest while 4^{th} arch are smallest in size. They prevent the escape of the food through gill slits.

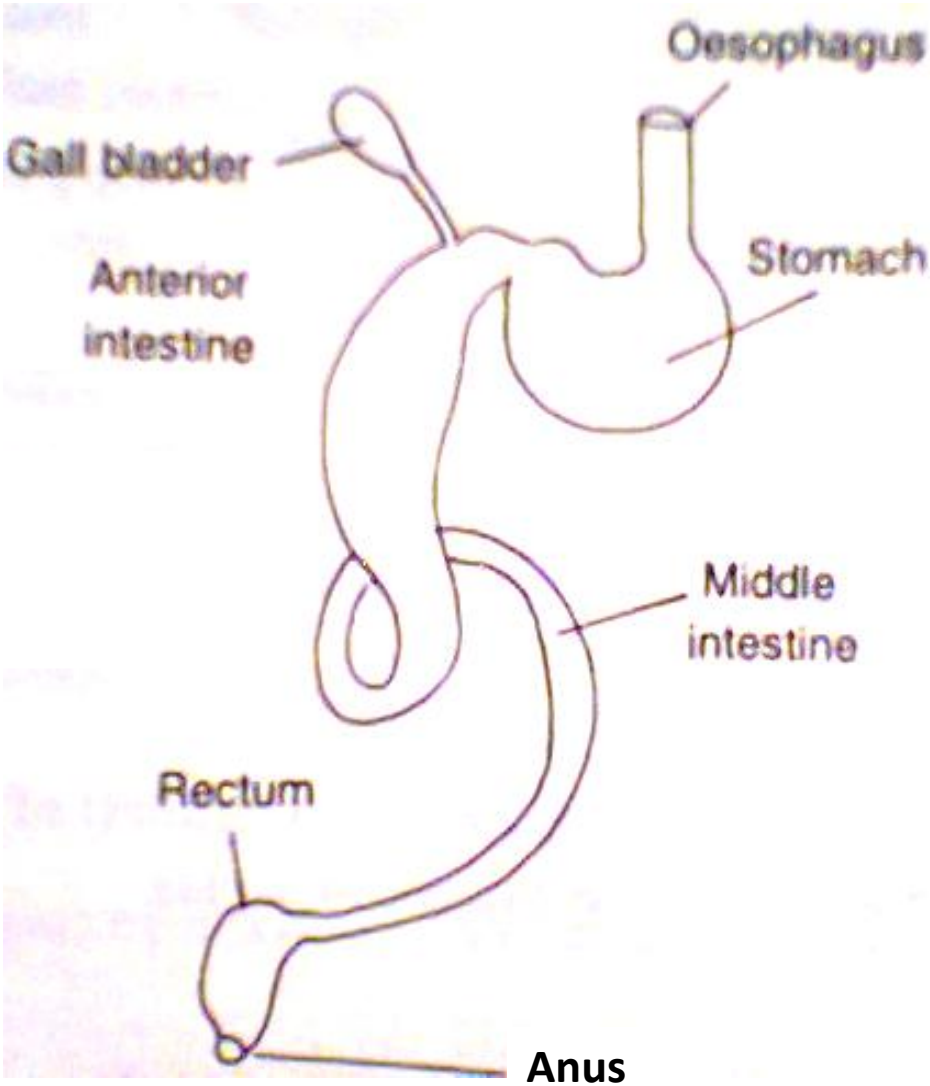
- **Gullet:** Pharyngeal cavity open into oesophagus by the mean of circular aperture called gullet. A pair of bony plates present on the dorsal side just anterior to the gullet bears **superior pharyngeal teeth**. Similarly a pair of bony plates borne by 4th gill arch bear **inferior pharyngeal teeth.** Mucous lining the posterior region of the bucco-pharynx is raised into prominent folds near the gullet.
- **Oesophagus:** Short tube behind the gullet which opens into the stomach.
- **Stomach:** Sac like structure with muscular walls. The distal end of the stomach continues into the intestine and the junction of the two is marked by a constriction called the pylorus guarded by a muscular sphincter. The mucous lining of the gut forms prominent folds and thick in stomach

L. S. Head of *Clarius batrachus*

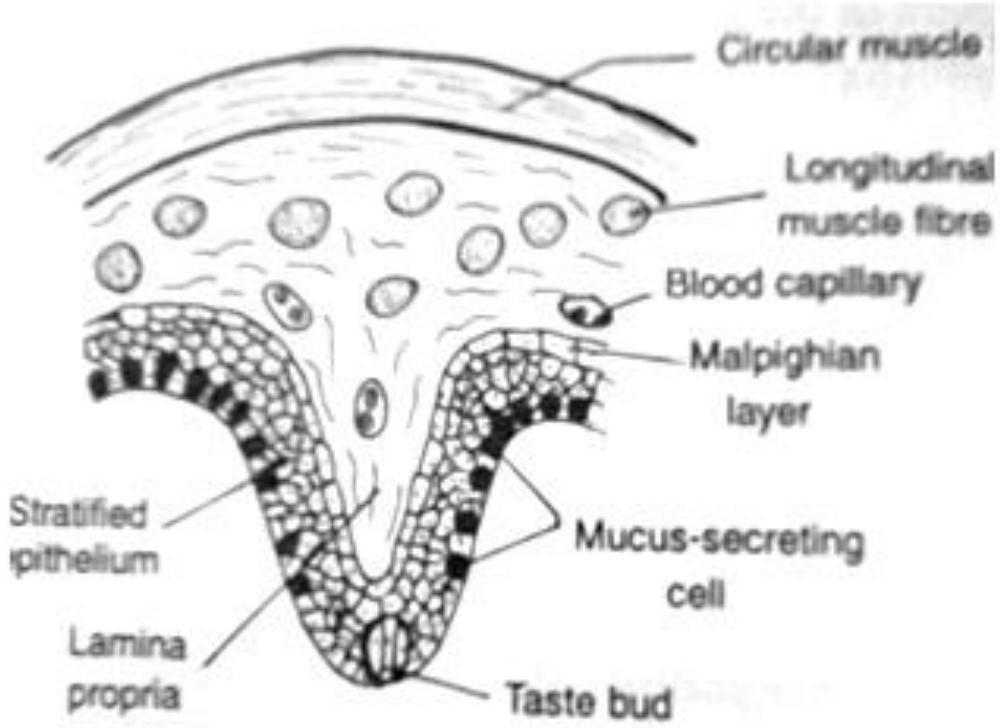


- **Intestine:** intestine is of moderate length having 1 or 2 coils only. Its wider proximal part and the narrow distal part opens into a slightly wider rectum. The mucous lining of the intestine show a zig-zag pattern in proximal region and reduce and indistinct at distal part.
- **Rectum:** Intestine is followed by rectum and opens to the exterior by anus.

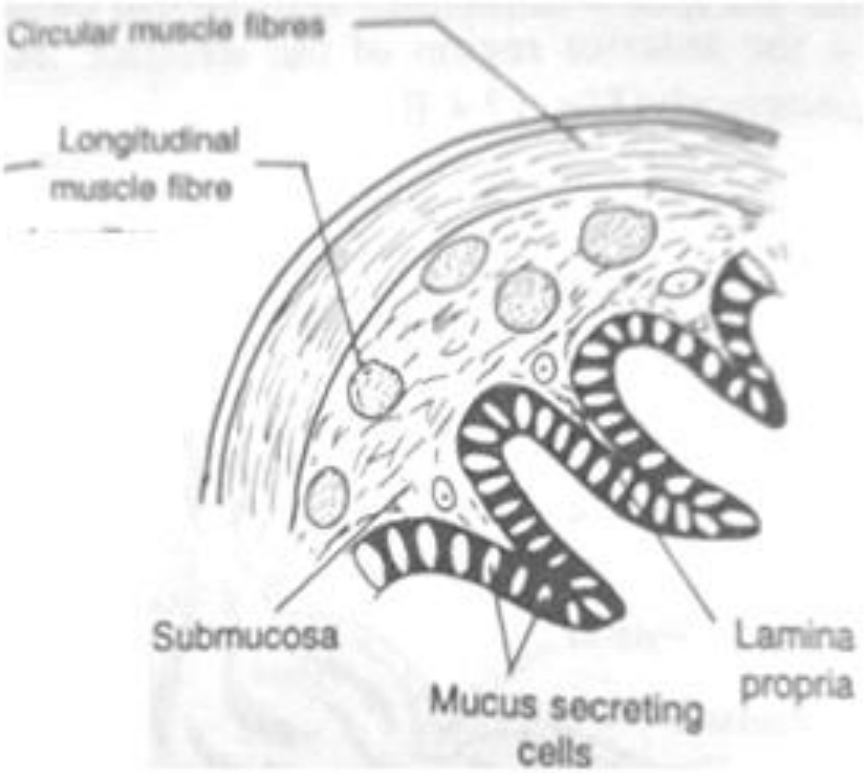
Alimentary Canal of *C. batrachus*



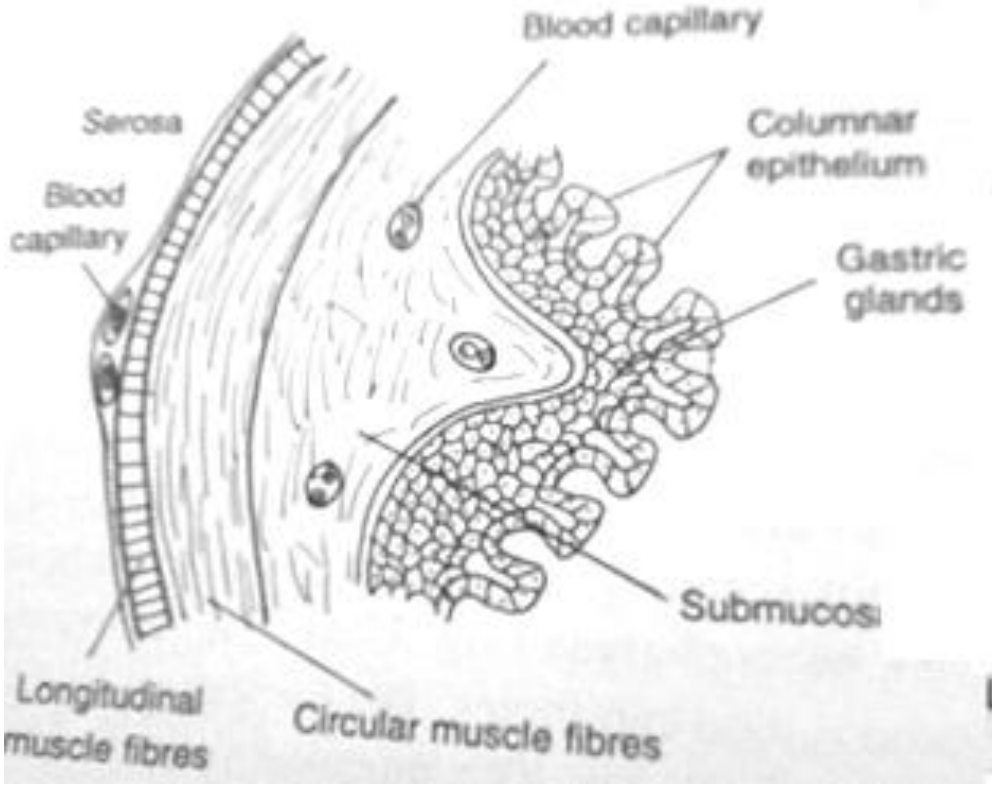
Histology of different subdivisions of alimentary canal



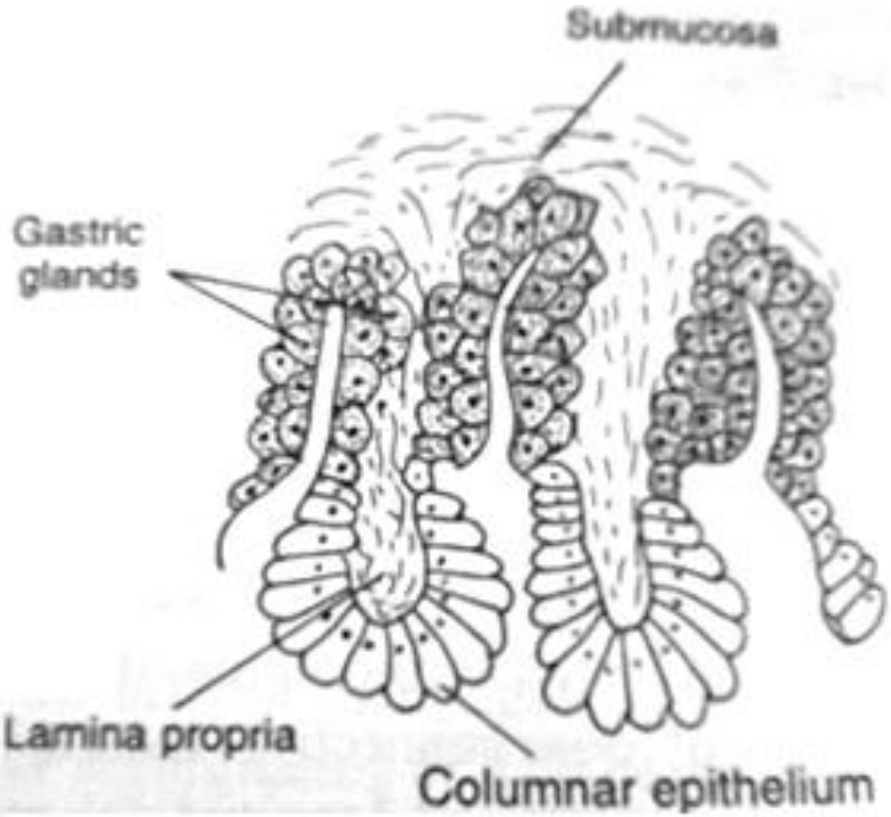
T. S. of Pharynx



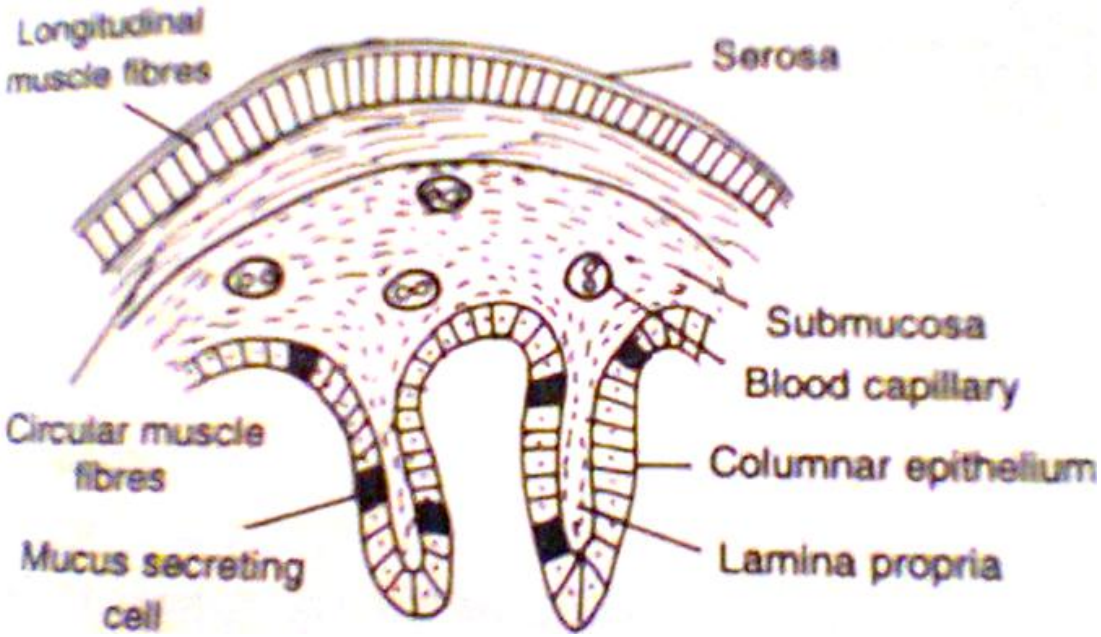
T. S. Of Oesophagus



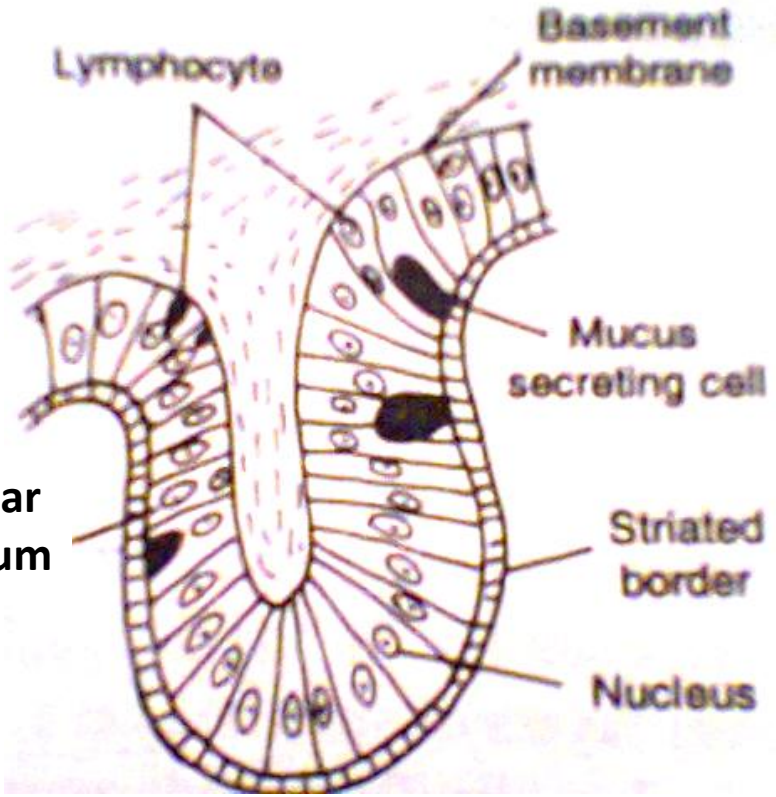
T. S. of Stomach



Part of gastric mucosa



T. S. of Intestine



Columnar epithelium

Modification of alimentary Canal

Modification of alimentary Canal

Fishes show great variation in the morphology of alimentary canal or gut in all the sub division i.e. Fore-gut, mid-gut and hind-gut.

Dentition:

- **Carnivorous and predatory** fishes have strong and pointed teeth. eg: *W. Attu, M. Seengala, C. Marulius, C. Punctatus, C. Straitus, Notopterus chitala, Harpodon neherius* etc. *N. Chitala* and *N. Notopterus* posses teeth on the tongue also.
- **Herbivorous** species, teeth are completely absent from the jaws and palate.
- In some **omnivore** like *C. batrachus* posses fine teeth on jaws and palate which other like T*. tor, P. sarana, C. reba, C. carpio* teeth are absent from the jaws and plate.
- In **plankton feeder** like *H. Hilsa* and *Gadusia chapra* havw complete edentulous buccopharynx.

Buccopharynx:

- In carnivorous species there is no clear demarcation between buccal cavity and pharyngeal cavity.
- In herbivore, there is clear demarcation between the buccal and pharyngeal cavity.

Gill Rakers:

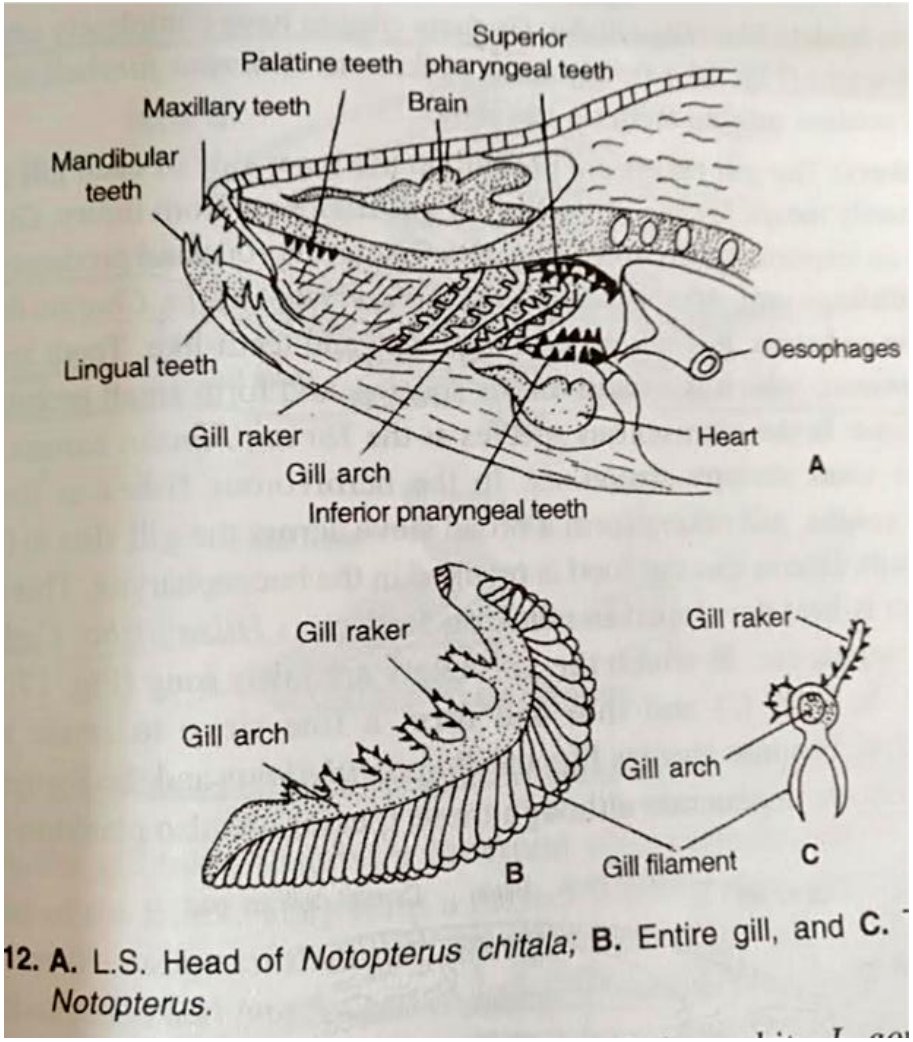
- In carnivorous and predatory fishes i.e. *W. attu, M. seengala*, *N. chitala*, C. marulius, *H. neherius,* gill rakers are long, hard and teeth like.
- In omnivorous species as the *T. tor, P. sarana*, the gill rakers are short stumpy structure.
- In herbivorous fishes i.e. *L. rohita*, *L. gonius* gill rakers form a broad sieve across the gill slits.
- In plankton feeder like *C. catla, H. hilsa, G. chapra* etc., gill rakers are fairly long and thin and form a fine sieve to retain zoo and phyto-planktons.

Taste buds and mucus secreting cells:

- In herbivore and omnivore fishes, a soft cushiony pad is present in the roof of the buccal cavity which has large number of papillae bearing taste buds and mucus secreting cells.
- Large number of taste buds are present in *C. catla*, *Puntius spp*., *Tor spp*., *C. mrigala, Schizothorax*,
- In carnivorous species like *Channa* and *Mystus* taste buds are less or absent

Oesophagus:

- In herbivorous and some omnivorous like *L. rohita, C. carpio, C. mrigala, P. saphore, T. tor, L. calbasu*, the oesophagus is short and narrow.
- In carnivorous and predatory fishes i.e. *W. attu*, *M. seenghal*a, *Channa spp*. Oesophagus is much longer and wider.



12. **A.** L.S. Head of *Notopterus chitala;* **B.** Entire gill, and **C.** *Notopterus.*

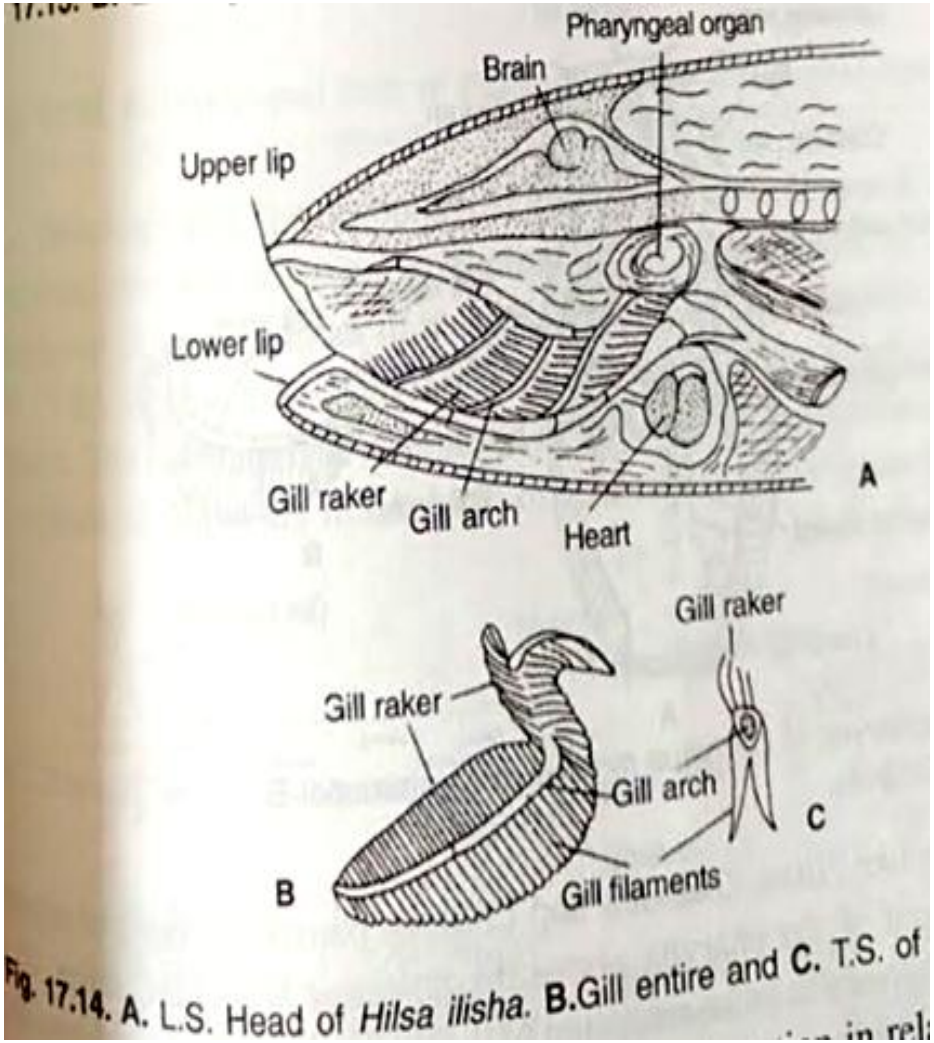
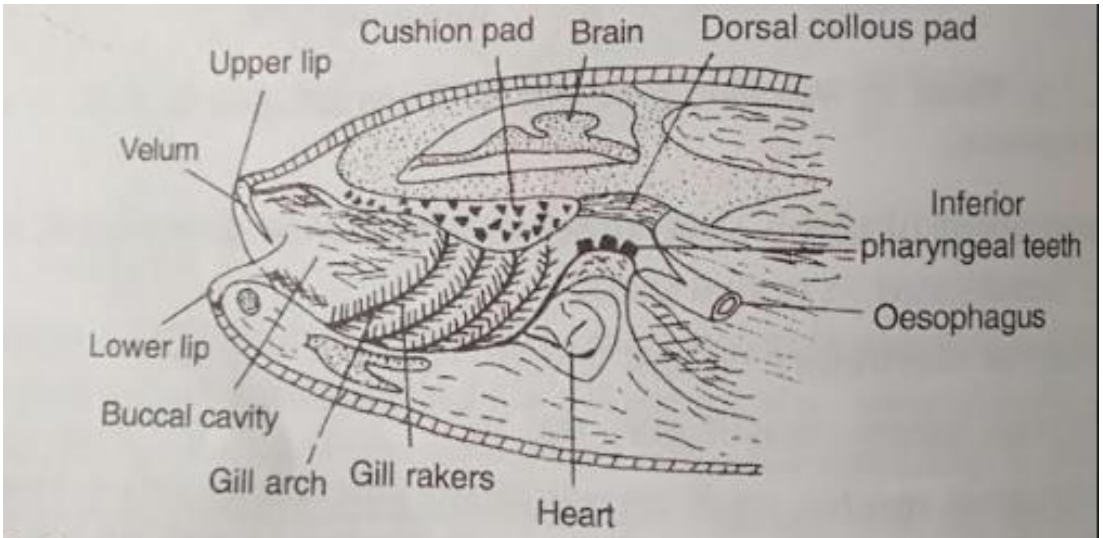
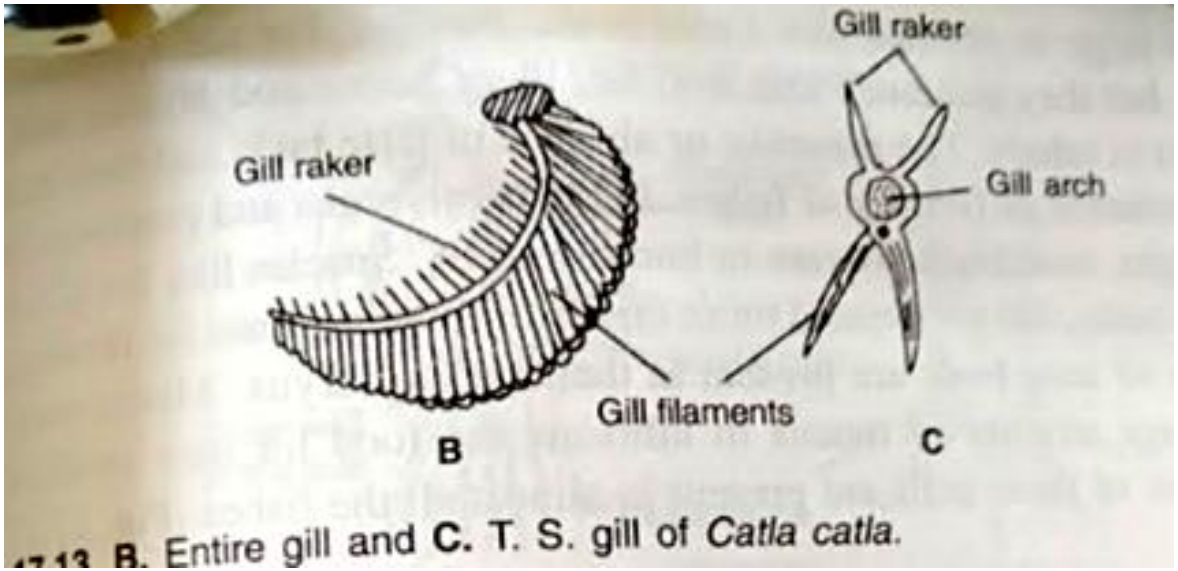


Fig. 17.14. **A.** L.S. Head of *Hilsa ilisha.* **B.**Gill entire and **C.** T.S. of



3. A. L.S. Head of *Catla catla*.



17.13. B. Entire gill and C. T. S. gill of *Catla catla*.

Stomach:

- In carnivorous fish, the stomach has prominent, thick mucosal folds and its wall are thick
- In plankton feeder as *Hilsa, Gadusia, Mugil,* the posterior region of the stomach reduce in size and greatly thickened so as to look like a gizzard.
- Some fishes (mostly carps) have no stomach so no acid phase of digestion occurs like *Labeo spp., C. mrigala, C. catla, Tor tor, P. saphore, P. sarana, etc.*

Intestinal Bulb:

- some fishes do not posses a true stomach and anterior part of the intestine become swollen to form a sac like structure called intestinal bulb. in these fishes oesophagus is followed by intestinal bulb and this is the special feature of cyprinids as *Labeo spp., C. mrigala, C. catla, T. tor, P. saphore, P. sarana* etc.

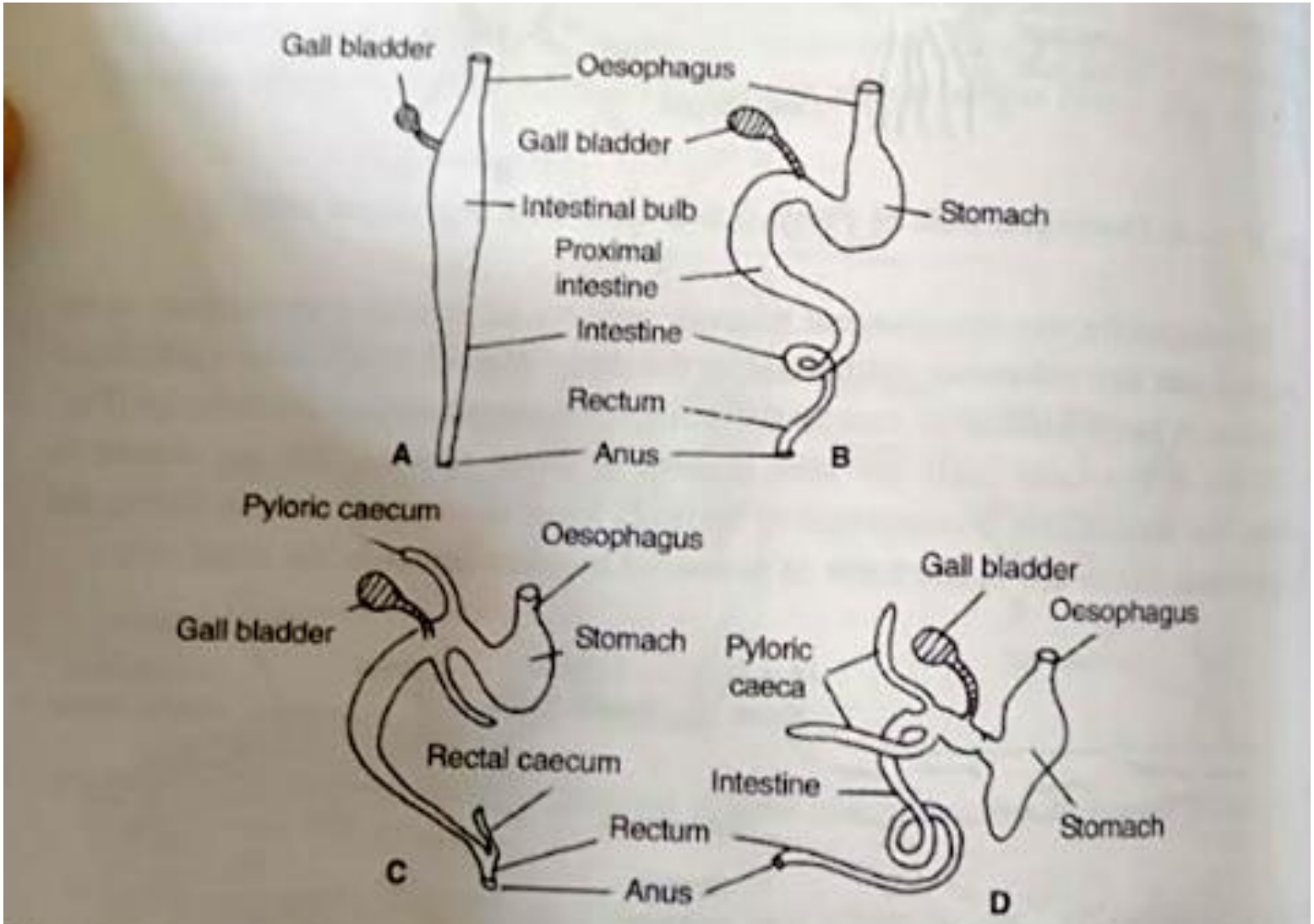
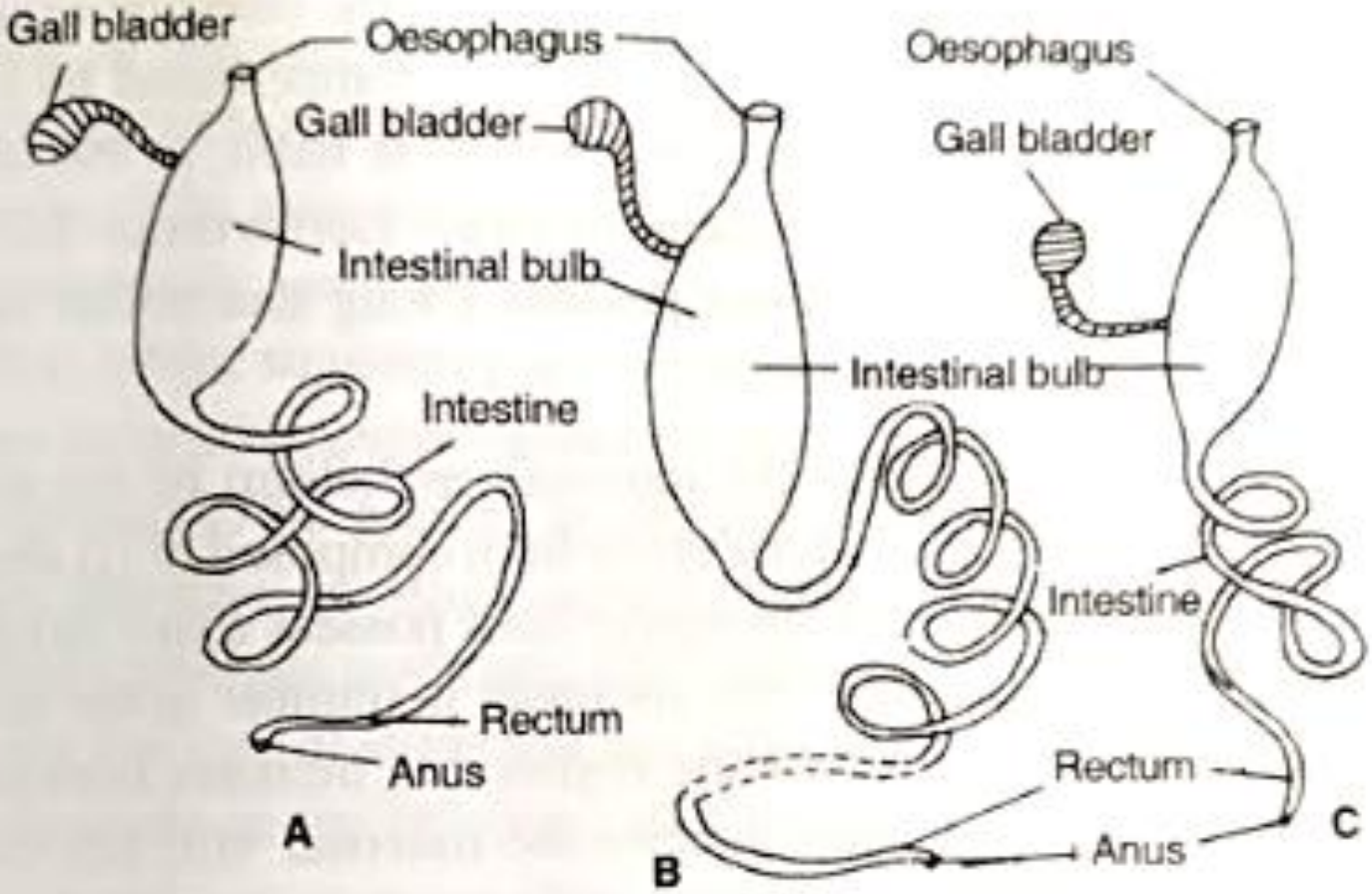


Fig. 17.18. Alimentary canal **of A.** *Xenentodon cancila*, **B.** *Mystus seenghala*, **C.** *Notopterus chitala*, and **D.** *Channa striatus* (all carnivorous species).



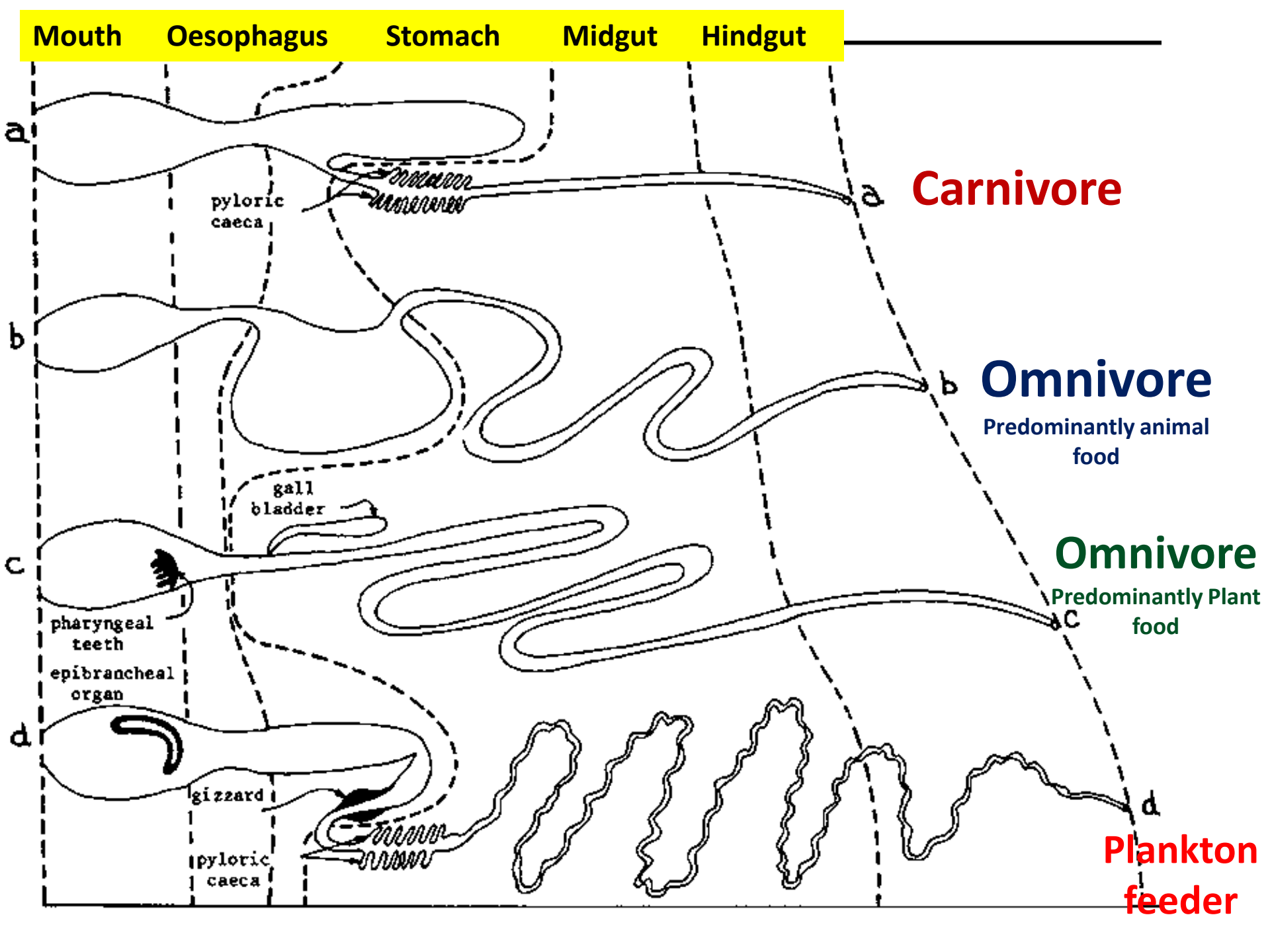
17.19. Alimentary canal of **A.** *Cirrhinus mrigala*, and **B.** *Tor tor* (both omnivorous) **C.** *Labeo rohita* (herbivorous).

Intestine:

- The main variation or modification in intestine is the length only.
- In most of the carnivore, length of intestine is short.
- In most of herbivore and plankton feeder, length of intestine is very long
- In omnivore, intestine is of moderate length.

Pyloric Caeca:

- Several finger like outgrowth at anterior part of the intestine or in the region of pylorus are called pyloric caeca.
- Pyloric caeca are present in species like *Notopterus, Channa, Hilsa, Harpodon, Mastacembelus.*
- Pyloric caeca are absent in stomach less fish species like IMC.
- They are also absent in *Wallago, Mystus*.
- They vary in number and size.


Mouth
Oesophagus
Stomach
Midgut
Hindgut
a
pyloric caeca
a
Carnivore
b
b
Omnivore
Predominantly animal food
gall bladder
c
Omnivore
Predominantly Plant food
pharyngeal teeth
epibrancheal organ
c
d
gizzard
pyloric caeca
d
Plankton feeder

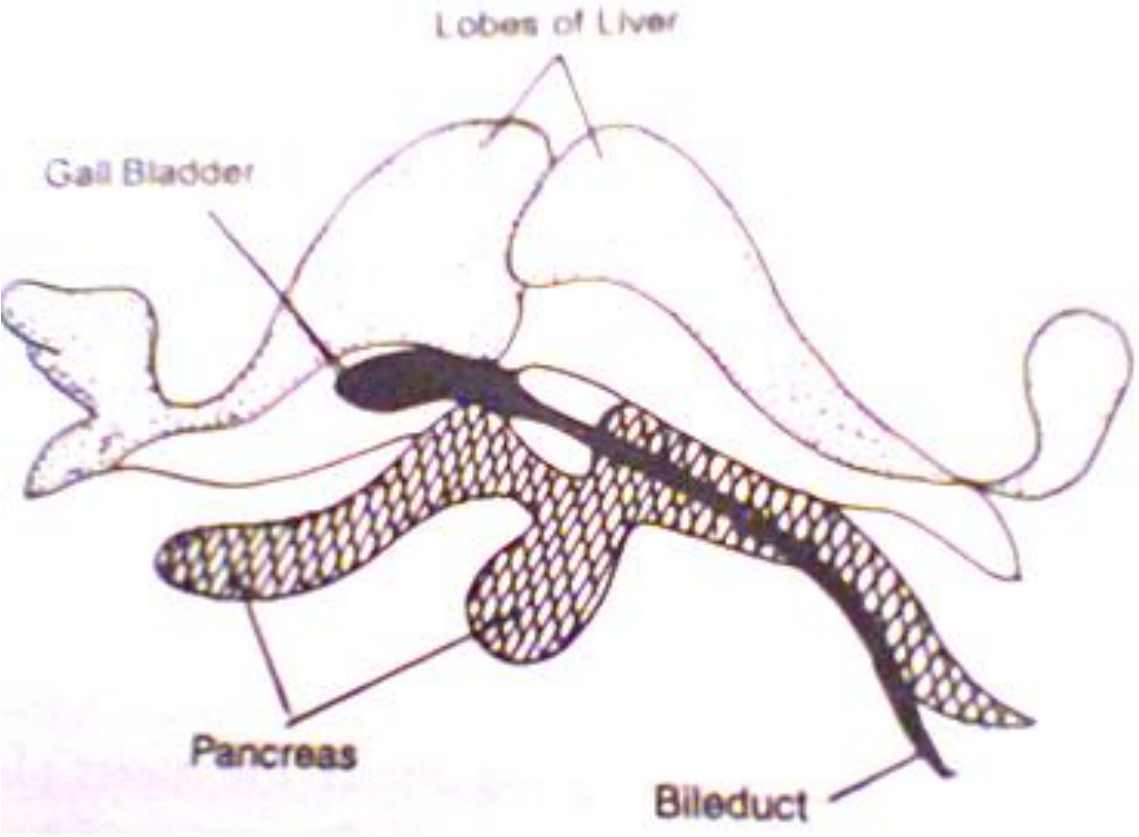
Digestive Glands & Digestion

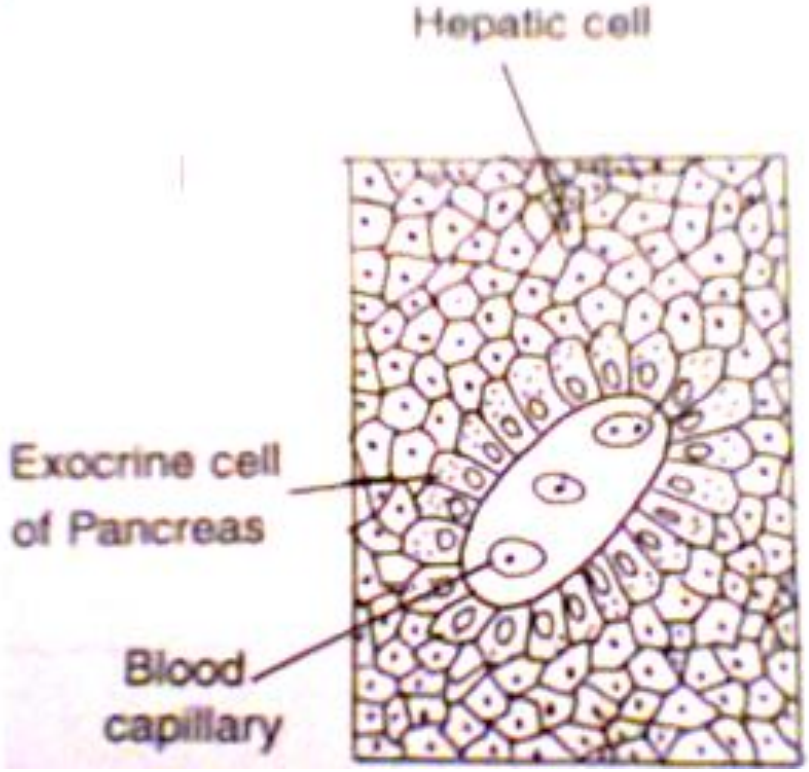
Digestive glands

- Three main digestives glands are liver, pancreas and gall bladder.
- **Liver**
- **Pancreas**
- **Gall bladder**

Digestive Glands: liver & pancreas (fish)

- Both organs produce digestive secretions
- liver produces bile but is also the primary organ for synthesis, detoxification and storage of many nutrients
- pancreas is primary source of digestive enzymes in most animals
- it also produces **zymogens** (precursors to enzymes)


Lobes of Liver
Gall Bladder
Pancreas
Bileduct


Hepatic cell
Exocrine cell
of Pancreas
Blood
capillary

Digestive Gland Modification: stomach

- *Channel catfish:* have true stomach that secretes HCl and pepsinogen (enzyme)

- *Common carp:* no stomach; however, "bulb" at anterior end of digestive tract, bile and pancreatic secretions empty into intestine posterior to cardiac sphincter, no secretion of gastrin (low pH)

- *Tilapia:* modified stomach, secretes HCl, well-defined pocket, pH varies w/digestal flow, has pyloric sphincter

- *Shrimp:* cardiac/pyloric sections, gastric secretions, gastric mill, straight shot to midgut

Digestive Gland Modification: Intestine

- *Channel catfish:* length less than whole body, no large/small version, slightly basic pH, digestive secretions, nutrient absorption, many folds for absorption

- *Common carp:* digestive tract is 3x whole body length, similar in activity to that of channel catfish

- *Tilapia:* tract is 6-8x that of body length, activities similar to that of other species

- *Shrimp:* short midgut w/midgut gland used for absorption/secretion/storage of nutrients, enzymes), slightly basic, blind tubules

- **Digestion:** the preparation of food by the animal for absorption
- involves the following processes:
- 1) mechanical reduction of particle size;
- 2) enzyme solubilization of organics;
- 3) pH solubilization of inorganics;
- 4) emulsification of fats

- **Absorption**: various processes that allow ions and molecules to pass through membranes of the intestinal tract into the blood, lymph, hemolymph, etc. to be metabolized by the animal

Summary of Digestive Enzymes

Site/Type	Fluid/enzyme	Function/notes
Stomach	HCl, Pepsinogen	Reduces gut pH, proteolysis by pepsin
Gastric secretions	tripsynogen, enterokinases,	Proteolysis
	Amylase	COH's
	Lipase	Lipids
	Esterase	Esters
	Chitinase	Chitin
Pancreas	HCO_3	Neutralizes HCl
	Proteases	Cleave peptide linkages
	Amylase	COH's
	Lipase	Lipids
	Chitinase	Chitin
Liver/bile	Bile salts, cholestrol	Increase pH, emulsify lipids
Intestine	Aminopeptidases	Split nucleosides
	Lecithinase	Phospholipids to glycerol + fatty acids