

# UNIT 3

## DIGESTIVE SYSTEM

### Structure

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### 3.1 INTRODUCTION

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In the previous unit you have studied about cartilage and bones of vertebrates. In this unit you will study that all vertebrates possess an alimentary canal as an organ for digestion and absorption of food materials. Digestion does not occur in a particular region of the alimentary canal but takes place in different regions so that digestion of food materials may be completed. All vertebrate alimentary canals have a common basic organization and similar major subdivisions. However, the differences seen in the anatomy in different animal groups is correlated to their different feeding habits. We shall discuss here the feeding mechanism in different groups of vertebrates such as fishes, amphibians, reptiles, birds and mammals and correlate with the adaptations seen in their alimentary canal.

We will start the unit with the study of structure and arrangement of teeth in vertebrates and see that they can be classified in different ways. Then we will discuss the feeding mechanisms and digestive systems of non-mammalian and mammalian vertebrates.

## Objectives

After reading this unit you should be able to:

- describe the dentition pattern in vertebrates,
- describe the feeding adaptations in vertebrates,
- discuss the organisation of vertebrate alimentary canal in relation to their feeding habits, and
- discuss the specialisation of alimentary canal of mammalian herbivores, carnivores and omnivores.

## 3.2 COMPARATIVE DENTITION

Teeth are hard structure present in the oral cavity and are present in nearly all the vertebrates particularly in all mammals in some stage of their life with some exceptions. For example, among mammals, in some teeth are not present in adults eg. in Whalebone whales, while in *Ornithorhynchus* (platypus) and *Tachyglossus* (echidna) teeth are absent throughout life. In echidna teeth develop in foetus and are discarded in uterus resulting in adults being devoid of them.

In most other vertebrates teeth develop partly from the epidermis and partly from the underlying dermis. There is a covering of enamel with an underlying layer of dentine. Fishes, amphibians and reptiles have simple pointed teeth. Some fishes like the chimeras and lungfishes have plated teeth that have rough or serrated ridges separated by grooves. In mammals each tooth is lodged in a socket called alveolus in the jaw. The part of tooth developed from epidermis is **enamel**. The remainder of tooth - **dentine, cement** and **pulp** - is formed from the sub-adjacent **mesodermal** tissue (Fig.3.1). Amongst vertebrates the teeth of lampreys are quite different from all others as they are cornified epidermal structures that do not have either enamel or dentine.

In fact, the dentition is so distinctive in different groups that it often becomes the basis for identifying living animals and fossil species.

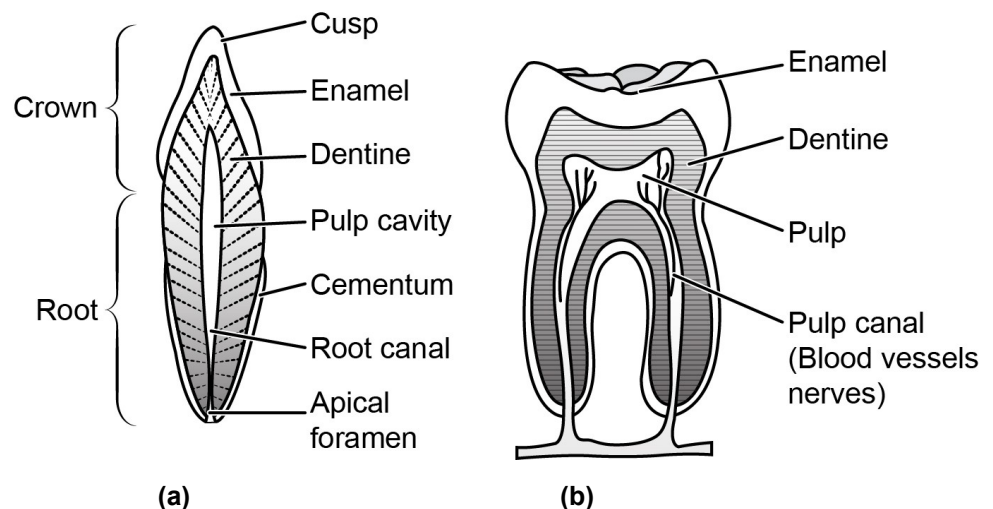


Fig. 3.1: Tooth structure (a) Tooth with single root, (b) Molar tooth with roots.

Teeth can be classified according to their attachment with the jaws (see Fig.3.2), appearance and nature of replacement as given in the Tables 3.1 and 3.2.

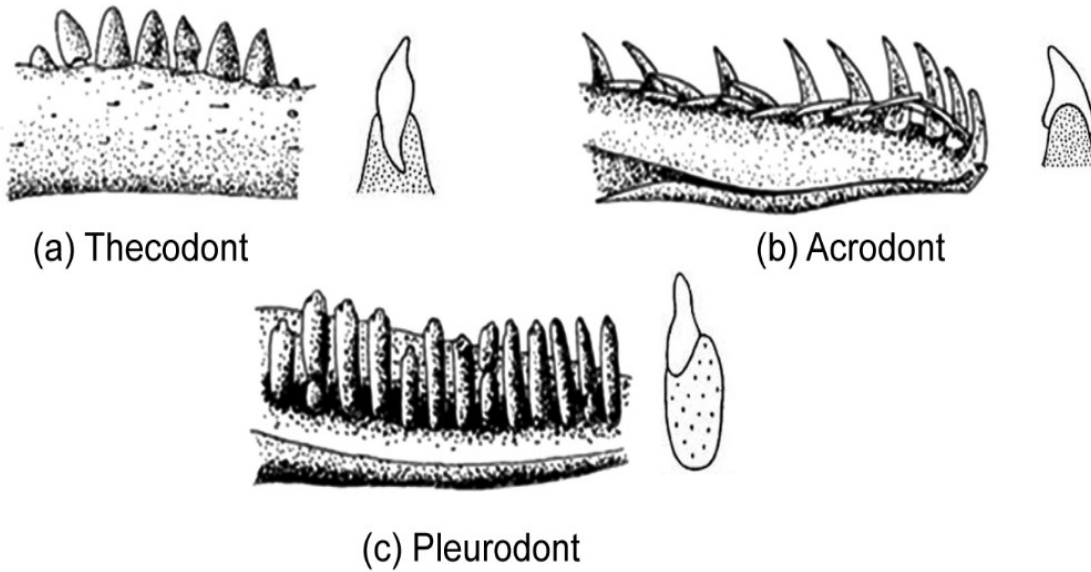


Fig. 3.2: Classification of teeth on the basis of attachment to the jaw bone. a) In thecodont type the teeth are set in sockets in the jaw bone as seen in mammals and alligators; b) In acrodont type the teeth are attached on the surface of the jaw bone as seen in most non-mammalian vertebrates; c) in pleurodont type the teeth are attached to the rim, on the inner side of the jaw bone as seen in modern amphibians and lizards.

Table 3.1: Types of teeth based on appearance.



Types of teeth	Appearance	Example
 Homodont	Teeth are uniform in appearance	Most non-mammalian vertebrates; dolphins and porpoises
 Heterodont	Teeth differ in general appearance, (incisors, canines, premolars and molars)	Humans, other mammals

Table 3.2: Types of Dentition based on the nature of their replacement.

Types of dentition	Nature of replacement	Example
Monophyodont	Only one set of teeth are present throughout life. Milk teeth persist and do not get replaced by permanent teeth	Beluga whales, most of cetacean that also include porpoise, dolphins, narwal, some rodents, insectivorous moles and marsupials.

Types of dentition	Nature of replacement	Example
Diphyodont	With just two sets of teeth the first set the deciduous dentition, or milk teeth appears during early life. It consists of incisors, canines and premolars but no molars. As the mammal matures these teeth are shed and replaced by permanent dentition consisting of second set of incisors, canines, premolars and molars.	Most mammals, Humans and other Primates
Polyphyodont	Teeth are continuously replaced. This type of dentition ensures rejuvenation of teeth if wear or breakage diminishes their function	Most lower vertebrates, sharks, amphibians, reptiles.

### Specialized Teeth in Mammals

The most specialized teeth among vertebrates are seen in mammals, the teeth are not only specialized to capture or clip food, but they are also specialized to chew it.

The heterodont dentition of mammals includes four types of teeth within the mouth - i.e. **incisor** at the front, **canine** next to them, **premolars** along the sides of the mouth, and **molars** at the back. Incisors are generally used at the front of the mouth for cutting or clipping; canines for puncturing and holding; premolars and molars for crushing or grinding food. It is often hard to distinguish premolars from molars visually. The collective term used for both is cheek or molariform teeth. Cheek teeth may be quite diverse, a reflection of their many specialized functions.

The number of each type differs among groups of mammals. The dental formula is shorthand expression of the number of each kind of tooth on one side of the jaw for a taxonomic group. For example, the dental formula of dog is:

$$I. \frac{3}{3}, C. \frac{1}{1}, Pm. \frac{4}{4}, M. \frac{2}{3}$$

This means that there are three upper and three lower incisors (I) one upper and one lower canine (C), four upper and four lower premolars (Pm), and two upper and three lower molar (M), 21 per side or 42 total (see Fig.3.3 also). Sometimes, the dental formula is written as 3-1-4-2/3-1-4-3, the first four numbers indicating the upper teeth and the second four numbers are the lower teeth. The dental formula for mouse is 1-0-0-3/1-0-0-3. You notice that the missing canines and premolars are indicated by zeros. Rodents do not have canines their incisors are used for gnawing, scraping and nibbling. The incisors are sharp and keep growing throughout life.

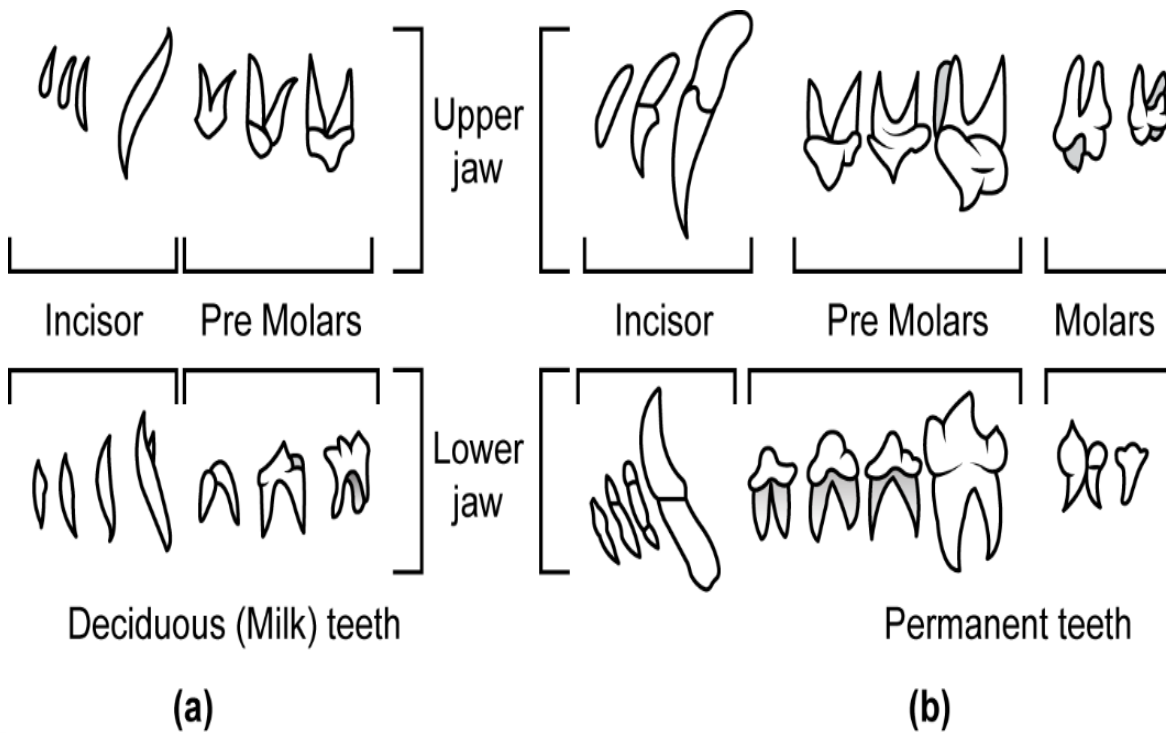
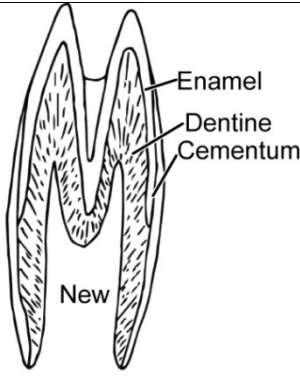
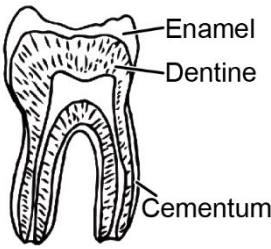
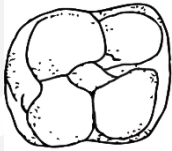
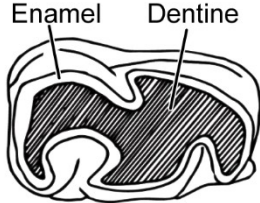
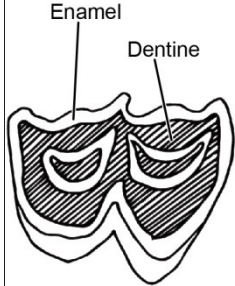


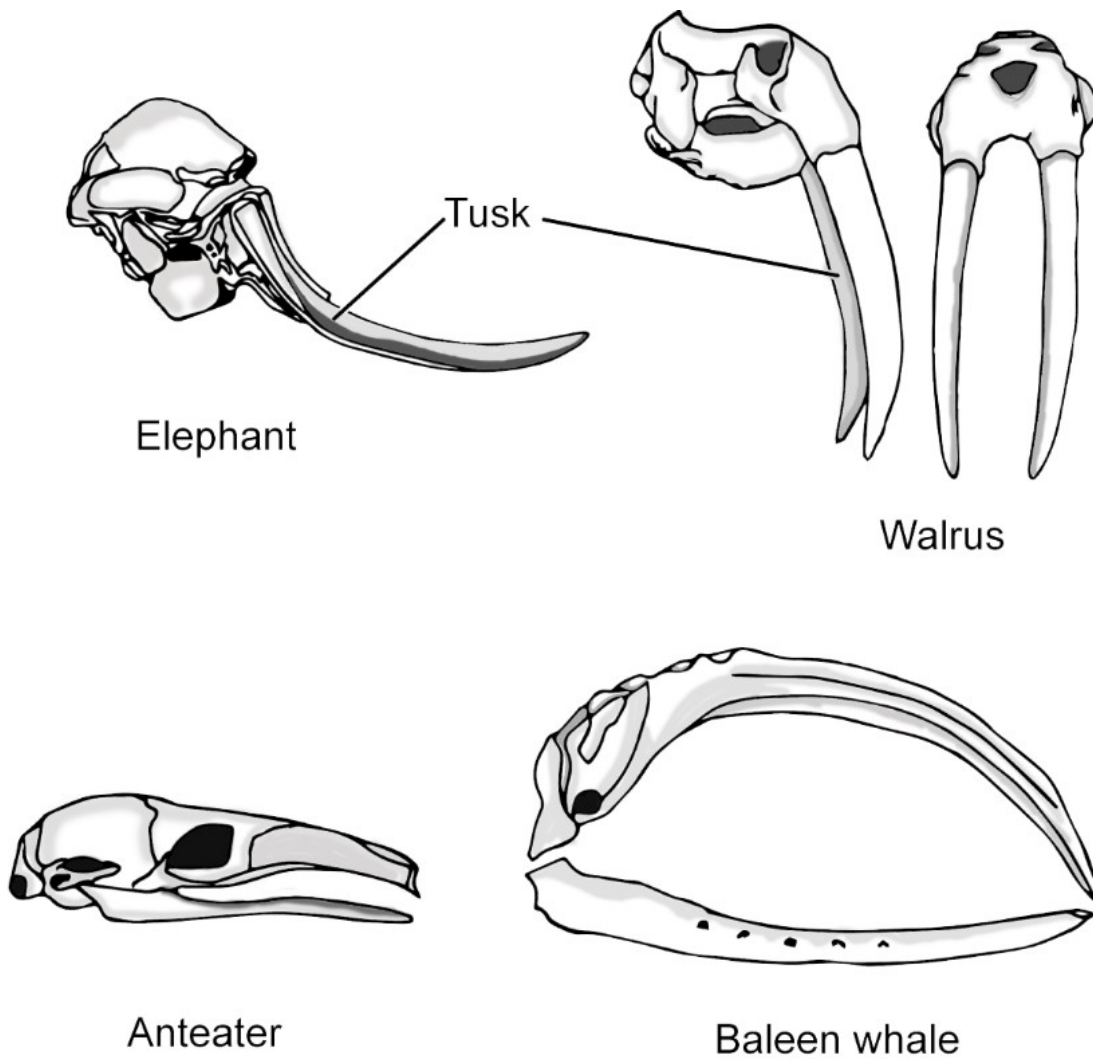
Fig. 3.3: a) Deciduous and b) Permanent dentition.

The teeth of mammals are modified according to their feeding habits and can be classified accordingly as given in Table 3.3. In herbivores the teeth are hypsodont that can grind plant material to break tough cell walls. Their cusp or occlusal surface is **worn** unevenly because the minerals which form the surface-enamel, dentine and cementum-differ in hardness. Occlusal surfaces are functionally important because they ensure that ridges and depressions persist throughout life, thereby maintaining a rough grinding surface which does not become smooth with continued use. The selenodont and lophodont teeth have folds of enamel running deep in between areas of dentine, as the teeth surfaces wear off the surface enamel is lost but the folds remain. The exposed dentine wears off so that ridges of enamel are separated by grooves of dentine thus forming good grinding surfaces.

Mammals possess a variety of specialized teeth. In some primates, cutting edges form on the upper canine and lower first premolar. These teeth are deployed in fights between individuals or in defense. In carnivores, the upper last premolar and lower first molar form **carnassials**, these specialized teeth slice against each other like a scissors to cut sinew and muscle. Tusks arise from different teeth in different species. In elephants, canines are absent but the tusks are elongated second pair of incisors in the upper jaw (Fig. 3.4) and in walrus, the paired tusks are upper canines that protrude downward (Fig. 3.4). In carnivorous mammals canine teeth together with powerful jaws are used to kill preys. Sometimes these teeth are used to puncture major blood vessels in the neck, of the prey causing the prey to bleed profusely and weakening it. Adult lion bites into the neck and collapses the trachea of the prey and suffocate. Some mammals such as anteaters and baleen whales lack teeth altogether (Fig. 3.4).

Table 3.3: Types of teeth on the basis of crown height and cusp pattern.

Types of tooth	Position of the crown	Example
 <p>Hypsodont</p>	<p>Crowns are high</p>	<p>Horse</p>
 <p>Brachyodont</p>	<p>Crowns are low</p>	<p>Human and Pigs</p>
<p><b>States of cusp pattern</b></p>		
 <p>Bunodont</p>	<p>Cusps form peaks</p>	<p>Omnivores like human</p>
 <p>Lophodont</p>	<p>Cusps drawn out into ridges</p>	<p>Perissodactyls and Rodents Rhinoceros Zebra, Rabbits, rats, elephants.</p>
 <p>Selenodont</p>	<p>Crescent shaped cusps</p>	<p>Artiodactyls e.g., Hippopotamus and African buffalo</p>



**Fig. 3.4: Tusks arise from both upper incisors in the elephant, and from canines in walrus. The teeth are absent in adult anteaters, and baleen whales.**

### SAQ 1

In the following statements, put a tick mark (✓) on the correct ones and a cross (×) mark on the incorrect ones in the given boxes.

- i) The part of the tooth developed from the epidermis is the enamel. ( )
- ii) Thecodont dentition has teeth arising from sockets in the jaw bone. ( )
- iii) Herbivores have specialized teeth known as carnassials. ( )
- iv) Some mammals have indefinite number of teeth e.g. elephant and monkey. ( )
- v) Elephants have extremely specialised teeth because they do not have canines and elongated pair of second incisors. ( )
- vi) Bunodont teeth have almost flat cusps. ( )

### 3.3 FEEDING MECHANISMS

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Obtaining nutritional essentials is clearly a key to the success of any animal/species. Much of the routine functioning of an animal is directed towards this purpose. For example, the complex and sophistication of the nervous system, evolved largely due to the selective pressure on obtaining of sufficient food and on avoidance of becoming someone else's meal. Animals use various strategies to feed. Some species search, stalk, pounce, capture, and kill. Sessile animals, unable to move about, resort to more subtle means, such as surface absorption, filter feeding or trapping. Vertebrates, have various feeding devices that are described here in a systematic evolutionary sequence. We will now discuss different devices employed by various groups of vertebrates.

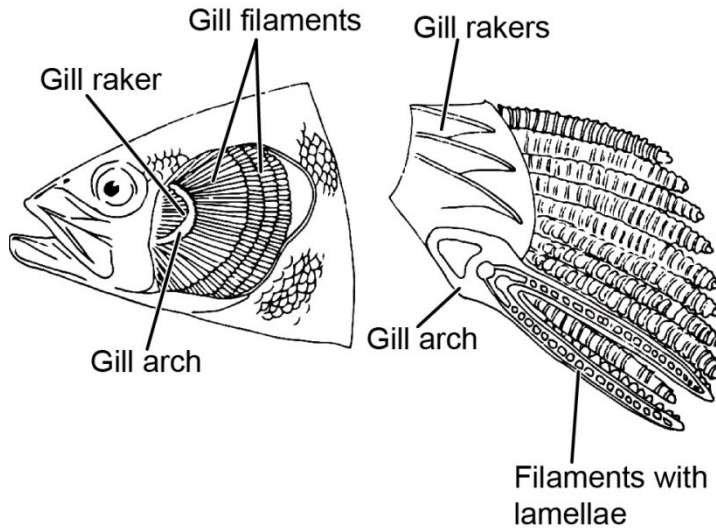
#### 3.3.1 Fishes

Cyclostomes, elasmobranchs, and teleosts, use a variety of feeding mechanisms. They have pointed teeth, mounted on jaws or palate, which aid in holding, tearing and/or swallowing prey. Most fishes are carnivores, they prey on a variety of animal food from zooplankton and insect larvae to large vertebrates. Some deep sea fishes are capable of eating prey nearly twice their own size. This is an adaptation for life in a world where meals are infrequent. Most advanced ray-finned fishes cannot masticate their food. Some such as the wolf eel have molar like teeth in the jaws for crushing their prey, that may include hard bodied crustaceans. Others grind their food using powerful pharyngeal teeth in the mouth to seize their prey. The incompressibility of water makes the task even easier for many large mouthed predators that use **suction feeding**. When the mouth is opened, a negative pressure is created which sweeps the prey inside. This method is mostly used by teleosts along with **ram feeding** in which the predator moves past the prey with its mouth open engulfing it along with the water.

One of the most important, successful and widely employed methods for feeding that evolved is filter feeding. Majority of filter feeders use ciliated surfaces to produce currents which can draw drifting food particles into their mouths. Free-swimming filter feeders like herring and basking shark have the advantage of being able to swim through their food and thus can be more selective in their feeding. The water flows out through the gills leaving the food behind (Fig. 3.5).

A second group of fishes are herbivores which eat flowering plants, algae and grasses. Although plant eaters are relatively few in number, they are crucial intermediates in the food chain especially in fresh water rivers, lakes, and ponds which contain very little plankton.

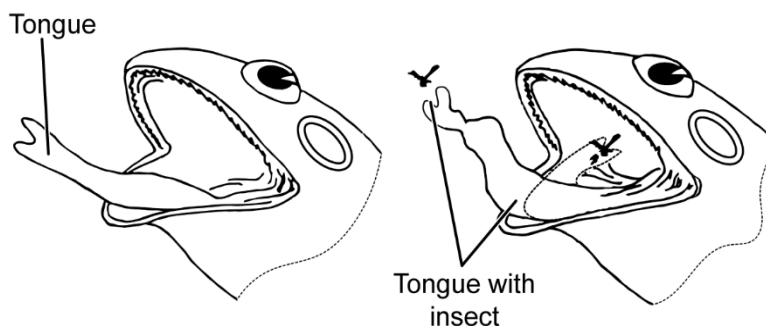
Another group of fishes are **omnivores** feeding on both plant and animal food. Finally there are **scavengers** which feed on organic debris and on the parasites that suck the body fluids of other fishes.



**Fig. 3.5: Herring and other filter-feeding fishes use gill rakers, which project forward from the gill bars into the pharyngeal cavity to strain out planktons. Herring swim almost constantly, forcing water and suspended food into the mouth, food is strained out by gill rakers, and water passes out of the gill openings.**

### 3.3.2 Amphibians

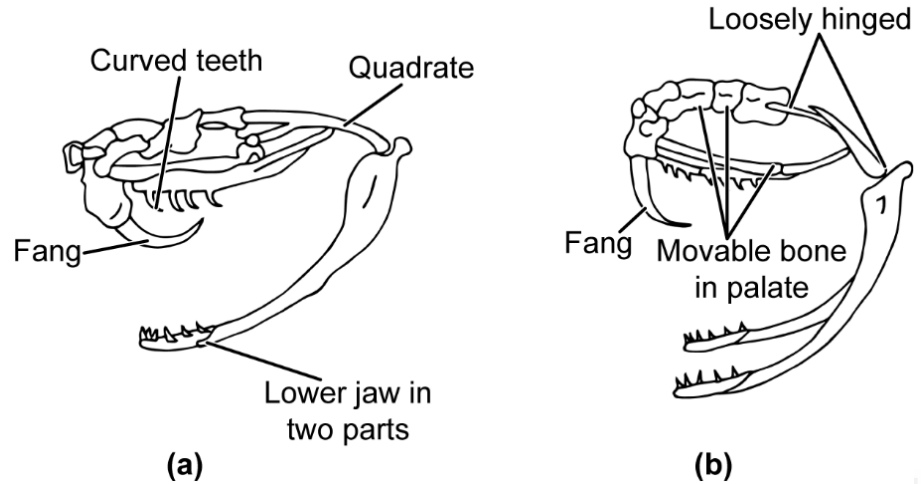
Adult amphibians consume a wide variety of food. Anurans and salamanders feed mostly on insects and other arthropods, while caecilians feed mostly on earthworms and other small bugs. Aquatic salamanders lunge at their prey with wide open mouths sucking it in with their expanded buccal cavity. Frogs are carnivores like most other adult amphibians. They feed on insects, spiders, worms, slugs, snails, millipedes or any thing else which moves and is small enough to be swallowed whole. They snap at moving prey with their protrusible tongue (Fig. 3.6) which is attached to the front of the mouth and is free behind. The free end of the tongue is highly glandular and produces a sticky secretion, that adheres to the prey. Teeth present on pre-maxillae, and vomers are used to prevent escape of prey but not for biting or chewing them. The larval stages of anurans (tadpoles) are herbivores, feeding on pond algae and other vegetable matter.



**Fig. 3.6: Feeding in frog showing the position of tongue in catching an insect. The tongue in frog is highly mobile. It is attached to the front of the mouth permitting the sticky organ to be flicked far out with considerable speed and accuracy, the insect sticks at the end and the tongue returns back in the mouth. The prey is then crushed against a peculiar patch of teeth on the roof of the mouth and swallowed whole.**

### 3.3.3 Reptiles

Reptiles are mostly carnivorous though some like the land turtles, tortoises are vegetarian feeding on grass and other vegetable matter. Green iguanas and *Uromastix* are also vegetarian while marine iguanas feed on sea weed. Reptiles like chameleon fling out their tongues to catch insects from a distance of several inches.



**Fig. 3.7: Rattlesnake skull in a side view. (a) Partly open. (b) Open for striking. The fangs are tubular for delivery of toxin and are hinged to facilitate their storage between strikes.**

Reptilian jaws or palate are provided with pointed teeth that help these animals in holding, tearing or swallowing their prey. Non-mammalian teeth are generally poorly differentiated from one another. One exception is found among the poisonous snakes, such as vipers, cobras and rattle snakes, which have modified teeth, called **fangs** which are used to inject venom (Fig. 3.7). These fangs are either equipped with a groove or are hollow, very much like a syringe needle to deliver venom at the site of bite. In rattle snakes, fangs fold back against the roof of the mouth, but extend perpendicularly when the mouth is opened to strike. Snakes cannot tear or chew their food. Captured prey is swallowed whole, a surprising feat since the prey is often larger than the snakes. The mouth is extremely flexible because of the arrangement of bones in the head and jaw. The lower jaw is loosely attached to the quadrate bone and can be disconnected while swallowing and even the bones of the palate are movable, all helping to draw the prey into the gaping mouth. The oesophagus and stomach can stretch considerably as can the body wall. There is no sternum, so the ribs can move freely as the prey passes through the gut. This enables a snake to swallow animals larger than the diameter of its head.

### 3.3.4 Birds

Birds have no teeth, but instead have horny beaks which exemplify adaptive radiation suited to a **gastronomic** (art of choosing, preparing and eating good food) life style.

Birds consume a variety of other animal foods such as seeds, fruit, insects, worms, molluscs, crustaceans, fish, frogs, reptiles, mammals as well as other

birds. A very large group of birds feed on nectar. Some birds are **generalists** that is, omnivorous like crows and bluejays that eat whatever is seasonally abundant. Others are **specialists** called **stenophagous**, or “narrow range eating” species that focus on a specific type of food.

Beaks of birds are strongly adapted to their feeding strategies. Beaks may be generalised as strong, pointed beaks of crows, to grotesque, highly specialised ones in flamingoes, hornbills and toucans. Figure 3.8 shows some of the specialized type of beaks that suit the birds feeding habits. The beaks of small seed eaters are short, stout, pointed like that of a sparrow. The crossbill is a unique type of seed eater, its upper and lower beaks do not align and are crossed, it can use the beak to open pine cones. Seed eating birds eat their food as whole, but may subject it to grinding in a muscular gizzard which contains stones (gastroliths) pebbles which aid birds in the grinding process. Insect eaters have thin, short pointed beaks. A well known insect eater is the woodpecker which has a straight, hard, chisel like beak. Anchored to a tree trunk with its tail serving as a brace, the woodpecker delivers powerful, rapid blows (upto 20 times/sec) to build nests or expose the burrows of wood boring insects. It then uses its long, flexible, barbed tongue (three times longer than the bill) to seek out insects in their holes and tunnels. Woodpecker’s skull is especially thick and fitted close to the brain to absorb shock.

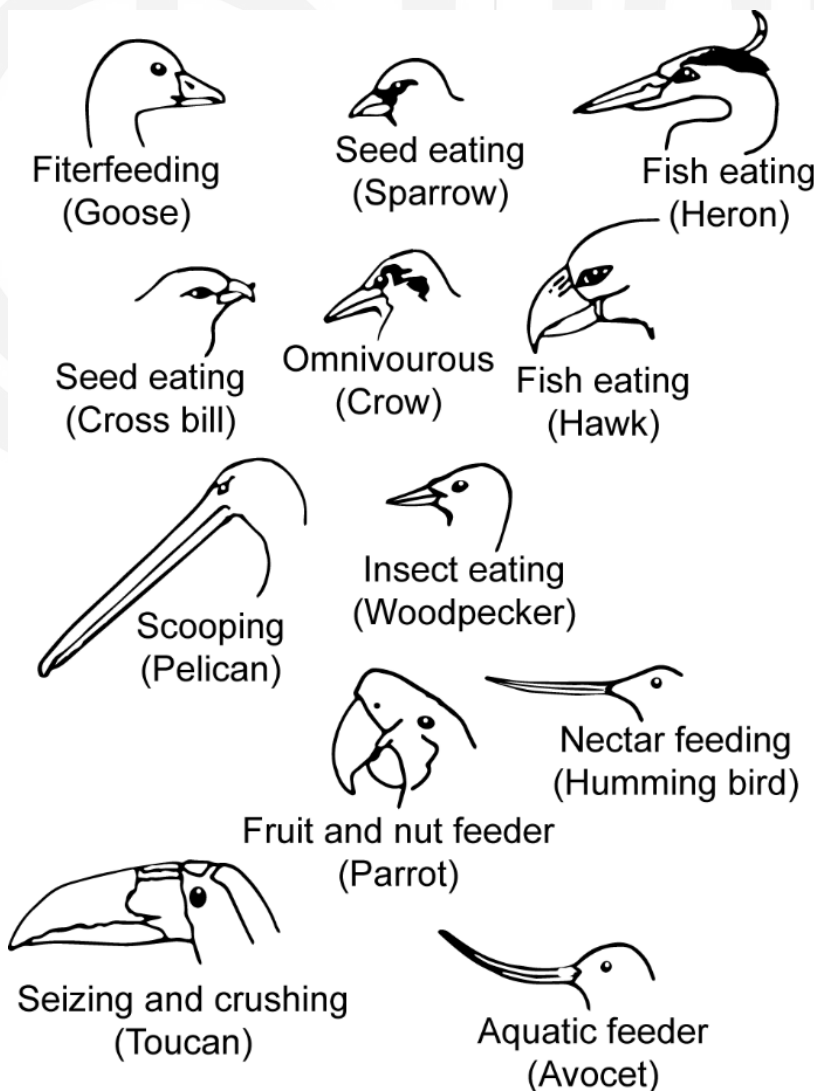


Fig. 3.8: Bird beaks adapted to different modes of feeding.

Water feeders like herons, egrets, kingfishers that eat fish have sharp pointed, spear like beaks. Though ducks and geese live near water, they don't eat fish and have long flat beaks that are used for straining water and mud from aquatic plants through comb like filters lining the beak edges.

Nectar eaters like the hummingbird has long, slender beak, that is a protective covering for its tongue. The tongue has two grooves that draw water by capillary action. They also supplement their diet by catching flying insects by widening the gape of the mouth as their mandible can be actively flexed downwards.

Birds of prey such as hawks, kites, owls, eagles etc., have interesting adaptations. In some cases, the feeding habits are reflected in the feet as well. Typically raptorial birds or birds of prey, have long, curved talons for grasping prey which they tear with their strong hooked beaks. Ground foraging species such as grouse and pheasants have heavy, strong feet for scratching the soil.



**Fig. 3.9: Convergence in filter-feeding mechanisms in the flamingo. The fringe along the edge of the flamingo's bill acts as strainer**

Flamingo uses a filter feeding apparatus (Fig. 3.9) to filter small organisms and other morsels it finds in the muddy bottoms of its fresh water habitat.

### **3.3.5 Mammals**

Mammals feed on a wide variety of food sources. Some mammals require highly specialised diets, while others are opportunistic feeders which live on diverse diet. In all mammals food habits and physical structure are intimately linked. Specializations for finding, capturing, reducing, swallowing, and digesting food determine the shape and habit of a mammal, Teeth, more than any other single physical characteristic, reveal the life habit of a mammal (Fig. 3.10). All mammals have teeth, except certain whales, monotremes and anteaters and their modifications are correlated with what they eat.

As mammals evolved, major changes occurred in the teeth and jaws during the mesozoic era. Unlike the uniform homodont dentition of the reptiles, mammalian teeth became differentiated to perform specialized functions such as: cutting, seizing, gnawing, tearing, grinding or chewing (please refer to section 3.2 again). Teeth differentiated in this way are called heterodont. The

primitive tooth formula, which represents the number of each tooth type in one half of the upper and lower jaw, was I,3/3, C 1/1, Pm 4/4, M 3/3. Members of the order Insectivora e.g., shrews, some omnivores and carnivores come closest to this primitive pattern (Fig.3.10). Unlike reptiles, mammals do not replace their teeth continuously throughout their lives. Most mammals grow just two sets of teeth, a temporary set called **deciduous** or **milk** teeth (set) which is replaced by a permanent set when skull has grown large enough to accommodate a full set. Only incisors, canines and premolars are deciduous; molars are never replaced and the single permanent set must last a life time.

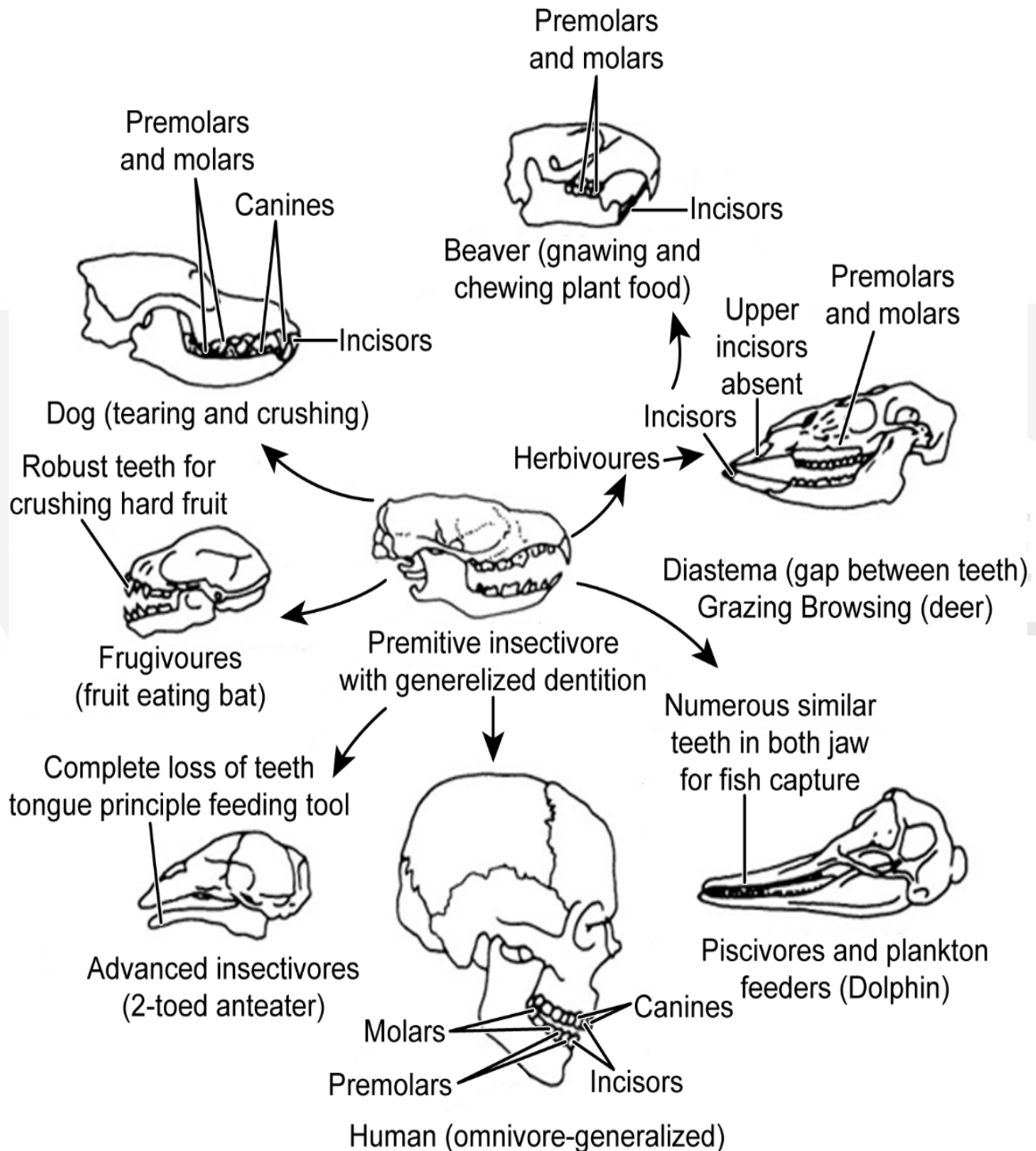


Fig. 3.10: Feeding specializations as shown by teeth of major trophic groups of eutherian mammals. The early eutherians were insectivores; all other types have evolved from them.

## SAQ 2

Fill in the blank spaces with appropriate words from the text.

- i) Majority of \_\_\_\_\_ use ciliated surfaces to produce currents that can draw drifting food particles into their mouth.
- ii) Fangs are either equipped with \_\_\_\_\_ which guides the \_\_\_\_\_ or are hollow, very much like a \_\_\_\_\_ needle.
- iii) Raptorial birds capture prey with their \_\_\_\_\_ or \_\_\_\_\_.
- iv) The tongue of frog flicks out to catch insects because it is attached in the \_\_\_\_\_ of the mouth.

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## 3.4 DIGESTIVE SYSTEM IN NON-MAMMALIAN VERTEBRATES

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The development of extracellular digestion in an alimentary canal was an important evolutionary innovation. It freed many animals from feeding continuously, for they could quickly ingest a few large chunks of food rather than slowly obtaining many particles small enough to enter cells and undergo intracellular digestion. The overall tubular organization of alimentary canal is efficient because it allows food to travel in one direction, passing through different regions of digestive specialization. Thus both acid and alkaline phases occur in the digestive tract of vertebrates, and both are active and at the same time providing different types of digestive action. In general, alimentary canals have four major divisions, the functions of which are (1) receiving food, (2) conducting and storing food, (3) digesting and absorbing nutrients and (4) absorbing water and defecating. Representative alimentary canals from different non-mammalian vertebrate classes are discussed in the following sub-sections.

### 3.4.1 Fishes

#### (a) Cartilaginous fishes

The digestive system of cartilaginous fishes comprises alimentary canal and glands of alimentary canal.

As you can see in fig. 3.11 the alimentary canal of *Scoliodon* consists of mouth, buccal cavity, pharynx, oesophagus, stomach, intestine and rectum. Mouth is a ventral crescentric opening which leads into a spacious dorso-ventrally compressed buccal cavity. The buccal cavity is lined with a thick mucous membrane raised ventrally into a thick fold to form the so called **tongue** which is non-muscular and non-glandular. The mucous membrane is rough due to the presence of dermal denticles. Teeth are oblique and have sharp more or less compressed cusps, the edges of which are smooth and non-serrated. Teeth are all alike in shape, **homodont**, and are borne in several parallel rows on the inner margin of the upper and lower jaws. Teeth are used to catch prey and prevent its escape but not to crush or masticate it.

Though there are several rows of teeth (polyphyodont) yet only one row functions at a time and the old row is replaced by a new one. There are no glands in the buccal cavity comparable to the salivary glands of higher vertebrates.

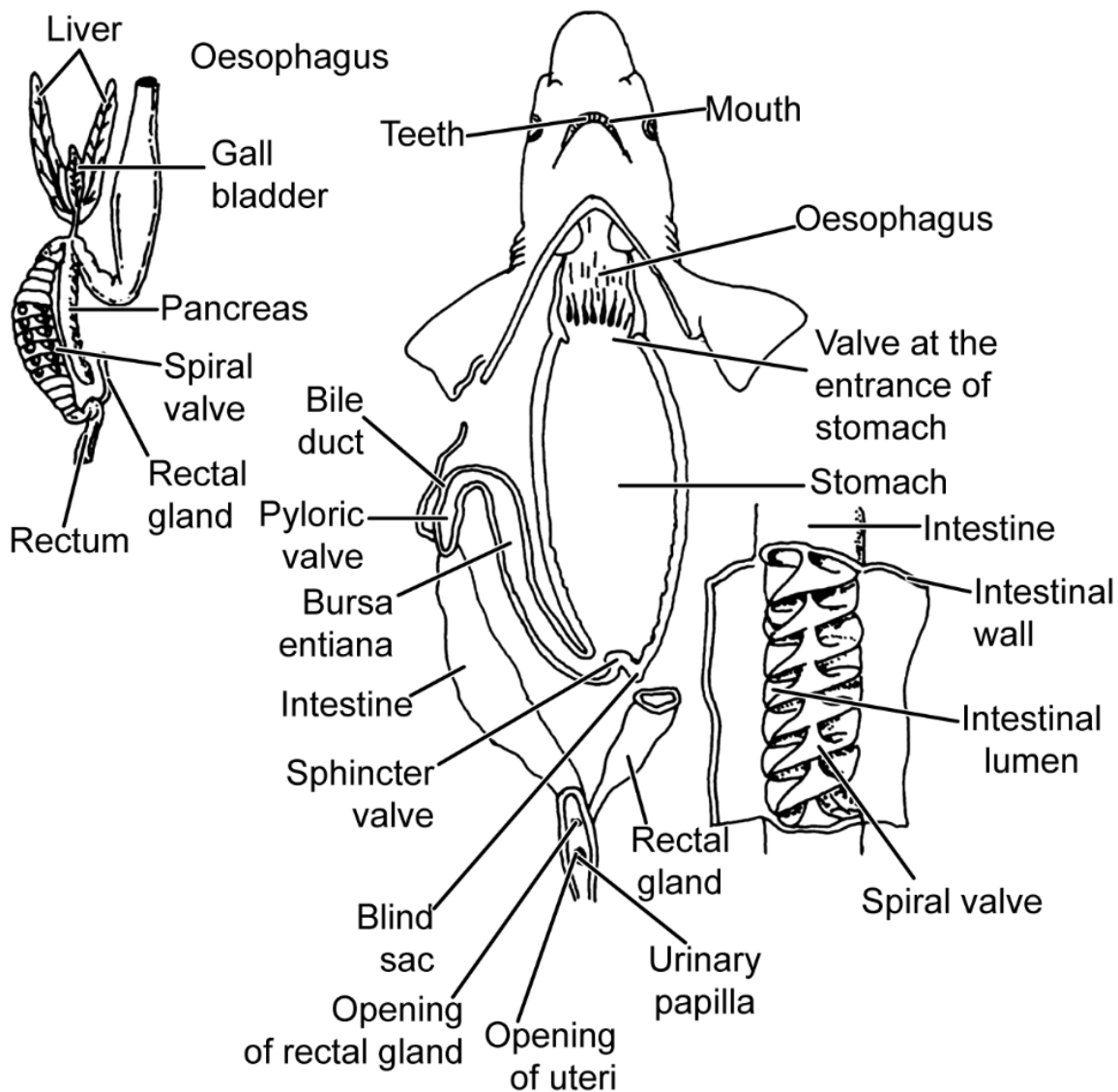


Fig. 3.11: *Scoliodon* alimentary canal.

The buccal cavity opens into pharynx on either side of which lie the internal openings of the spiracle and five gill-pouches. The cavity of pharynx is lined with mucous membrane containing numerous dermal denticles. The secretion of mucous glands in the pharynx has no digestive function but simply helps in lubricating the passage of food.

The pharynx narrows posteriorly to form the short oesophagus which has thick muscular walls with an internal lining of mucous membrane raised into longitudinal folds.

The oesophagus widens posteriorly to form a large muscular stomach. The stomach is bent on itself and forms a J-shaped organ, the long proximal limb called the **cardiac stomach** while the short distal limb is called the **pyloric stomach**. At the junction of cardiac and pyloric limbs there is a blind outgrowth, the **blind sac**. The inner mucous lining of the **cardiac stomach** is

also thrown into prominent longitudinal folds that end in the depression of the **blind sac**. At the end of **pyloric** stomach there is a small muscular chamber called **bursa entiana**. The opening of pyloric stomach into the bursa entiana is guarded by a circular band of muscle fibres called the pyloric valve.

The bursa entiana continues into the intestine. The intestine is a wide tube running straight backward into the abdominal cavity and opens posteriorly into the rectum. The internal surface of the intestine is increased by a characteristic fold of the mucous membrane, the **spiral valve**, having one edge attached to the inner wall of the intestine and the other rolled up longitudinally on itself into a spiral, making an anti-clock wise spiral of about two and a half turns. In a transverse section the spiral valve looks like a watch spring. The spiral valve serves not only to increase the extent of the absorptive surface of the intestine but also prevents rapid flow of food through the intestine.

The rectum is the last part of the alimentary canal. The tubular rectal (caecal) gland opens dorsally into the rectum. The rectum leads into cloaca into which the alimentary canal as well as the urinogenital ducts open.

The glands of alimentary canal comprise a massive bilobed liver and a thin V shaped gall bladder. The bile duct opens in the anterior part of the intestine where the spiral valve starts. The pancreas is a pale compact irregular body lying between the fold of the stomach and intestine.

#### (b) Bony fishes

The digestive organs vary much in structure. The mouth, which is placed at, or near, the anterior end of the head, usually has the form of a transverse slit, and can sometimes be extended forward by means of the movable supporting bones of the upper and lower jaws. Some fishes are toothless but in most instances teeth are present, their succession is perpetual, i.e., injured or worn out teeth are replaced at all ages.

In a very large majority of teleost species the teeth are small, conical, and recurved, suitable for preventing the struggling prey from slipping out of the mouth, but quite unfitted for either tearing or crushing. In some bony fishes alimentary canal shows little differentiation into regions, but as a rule, gullet, stomach, duodenum, ileum and rectum are more or less clearly distinguishable histologically. The stomach is V-shaped but its cardiac region may be prolonged into a blind pouch (Fig. 3.12). This is often very distensible, allowing some of the deep-sea Teleostei to swallow fishes as large as themselves. In many genera of several families stomach is entirely absent.

Globe fishes can inflate the gullet with air or water, as a result of which they can float upside down. A spiral valve is very well developed in *Polypterus* and Sturgeons, vestigial in *Lepisosteus* and *Amia*, and absent or vestigial in all Teleostei, except possibly in *Chirocentrus* (Isospondyli). A trace occurs in the herring. Liver is usually large. Pancreas may be present as a compact gland, or may be widely diffused between layers of the mesentery, or in part surrounded by the liver. **Pyloric Caeca** are commonly present, and vary in number from a single one to two hundred. Anus is always distinct from, and in front of the urinogenital aperture.

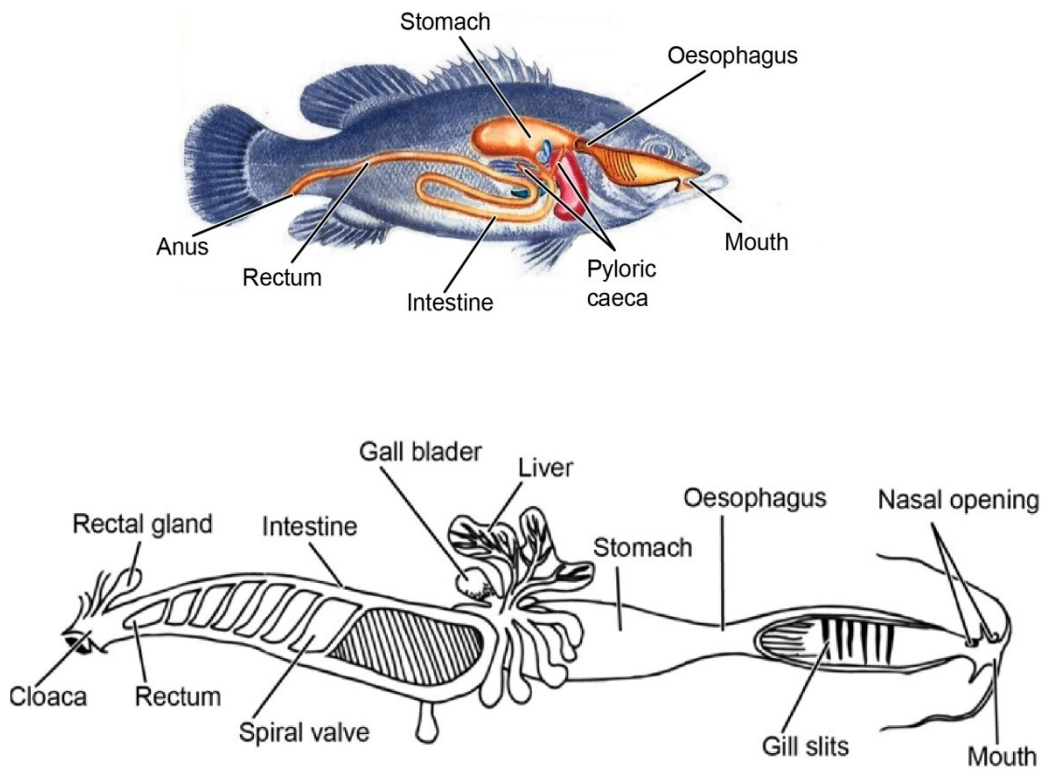


Fig. 3.12: Digestive tract of a Teleost fish (bass).

### 3.4.2 Amphibians

The mouth opening is a wide slit. Teeth, which are ankylosed to the bones, are present upon the premaxillae, maxillae and vomers. They are absent in *Pipa* and some toads. Tongue is immovable in Urodela, movable and free behind in Anura, in which it is used as a prehensile organ. Salivary glands are not present. In many oesophagus, stomach, small intestine and rectum are present.

We consider the frog as a typical example of amphibians. The alimentary canal of frog consists of buccal cavity, pharynx, oesophagus, stomach and intestine ( Fig.3.13). Mouth leads into a wide and broad cavity called buccal cavity lying between the two jaws, the upper and the lower one. The buccal cavity in its roof near the vomerine teeth has two openings, the internal nares connecting with the nostrils through which respiratory gases pass to and from the buccal cavity during respiration.

The pharynx leads into a broad tubular part of the alimentary canal called oesophagus. This part of alimentary canal is very short due to the absence of neck. But the oesophagus is highly distensible as its inner lining is thrown into a large number of longitudinal folds that allow its expansion during the passage of the ingested food to the stomach. The stomach comprises two parts, the anterior expanded **cardiac part** and the posterior short narrow **pyloric part**. The stomach opens into long tubular part the intestine consisting of two parts the **small** and **large** intestine. The small intestine leads to a short, broad colon or large intestine called rectum. The hind end of the rectum is called the **cloaca** and possesses a median ventral appendage, the urinary bladder. The urinary and generative ducts open into cloaca. The cloaca opens to the exterior by the anus. The digestive glands such as liver and pancreas are present and the liver has a gall bladder.

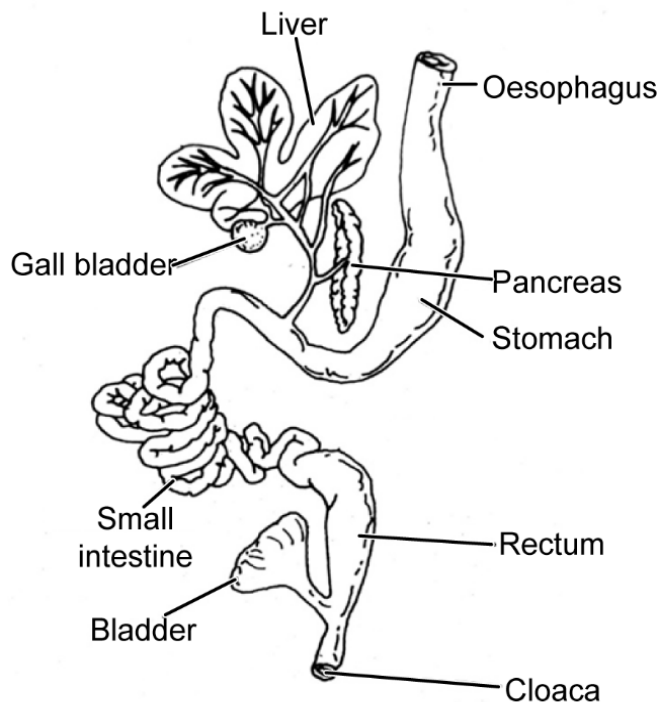


Fig. 3.13: Digestive tract of an amphibian (frog).

### 3.4.3 Reptiles

Teeth are usually present on the premaxillae, maxillae and dentary, and frequently on the palatine and pterygoid. They are continually replaced, and are pleurodont, acrodont, or thecodont. Teeth are conical or hooked and are adapted for prehension not for mastication except in some extinct forms. In *Chelonia* teeth are absent, being replaced by the horny epidermal beak-like covering of jaws.

In this section to make you understand the digestive system of reptiles we will describe the digestive system of a *Uromastix* lizard (Fig. 3.14). The alimentary canal is a long and convoluted tube. It can be divided into mouth, buccal cavity, pharynx, oesophagus, stomach, duodenum, ileum or small intestine, colon or large intestine, rectum and cloaca. The mouth opening is a wide gap bounded by the upper and lower immovable and muscular lips. The mouth opens into the buccal cavity which has a well developed muscular tongue on its floor. Tongue is attached to the floor of the buccal cavity along the median ventral line. The tongue is long, bifid and protrusible having voluntary muscles, taste buds and mucous glands. In the upper jaw, teeth are present on premaxillae and maxillae, whereas in the lower jaw the dentary bears teeth. The teeth of *Uromastix* are pleurodont which means teeth are attached to the outer border of the bones of jaw.

The pharynx lies posterior to the tongue. The lining of the pharynx is thrown into longitudinal folds. The pharynx leads posteriorly into the oesophagus. It is capable of great distension and it opens into long cylindrical sac like structure the stomach which is wider than the oesophagus. It has thick muscular walls and lies in the left half of the body and is curved having the appearance of U-shape. The stomach is differentiated into two parts; the anterior part is known as **cardiac stomach** which lies dorsal to the left lobe of the liver, and the posterior part is known as **pyloric stomach** lying slightly to the right side. The

wall of the stomach is much thicker than that of the oesophagus and of the intestine. Numerous well developed longitudinal folds of mucous membrane are seen in the lumen of both cardiac and pyloric stomach. Stomach is the place where digestion occurs. The pyloric wall is in the form of a muscular ring lining of the inner wall of the posterior extremity of the pyloric stomach.

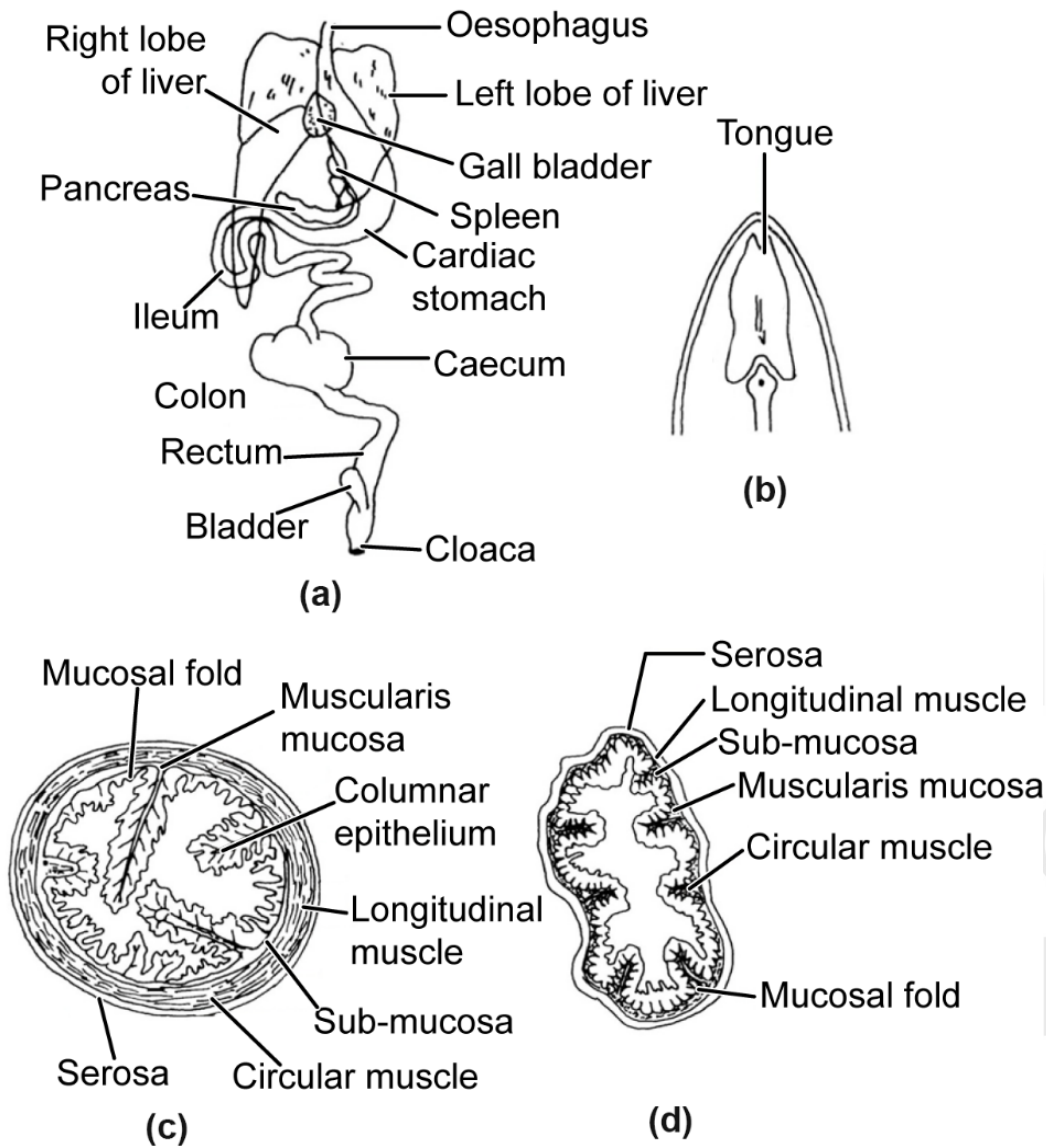


Fig. 3.14: *Uromastix*; a) Alimentary canal, b) Tongue, c) T.S. of cardiac stomach, d) T.S. of pyloric stomach.

The small intestine consists of an anterior duodenum and a posterior ileum. The duodenum is U-shaped and receives bile and pancreatic juices. Both duodenum and ileum show closely set wavy longitudinal folds of mucosa.

You can see from Fig. 3.14 a that ileum opens into a large intestine which comprises a proximal colon and distal rectum. The caecum pouch arises from the junction of ileum and colon. Rectum opens into cloaca that in turn opens to the exterior by the cloacal opening. The cloaca consists of three chambers, the coprodaeum, the urodaeum and the proctodaeum. Different chambers of cloaca serve for reabsorption of water both from faeces and urine. The digestive glands that are associated with the alimentary canal are gastric glands, liver, pancreas and intestinal glands.

The salivary glands are usually absent in all reptiles. There is a sub-lingual gland in *Chelonia*. Both upper and lower labial glands and palatal and lingual glands are always present. The poison glands of snakes are upper labial salivary glands.

### 3.4.4 Birds

In spite of great differences in the mode of nourishment the avian digestive organs present a fairly uniform structure; their unusual structures in the digestive system are adaptations for flight. The jaws are covered by a hard horny sheath (rhamphotheca) and transformed into the beak. The rhamphotheca is often composed of several pieces (compound). True teeth are entirely absent, at least in living birds. While the upper beak is formed by the fused premaxillae, the maxillae and the nasal bones, the lower beak corresponds to the two rami of the lower jaw, the fused extremities of which are known as the **myxa** (Fig.3.15). The form and development of the beaks vary extremely according to the special mode of subsistence (see Fig. 3.8 again).

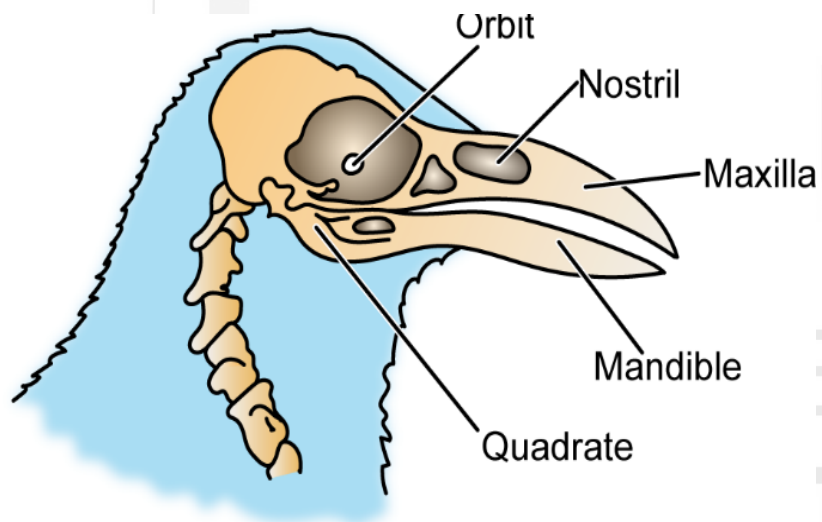


Fig. 3.15: Typical beak structure of birds.

Tongue which is always movable, lies on the floor of buccal cavity. It consists of horny or fleshy covering of two cartilages attached to the anterior end of the hyoidbone and serves for pushing the food back, and frequently for seizing food. Oesophagus is muscular, longitudinally folded and the length generally depends on the size of the neck. It frequently possesses a dilation known as crop especially in birds of prey, and also in granivorous birds, in which the food is stored and softened (Fig. 3.16a). In pigeons crop bears two small rounded accessory sacs.

The lower end of oesophagus is dilated into a glandular proventriculus, which is followed by wide muscular stomach called gizzard. While the proventriculus has, as a rule, an oval form and is smaller than the gizzard, the latter is provided with muscular walls, which are weak in birds of prey and strong in granivorous birds. In granivorous birds gizzard is well adapted for mechanical preparation of the softened food material by the possession of two solid plates, which form the horny internal wall and rub against one another (Fig. 3.16 b). It contains small stones which the bird swallows to aid in the grinding of the

food. The first loop of small intestine which is corresponding to duodenum surrounds the elongated pancreas. The 3 ducts of pancreas and the usually double bile ducts, open in this region. A gall bladder is present. The beginning of the short, large intestine is marked by the presence of a circular valve, and by the origin of two caeca. There is no distinction between colon and rectum, and the large intestine passes into the cloaca, into which the urinogenital apparatus also opens. The entrance into the cloaca is marked by a sphincter-like circular fold. A peculiar glandular sac the bursa Fabricii opens into the dorsal wall of the cloaca.

Cloaca usually presents three fairly well-marked divisions separated by folds (Fig. 3.16 c). The anterior of these, often called the **coprodaeum** is the dilated hind end of the rectum. The lining of coprodaeum is, however, different from that of the rectum from which it is often separated by a fold. The middle chamber is called the **urodaeum**: it is smaller than the other two chambers and receives the openings of the urinogenital duct. The posterior chamber which opens to the outside by the **vent**, may be termed the **vestibule**; it receives the bursa Fabricii dorsally.

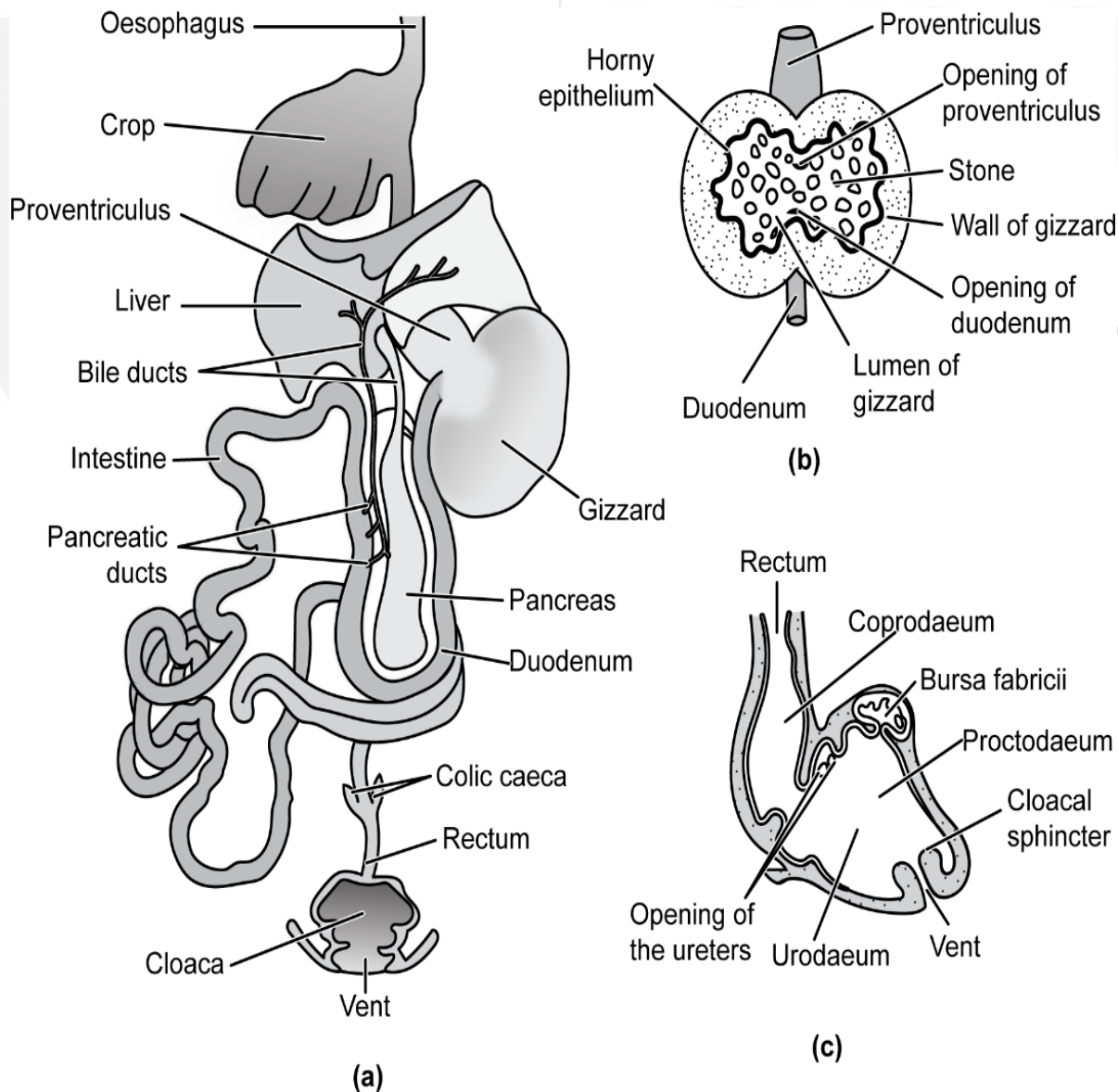


Fig. 3.16: Digestive tract of pigeon.

**SAQ 3**

Match the statement given in **column B** with the chordate group given in **column A**.

Column A	Column B
Fish (cartilaginous and bony)	i) A crop and gizzard is present
Amphibians	ii) Salivary glands are absent but lingual glands are present.
Reptiles	iii) In many genera of several families stomach is entirely absent.
Birds	iv) True teeth are entirely absent.
	v) Tongue like structure formed of ventrally raised mucous membrane.
	vi) Teeth are polyphyodont but only one row functional at one time.
	vii) Tongue is bifid has taste buds and glands.
	viii) Intestine has spiral valve that increases the absorptive surface.
	ix) Mouth is an anterior transverse slit that can be extended forward to catch prey.
	x) Vomarine teeth present.

### **3.5 DIGESTIVE SYSTEM IN MAMMALS**

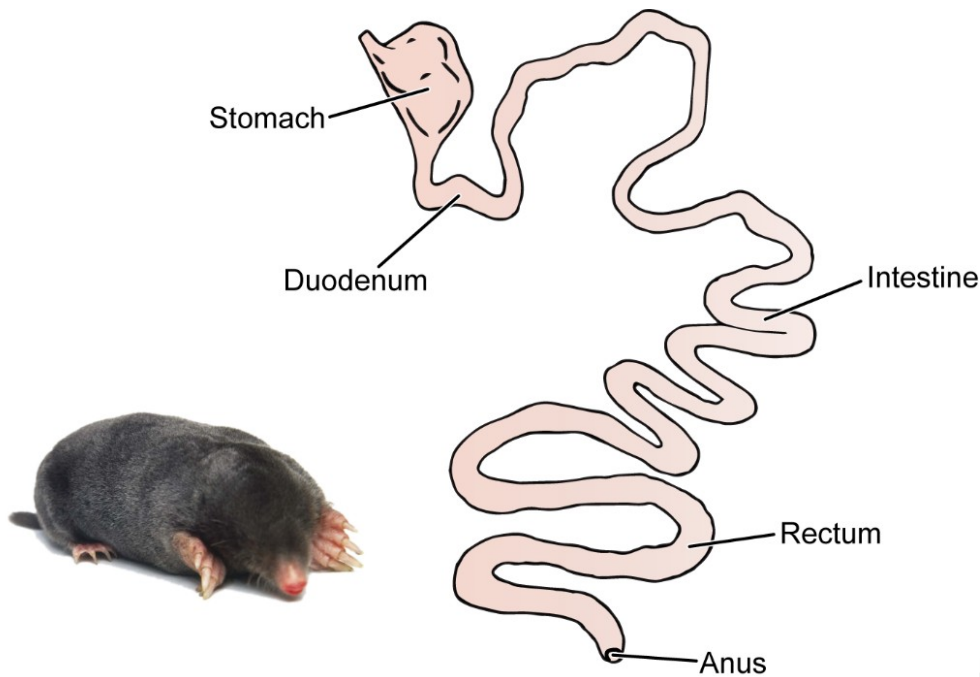
The feeding or trophic, apparatus of a mammal includes the oral structures (teeth, jaws, tongue), alimentary canal, and accessory digestive glands (salivary glands, liver and pancreas). Accordingly their digestive tracts are adapted to their particular feeding habits. On the basis of food habits, mammals are divided among several trophic or nutritional groups (see Fig. 3.10 again).

#### **3.5.1 Trophic Groups in Mammals**

The three basic trophic groups in mammals are insectivores, carnivores and herbivores, and many feeding specializations have evolved in each groups.

**Insectivores** are small mammals, usually opportunistic feeders, that feed on a variety of small invertebrates, such as worms, grubs and insects. Examples are shrews, moles, anteaters, and most bats. Since insectivores eat little fibrous vegetable matter which requires prolonged fermentation, their intestinal tract tends to be short (Fig. 3.17). The insectivorous is not a sharply distinguished category since carnivores and omnivores often include insects in

their diet. Even many rodents which are considered herbivores, may have a mixed diet of insect larvae, seeds and fruits.

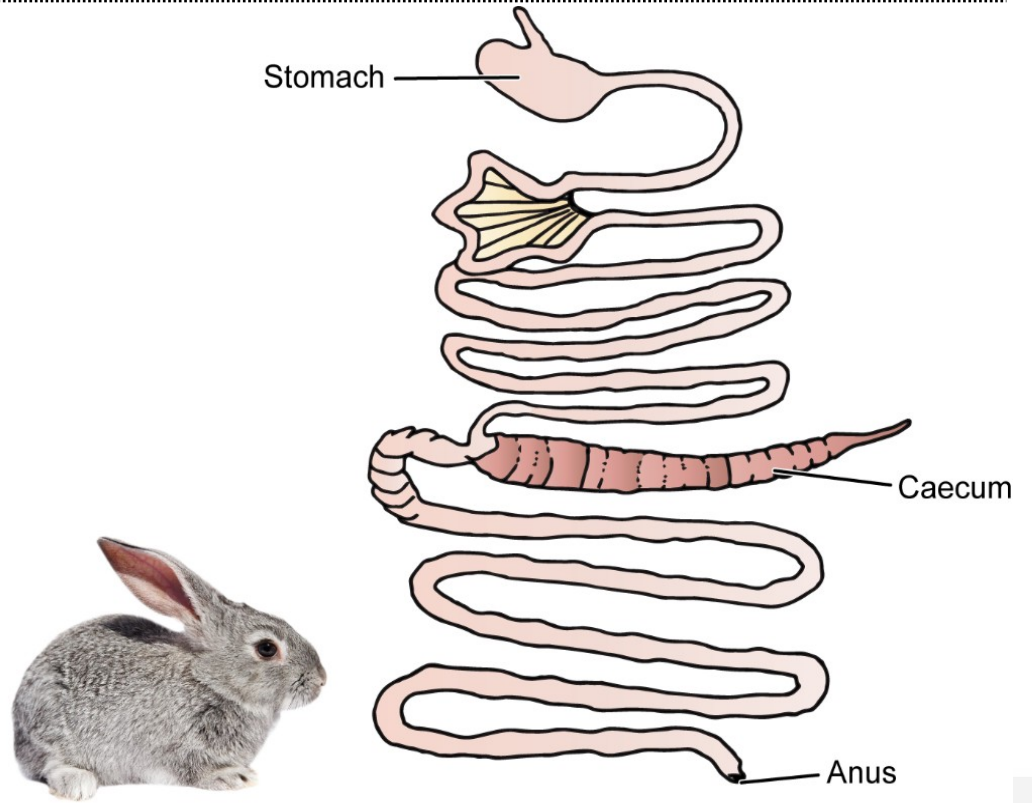


**Fig. 3.17: Digestive System of an insectivore showing short intestine. Note there is no caecum.**

**Herbivorous** mammals which feed on grasses and other vegetation form two main groups; the browsers and grazers, such as the ungulates, that are, hooved mammals including horses, deer, antelope, cattle, sheep and goats, and the gnawers such as the rodents which include rabbits and hares. In herbivores, the canines are either reduced in size or may be absent, while the molars that are adapted for grinding, are broad and usually high-crowned. Rodents have sharp chisel-shaped incisors which grow throughout life and must be worn away to keep pace with their continuous growth. If the incisors do not grow continuously, the cutting surface of the teeth will get eroded soon by its excessive use due to its continuous gnawing habit.

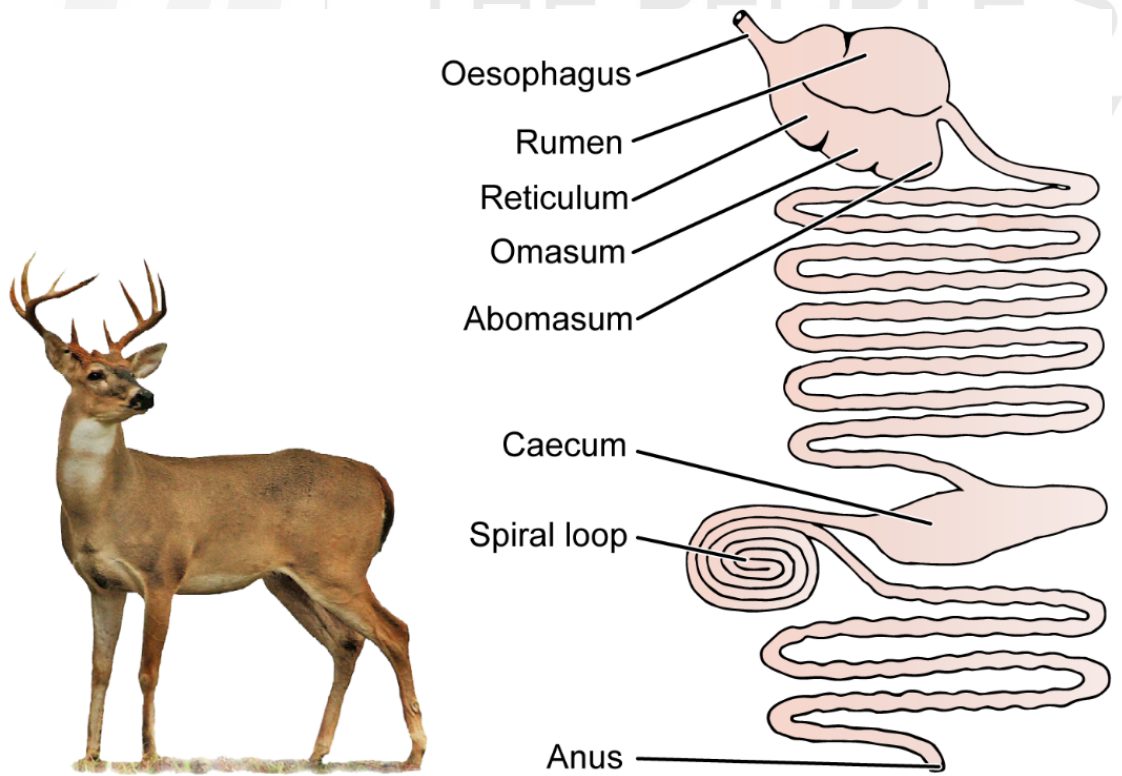
Herbivorous mammals have a number of interesting adaptations for dealing with their fibrous diet of plant food. **Cellulose**, the structural carbohydrate of plants, is potentially nutritious foodstuff, composed of long chains of glucose units. However, glucose molecules in cellulose are linked by a type of chemical bond that few enzymes can attack. No vertebrate synthesizes cellulose splitting enzymes. Instead, the herbivores harbour a microflora of anaerobic bacteria and protozoa in the gut. These bacteria and protozoa breakdown and metabolize cellulose, releasing a variety of fatty acids, sugars, and starches which the host can absorb and use.

In some of the herbivores like horses, zebras, rabbits, hares, deer, elephants and many rodents, gut has a spacious side pocket or diverticulum, called a **caecum** that serves as a fermentation chamber and absorptive area (Fig. 3.18 & 3.19). Hares, rabbits and some rodents often eat their faecal pellets (**coprophagy**) giving the food a second pass-through the fermentating action of the intestinal bacteria. Coprophagy also provides an opportunity for the animal to obtain vitamins produced by the bacteria lodged in the caecum.



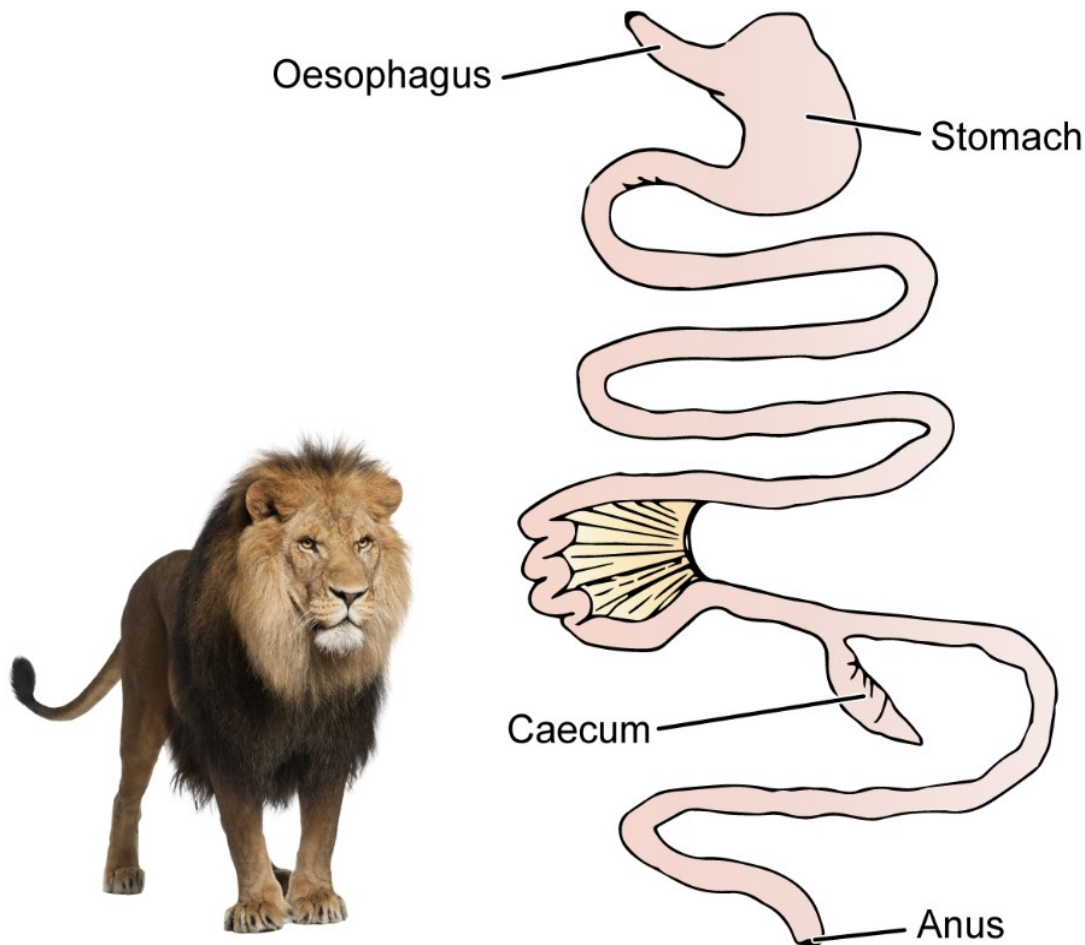
**Fig. 3.18: Digestive System of a non-ruminant herbivore (rabbit) showing simple stomach and a large caecum.**

Ruminants like cattle, bison, buffalo, goats, antelopes, sheep, deer, giraffes etc. have a huge four chambered stomach (Fig. 3.19). You will learn more about the specialized ruminant stomach a little later in this section.



**Fig. 3.19: Digestive System of a ruminant herbivore (deer) showing four-chambered stomach with Large rumen, and long sized small and large intestines.**

**Carnivorous** mammals feed mainly on herbivores. This group includes foxes, dogs, weasels, wolverines, cats, lions, tigers etc. Carnivores are well equipped with biting and piercing teeth and powerful clawed limbs for killing the prey. Since their protein diet is easily digested in comparison to the woody food of herbivores, their digestive tract is shorter and the caecum is small or absent (Fig.3.20).



**Fig. 3.20: Digestive system of a carnivore showing short intestine and colon, small caecum.**

Generally carnivores lead more active life than do the herbivores. Since a carnivore must find and catch its prey, there is a premium on speed and intelligence; many carnivores, such as cats are known for their stealth and cunningness in hunting prey. This has led to a selection of herbivores capable either of defending themselves or of detecting and escaping carnivores. Thus for the herbivores, there has been a premium on keen senses and agility. Some herbivores, however, survive by virtue of their sheer size e.g. elephants or by defensive group behaviour for example North American musk oxen.

**Omnivorous** mammals live on both plants and animals for food. Examples are pigs, racoons, rats, bears and most primates including human beings. Many carnivore forms also eat fruits, berries and grasses when hard pressed. The fox which usually feeds on mice, small rodents and birds, eats frozen apples, beech nuts, and corn when its natural food is scarce. For most mammals, searching for food and eating occupy most of their active life. Some

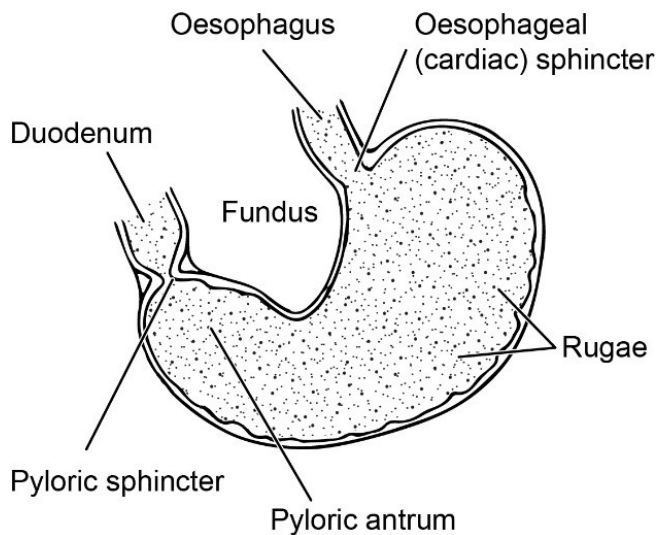
migrate to regions where food is in plenty, while others hibernate and sleep during the winter months. But there are many provident mammals which build up food stores during period of plenty. This habit is most pronounced in rodents such as squirrels, chipmunks, gophers and certain mice.

### 3.5.2 Digestive Tract

The mouth in mammals is bound by fleshy lips. On the floor of the mouth is situated a tongue which is usually well developed, but varies in size and shape in different orders of mammals. In some herbivorous animals it can be curled around grass and thus helps pull it into the mouth. Its surface is covered with papillae of different kinds. The papillae are sometimes horny, serving for either grinding of food, or for the dressing of the hairy coat. Thus the tongue and lip margins in many mammals are equipped with raised processes which can be moved up and down along the interspaces of the teeth (and on the surfaces of the teeth) in a cleansing action. In association with the papillae of the tongue there are special end organs of taste (**taste buds**) which are often arranged in zones. The sense of taste differs profoundly among various groups. The roof of the mouth is formed in front by the hard palate, consisting of the horizontal palatine plates of the maxillary and palatine bones covered with mucous membrane bearing palatal folds. Behind the hard palate there is a backward projection of the soft muscular fold of the soft palate which divides the cavity of the pharynx into an upper and a lower chamber. In some forms the soft palate also bears taste buds. In **Primates** a free-hanging **uvula** and soft palate are raised to close off the nasopharynx and prevent the entrance of food into it. In front of the opening, leading from the lower division of the pharynx into the larynx, is a cartilaginous plate called epiglottis a primitive form of which is found in certain lower vertebrates like frogs. The epiglottis, anatomically part of the larynx, assists the reflex swallowing mechanism by preventing food from entering trachea.

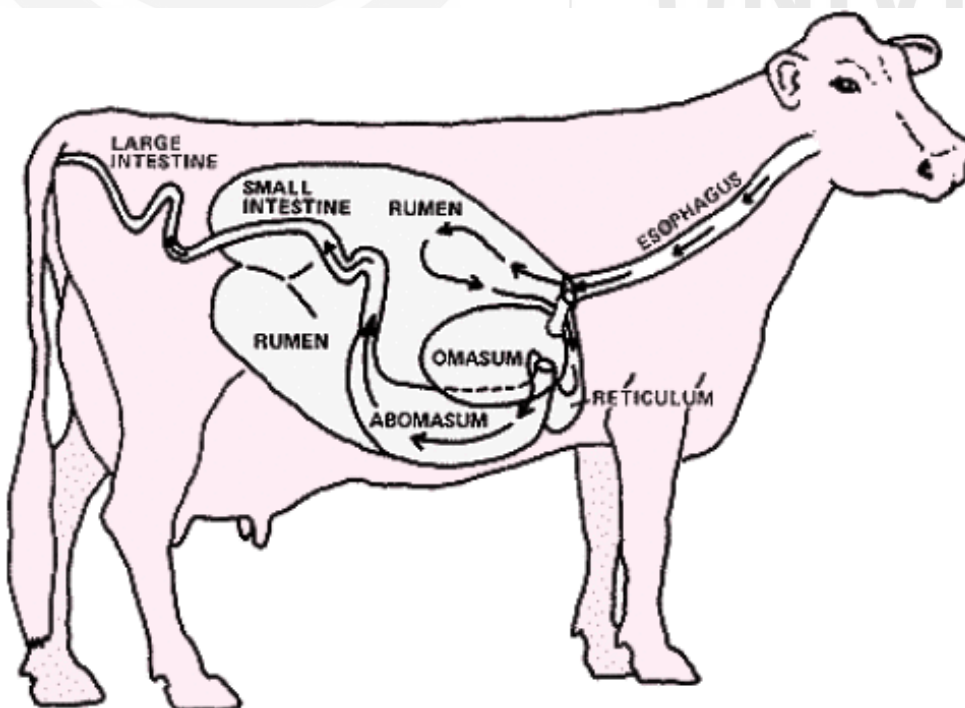
The oesophagus is a simple, straight tube in which food is propelled by peristaltic contractions of the muscular walls, which like the act of swallowing or deglutition, are reflex and involuntary. The opposite action, **retroperistalsis** enables ruminants to regurgitate stomach content for more leisurely mastication, and many other animals to expel injurious substances accidentally swallowed.

The stomach varies greatly in different mammalian orders. In majority of mammals including humans it is **monogastric** or single chambered (Fig. 3.21). When empty it is a rather small chamber but can stretch upto 20 times to accommodate food, a quality that is useful for animals that feed when food is available. It is the site of major protein digestion except in ruminants. But in certain groups it is complicated by the development of internal folds, and may be divided by constrictions into several functionally different chambers. Such complication reaches its extreme in the ruminants of order Artiodactyla. In a typical ruminant (see Fig. 3.22 (i)) such as sheep, deer or cow, stomach is divided into 4 chambers - the **rumen** (or punch), the **reticulum**, **omasum** and the **abomasums** (or rennet stomach). The epithelium of both rumen and reticulum is highly reminiscent of that of the oesophagus.

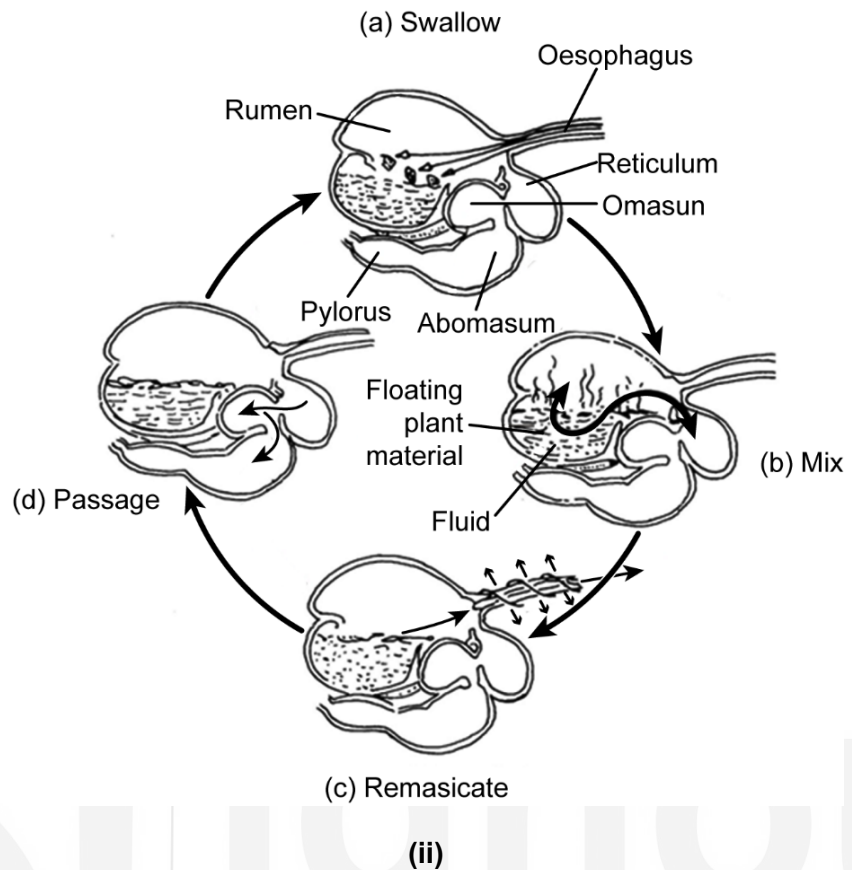


**Fig. 3.21: Monogastric stomach showing major parts of the mammalian stomach.**

When a ruminant feeds on grass, it is saturated by copious saliva passes down the oesophagus to the rumen, where it lies until the animal finishes eating. There the food is broken down by the rich microflora and then formed into small balls of cud. At its leisure the ruminant returns the cud to its mouth where the cud is deliberately chewed at length to crush the fiber. Swallowed again, food returns; to the rumen where it is digested by the cellulolytic bacteria (Fig. 3.22 (ii)). The pulp is then passed on to the **reticulum**, then to **omasum** and finally to the **abomasum** that is true acid stomach, where proteolytic enzymes are secreted and normal digestion takes place. In general herbivores having large, long digestive tracts must eat a considerable amount of plant food to survive. A large African elephant weighing 6 tons must consume 135 to 150 kg of rough fodder each day to obtain sufficient nourishment to survive.



(i)



**Fig. 3.22 : i) Digestive system of ruminants; ii) Foregut fermentation in the bovine stomach. (a) In ruminants, food is clipped, rolled into a bolus, mixed with saliva, and swallowed. (b) Contractions spread through rumen and reticulum in cycles that circulate and mix the bolus. Contents separate into fluid and particulate material. Floating, fibrous plant material and a pocket of gas forms during fermentation. (c) Poorly masticated bolus of plant material is regurgitated and re-chewed later to break down fibrous cell walls mechanically and expose further plant tissue to the enzymes cellulases. Respiratory inhalation, without opening the trachea, produces negative pressure around the oesophagus to draw some of this poorly masticated material into the oesophagus through the gastroesophageal sphincter. Peristaltic waves moving forward in the wall of the oesophagus rally the bolus into the mouth for re-chewing. (d) The omasum transports reduced bolus from the reticulum to the abomasums in two phases. First, relaxation of omasal walls produces negative pressure that draws fine particulate material from the reticulum into its own lumen. Next, contraction of the omasum forces these particulates into the abomasum, the stomach region rich in gastric glands. Thus, the abomasum is the first true part of the stomach.**

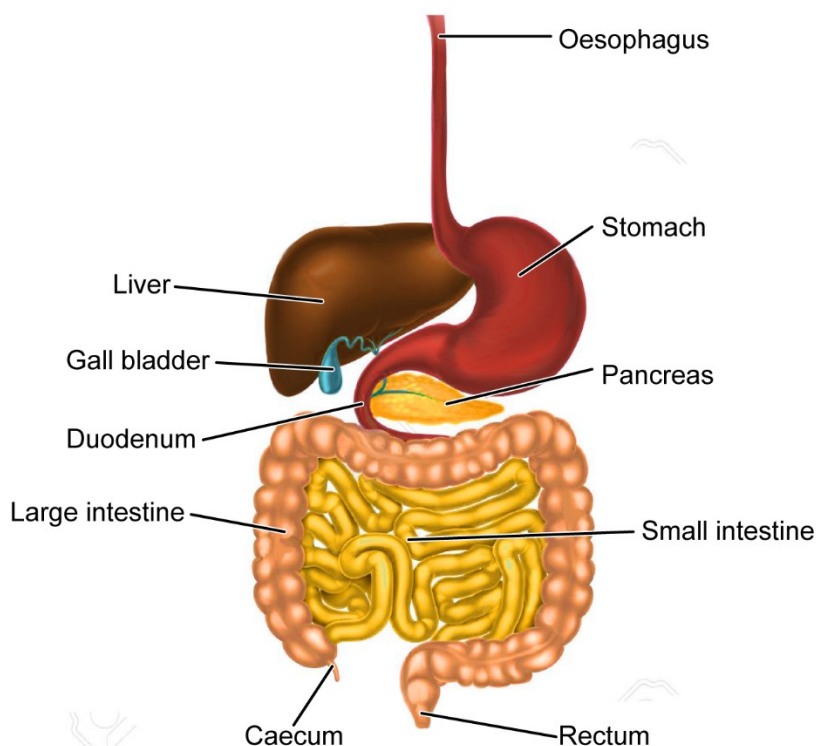
The oesophagus opens into the rumen close to its junction with the reticulum. The rumen is much larger than the rest. Its mucous membrane is beset with numerous short villi. The reticulum, is much smaller than the rumen, has its mucous membrane raised up into a number of anastomosing ridges. These are capable of closing together in such a way as to convert the groove into a canal. The mucous membrane of omasum is raised up into numerous longitudinal leaf-like folds. The abomasum, smaller than the rumen but larger than the reticulum, has a smooth vascular and glandular mucous membrane.

In some ruminants omasum is absent. In the rumen and reticulum of deer, cattle, sheep etc., there exist a dense population of protozoa and bacteria that attack and break down cellulose which forms the major part of the diet. Fermentation produces acetic, butyric and propionic acids which are neutralized by sodium bicarbonate secreted in the saliva. As a result methane and CO<sub>2</sub> are produced and belched out.

Food residues, fluid and micro-organisms move down the alimentary canal. In the omasum fluid is absorbed. In the abomasum, the protozoa and probably the bacteria, are destroyed by secreted HCl. The abomasum also produces digestive enzymes. In camels stomach is not as complex as in the more typical ruminants. There is no distinct omasum, and the rumen is devoid of villi. Both rumen and reticulum have connected with them a number of pouch like diverticula, the openings of which are capable of being closed by sphincter muscles. In **Cetacea** stomach is also divided into compartments. In porpoises (sea animals like a dolphin or a small whale) oesophagus opens into a spacious rumen, the cardiac compartment of the stomach, which has a smooth, thick, mucous membrane. This is followed by a second median chamber of considerably smaller dimensions. This has a glandular mucous membrane, which is thrown into a number of complex folds. A long and narrow third or pyloric, compartment follows terminating in a constricted pyloric aperture. Beyond this beginning of the small intestine is dilated into a bulb.

Absorption of nutrients takes place in the small intestine which is the longest part of the alimentary canal in most vertebrates (see the figures of digestive tracts in the previous sub-section). The inner surface of the intestine is highly folded with finger like projections that increase the absorptive surface. In humans (see Fig. 3.23) the intestines are divided broadly in three regions: the **duodenum** which connects to the stomach, the **jejunum** where most of the carbohydrates and amino acids are absorbed and the third part is known as **ileum**, where vitamins and bile salts are absorbed into the blood stream.

A **caecum**, situated at the junction of large and small intestine is usually present, but varies greatly in extent in the different orders and families. In general, it is much larger in vegetarian than in carnivorous forms. Among herbivores it is those that have a simple stomach such as the rabbit, that have the largest caecum (Fig. 3.18). The caecum is simple in **monotremes**, absent in sloths, some **cetaceans** and in a few carnivores. It is relatively enormous (about 250 cm. long) in the marsupial Koala, *Phascolarctos* (which eats mostly eucalyptus leaves). In humans and a few other animals (civets, some rodents, monkeys) the distal end of the caecum has degenerated into an appendix vermiformis (Fig. 3.23). The proportion of vegetable material ingested is not, however, the only factor governing the size of the caecum. In ruminants caecum is relatively small. In ruminants the colon too, is comparatively unimportant: but in non-ruminant herbivores such as horses both caecum and colon are enormous. All material passing from ileum to colon enters caecum which in horses, may be some four feet long and holds as much as eight gallons. In horses caecum has fluid storing and digestive functions. The large colon in horses is principally absorptive in function although some bacterial but not enzymatic digestion occurs therein.



**Fig. 3.23: Human digestive tract.**

The rectum is the terminal part of the large intestine as seen in Fig.3.23. Its primary function is to store faeces until defecation through the anus. The Prototherians resemble reptiles, birds and Amphibia and differ from most mammals in the retention of a cloaca. Into this not only rectum but the urinary and the genital ducts open. In marsupials a common sphincter muscle surrounds both anal and urinogenital apertures. In female there is a definite cloaca. In nearly all eutherians the apertures are distinct, and separated from one another by a considerable space the **perinaeum**.

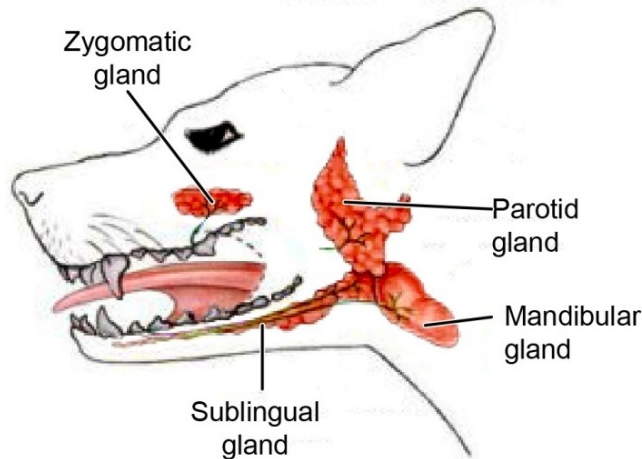
### **3.5.3 Digestive Glands of Mammals**

The accessory glands of the mammalian digestive system are the three pairs of salivary glands, liver, its storage organ the gall bladder and the pancreas.

- i) **Oral Glands** : The epithelium of buccal cavity contains a rich source of cells which secrete mucous and serous fluid. These secretory cells when clustered together and empty their secretion via common duct are called oral glands. Secretions from most of these glands, in addition to lubrication of food, may also help maintain healthy oral membranes, neutralize toxins carried by prey, and perhaps initiate the chemical stages of digestion.

The most common oral glands in mammals are the salivary glands. There are usually three primary pairs of salivary glands, named for their approximate positions: **mandibular** (submandibular or submaxillary), **sublingual**, and **parotid**. They form the **saliva**, which is added to food in the mouth. These three pairs of glands lie at the angle of the jaws, usually at about the juncture between the head and the neck, but they are positioned superficial to the neck musculature. Ducts from the

mandibular and sublingual glands run anteriorly and release secretions into the floor of the buccal cavity. The duct from the parotid gland opens into the roof of the buccal cavity. In some species, additional salivary glands may be present. In dogs, cats, and some other carnivores, a **zygomatic** (orbital) gland is present, usually beneath the zygomaticarch (Fig. 3.24). Like most digestive secretions, saliva contains mucous, salts, proteins, and a few enzymes, most notably **amylase**, which initiates starch digestion. Saliva also aids swallowing by lubricating food.



**Fig. 3.24: Salivary glands of a mammal, dog. Note the locations of the main salivary glands (sublingual, mandibular, and parotid) along with their ducts leading to the buccal cavity. All mammals possess these three salivary glands. In dogs and cats, a zygomatic gland is also present.**

- ii) **Liver** : Like all vertebrates, mammals possess a liver. The liver is the second largest organ in the body only exceeded in size by the skin. It functions in a wide variety of roles. Early in foetal life, the liver is directly involved in the production of red blood cells, and later it is involved in the destruction of old blood cells. It consists of two parts or main divisions (i.e. right and left) completely separated from one another by a fissure termed the **umbilical**, owing to its marking the position of the foetal **umbilical** vein. Throughout life, liver detoxifies and removes toxic substance from the blood. Majority of mammals have a **gall-bladder**. When it is present, it is attached to or embedded in, the right central lobe of the liver. The gallbladder is absent in cyclostomes, most birds, and a few mammals, but otherwise is present throughout vertebrates. Gall bladder is absent in the Perissodactyla (horse, tapirs rhinoceros), the hyracoids and some rodents. Bile is manufactured by hepatocytes in the liver and collected in the bile ducts, stored in the gallbladder, and emptied into duodenum the via the common bile duct to **emulsify** fats, or break them up into smaller droplets. Carbohydrates, proteins, and fats are stored and metabolized in the liver. The liver is one of the most heavily vascularized organs of the body, being supplied with arterial blood via the hepatic artery. However, it is also supplied with venous blood via the hepatic portal vein which runs directly from the intestines and spleen to the liver, and delivers blood rich in nutrients absorbed products of digestion.
- iii) **Pancreas** : In embryo the development of the pancreas is closely associated with liver development. The pancreas arises from two

unpaired diverticula: the **dorsal pancreatic diverticulum**, a bud directly from the gut; and the **ventral pancreatic diverticulum**, a posterior bud of the hepatic diverticulum. These dorsal and ventral pancreatic rudiments may have independent ducts supplying pancreatic juices to the intestine.

Whether one or two, the ducts empty into the duodenal portion of the intestine and release an alkaline exocrine product, **pancreatic juice**, composed of the proteolytic enzyme trypsinogen, which is converted within the intestine to the active protease, **trypsin**. Amylases for carbohydrate digestion and lipases for fat digestion are also secreted. Embedded in the pancreas are small **pancreatic islets** (islets of Langerhans) that produce the hormones **insulin** and **glucagon**, both of which regulate the level of glucose in the blood. The pancreas is thus both an exocrine gland, producing pancreatic juice, and an endocrine, gland, producing insulin and glucagon.

### SAQ 4

Tick out (✓) the correct answer in the box.

- (i) Which organ in herbivores serves a fermentation chamber and provides absorptive area?
- (a) Liver
- (b) Gall bladder
- (c) Pancreas
- (d) Caecum
- (ii) In which mammals stomach is divided into 4 chambers?
- (a) carnivores
- (b) ruminants
- (c) rodents
- (d) Insectivores
- (iii) In which mammal caecum has fluid storing and digestive functions?
- (a) Kangaroo
- (b) Lion
- (c) Horse
- (d) Man
- (iv) In which mammals the cloaca is retained?
- (a) Insectivores
- (b) Protherians
- (c) Carnivores
- (d) Cetacians

## 3.6 SUMMARY

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Let us sum up what we have learnt in this unit:

- Teeth are present in all vertebrates except birds at some stage in their lives. Teeth develop partly from the epidermis and partly from the underlying dermis. Teeth can be classified according to their way of placement in the jaw, nature of replacement and their appearance. Mammals have two distinct sets of teeth, the deciduous (milk) and the permanent dentition. The number of various categories of teeth in the jaws in mammals is conveniently expressed by a dental formula in which the kind of teeth such as incisor, canine, premolar and molar are indicated by the initial letters as i, c, pm, m.
- Animals use various strategies to feed. Some species search, stalk, pounce, capture, and kill. In lower vertebrates such as cyclostomes, elasmobranchs, teleosts, the most successful and widely used method for feeding is filter feeding. These filter feeders use ciliated surfaces to produce currents which draw drifting food particles into their mouths. Amphibians capture their food using their tongue, swallow their food whole, their teeth only help to hold the prey. In reptiles jaws or palate are provided with pointed teeth which help these animals in holding, tearing or swallowing their prey. Whereas birds have no teeth, but instead of that they have horny beaks which exemplify adaptive radiation suited to a gastronomic life style. Mammals make extensive use of their teeth for killing, cutting and grinding it up and accordingly teeth have evolved very different shapes for those purposes.
- The digestive organs vary much in structure in different vertebrate groups which is correlated with the nature and abundance of their food. Overall the digestive system is a tubular organization of alimentary canal because it allows food to travel in one direction, passing through different regions of digestive specialization. In general alimentary canals in vertebrates have four major divisions, the functions of which are (1) receiving (2) conducting and storage, (3) digestive and absorbing nutrients and (4) absorbing water and defecating.
- The oral cavity receives the food and oesophagus conducts the food by peristaltic motion and connects to the stomach. In birds the oesophagus may have a diverticulum called crop to store grain. The stomach is amuscular chamber which is the site of storage and digestion. It shows increasing specialization from fishes to amphibians to reptiles. Birds have a proventriculus (glandular stomach) and ventriculus (muscular stomach or gizzard).
- In majority of mammals the stomach is relatively simple muscular sac like structure but in ruminants such as cattle, buffalo, goats, sheep, deer etc. it has four chambers. In ruminants food is swallowed, saturated by copious salivations and passes into the rumen and reticulum where it lies until, having finished feeding, the animal begins ruminating or chewing the cud.
- The small intestine is the longest part of the alimentary canal. It is the site of absorption of digested food. The colon is the large intestine and the site of absorption of water.

