

# CHAPTER 4

## ANIMAL KINGDOM

### 4.1 Basis of Classification

### 4.2 Classification of Animals

When you look around, you will observe different animals with different structures and forms. As over a million species of animals have been described till now, the need for classification becomes all the more important. The classification also helps in assigning a systematic position to newly described species.

#### 4.1 BASIS OF CLASSIFICATION

In spite of differences in structure and form of different animals, there are fundamental features common to various individuals in relation to the arrangement of cells, body symmetry, nature of coelom, patterns of digestive, circulatory or reproductive systems. These features are used as the basis of animal classification and some of them are discussed here.

##### 4.1.1 Levels of Organisation

Though all members of Animalia are multicellular, all of them do not exhibit the same pattern of organisation of cells. For example, in sponges, the cells are arranged as loose cell aggregates, i.e., they exhibit **cellular level** of organisation. Some division of labour (activities) occur among the cells. In coelenterates, the arrangement of cells is more complex. Here the cells performing the same function are arranged into tissues, hence is called **tissue level** of organisation. A still higher level of organisation, i.e., **organ level** is exhibited by members of Platyhelminthes and other higher phyla where tissues are grouped together to form organs, each specialised for a particular function. In animals like Annelids, Arthropods, Molluscs,

Echinoderms and Chordates, organs have associated to form functional systems, each system concerned with a specific physiological function. This pattern is called **organ system** level of organisation. Organ systems in different groups of animals exhibit various patterns of complexities. For example, the digestive system in Platyhelminthes has only a single opening to the outside of the body that serves as both mouth and anus, and is hence called incomplete. A complete digestive system has two openings, mouth and anus. Similarly, the circulatory system may be of two types:

- (i) **open type** in which the blood is pumped out of the heart and the cells and tissues are directly bathed in it and
- (ii) **closed type** in which the blood is circulated through a series of vessels of varying diameters (arteries, veins and capillaries).

#### 4.1.2 Symmetry

Animals can be categorised on the basis of their symmetry. Sponges are mostly **asymmetrical**, i.e., any plane that passes through the centre does not divide them into equal halves. When any plane passing through the central axis of the body divides the organism into two identical halves, it is called **radial symmetry**. Coelenterates, ctenophores and echinoderms have this kind of body plan (Figure 4.1a). Animals like annelids, arthropods, etc., where the body can be divided into identical left and right halves in only one plane, exhibit **bilateral symmetry** (Figure 4.1b).

#### 4.1.3 Diploblastic and Triploblastic Organisation

Animals in which the cells are arranged in two embryonic layers, an external **ectoderm** and an internal **endoderm**, are called **diploblastic** animals, e.g., coelenterates. An undifferentiated layer, mesoglea, is present in between the ectoderm and the endoderm (Figure 4.2a).

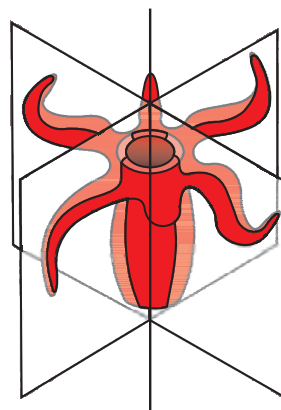


Figure 4.1 (a) Radial symmetry

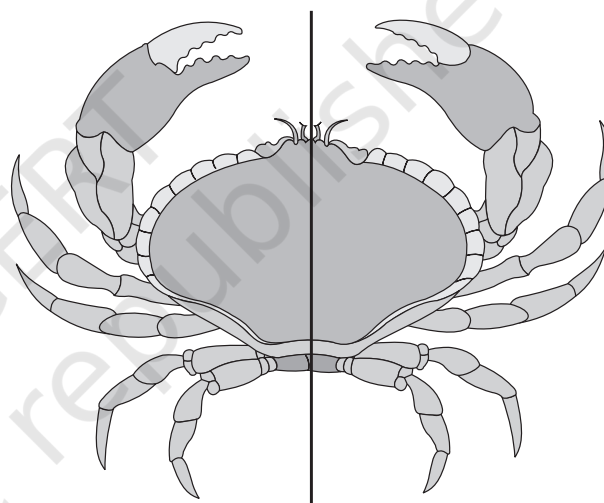


Figure 4.1 (b) Bilateral symmetry

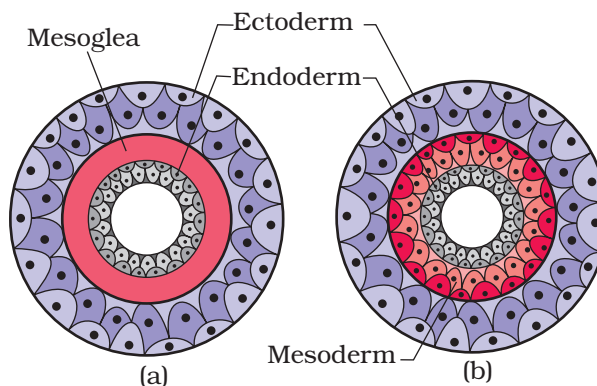
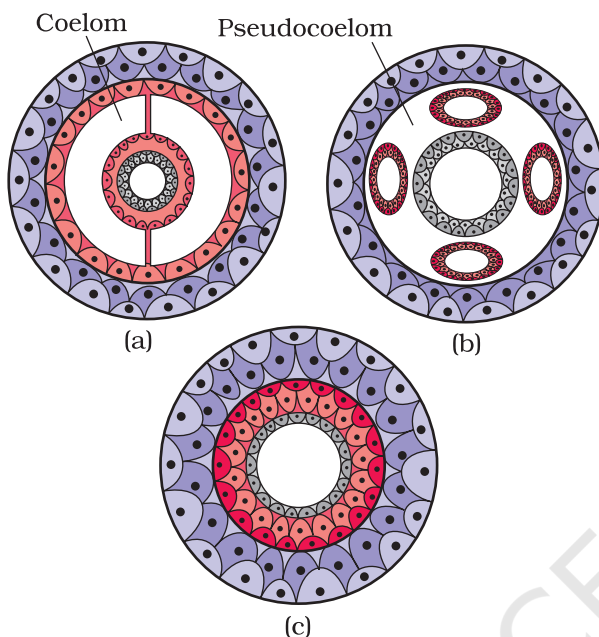


Figure 4.2 Showing germinal layers :  
(a) Diploblastic (b) Triploblastic

Those animals in which the developing embryo has a third germinal layer, **mesoderm**, in between the ectoderm and endoderm, are called **triploblastic** animals (platyhelminthes to chordates, Figure 4.2b).



**Figure 4.3** Diagrammatic sectional view of :  
(a) Coelomate (b) Pseudocoelomate  
(c) Acoelomate

#### 4.1.4 Coelom

Presence or absence of a cavity between the body wall and the gut wall is very important in classification. The body cavity, which is lined by mesoderm is called **coelom**. Animals possessing coelom are called **coelomates**, e.g., annelids, molluscs, arthropods, echinoderms, hemichordates and chordates (Figure 4.3a). In some animals, the body cavity is not lined by mesoderm, instead, the mesoderm is present as scattered pouches in between the ectoderm and endoderm. Such a body cavity is called pseudocoelom and the animals possessing them are called **pseudocoelomates**, e.g., aschelminthes (Figure 4.3b). The animals in which the body cavity is absent are called **acoelomates**, e.g., platyhelminthes (Figure 4.3c).

#### 4.1.5 Segmentation

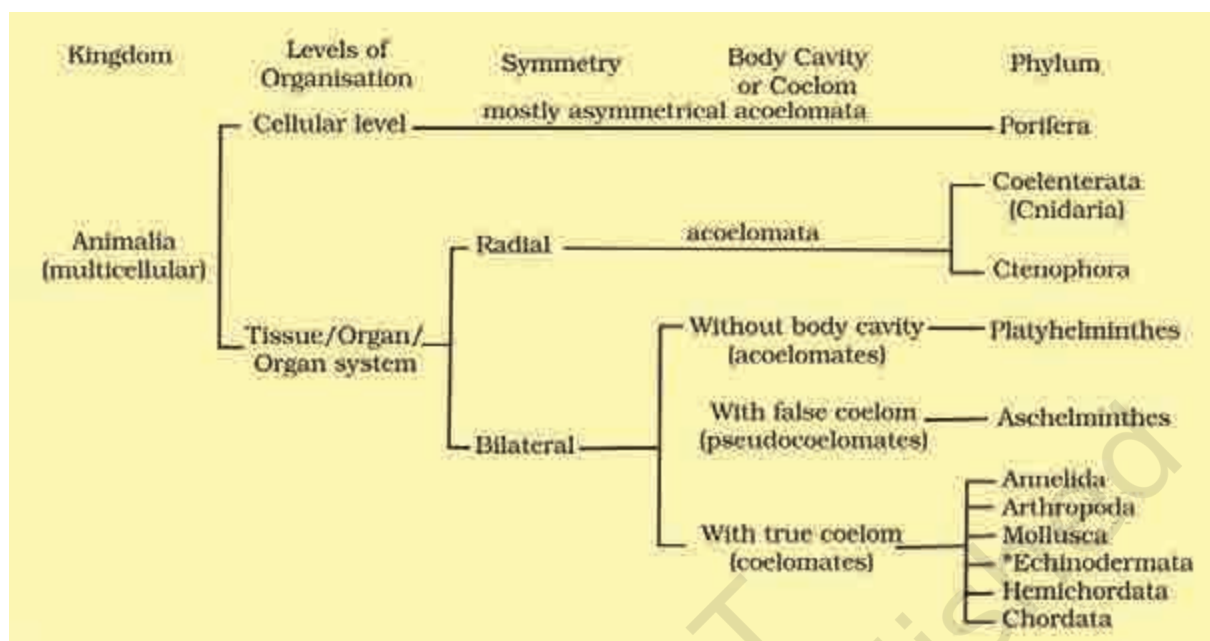
In some animals, the body is externally and internally divided into segments with a serial repetition of at least some organs. For example, in earthworm, the body shows this pattern called metameric segmentation and the phenomenon is known as **metamerism**.

#### 4.1.6 Notochord

Notochord is a mesodermally derived rod-like structure formed on the dorsal side during embryonic development in some animals. Animals with notochord are called chordates and those animals which do not form this structure are called non-chordates, e.g., porifera to echinoderms.

### 4.2 CLASSIFICATION OF ANIMALS

The broad classification of Animalia based on common fundamental features as mentioned in the preceding sections is given in Figure 4.4.



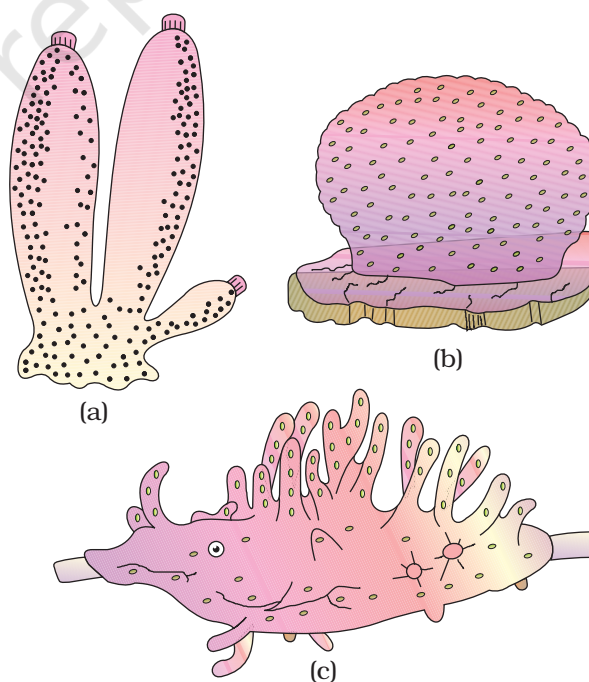
\*Echinodermata exhibits radial or bilateral symmetry depending on the stage.

**Figure 4.4** Broad classification of Kingdom Animalia based on common fundamental features

The important characteristic features of the different phyla are described.

#### 4.2.1 Phylum – Porifera

Members of this phylum are commonly known as sponges. They are generally marine and mostly asymmetrical animals (Figure 4.5). These are primitive multicellular animals and have cellular level of organisation. Sponges have a water transport or canal system. Water enters through minute pores (**ostia**) in the body wall into a central cavity, **spongocoel**, from where it goes out through the **osculum**. This pathway of water transport is helpful in food gathering, respiratory exchange and removal of waste. **Choanocytes** or collar cells line the spongocoel and the canals. Digestion is intracellular. The body is supported by a skeleton made up of **spicules** or **spongin fibres**. Sexes are not separate (**hermaphrodite**), i.e., eggs and sperms are produced by the same individual. Sponges reproduce asexually by fragmentation and sexually by formation of gametes. Fertilisation is internal and development is indirect having a larval stage which is morphologically distinct from the adult.

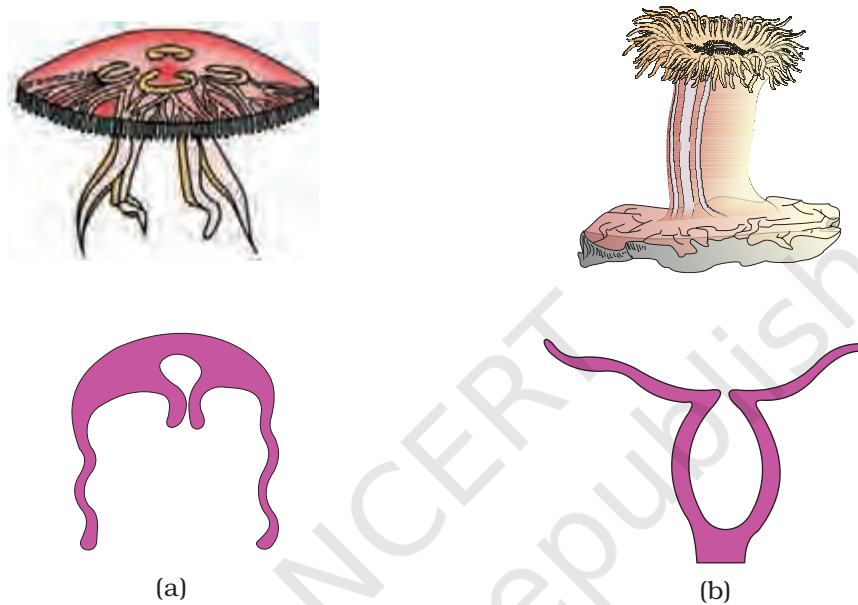


**Figure 4.5** Examples of Porifera : (a) *Sycon* (b) *Euspongia* (c) *Spongilla*

Examples: *Sycon* (Scypha), *Spongilla* (Fresh water sponge) and *Euspongia* (Bath sponge).

#### 4.2.2 Phylum – Coelenterata (Cnidaria)

They are aquatic, mostly marine, sessile or free-swimming, radially symmetrical animals (Figure 4.6). The name cnidaria is derived from the



**Figure 4.6** Examples of Coelenterata indicating outline of their body form :  
(a) *Aurelia* (Medusa) (b) *Adamsia* (Polyp)



**Figure 4.7**  
Diagrammatic view of  
Cnidoblast

cnidoblasts or cnidocytes (which contain the stinging capsules or nematocysts) present on the tentacles and the body. Cnidoblasts are used for anchorage, defense and for the capture of prey (Figure 4.7). Cnidarians exhibit tissue level of organisation and are diploblastic. They have a central gastro-vascular cavity with a single opening, mouth on **hypostome**. Digestion is extracellular and intracellular. Some of the cnidarians, e.g., **corals** have a skeleton composed of calcium carbonate. Cnidarians exhibit two basic body forms called **polyp** and **medusa** (Figure 4.6). The former is a sessile and cylindrical form like *Hydra*, *Adamsia*, etc. whereas, the latter is umbrella-shaped and free-swimming like *Aurelia* or jelly fish. Those cnidarians which exist in both forms exhibit alternation of generation (Metagenesis), i.e., polyps produce medusae asexually and medusae form the polyps sexually (e.g., *Obelia*).

Examples: *Physalia* (Portuguese man-of-war), *Adamsia* (Sea anemone), *Pennatula* (Sea-pen), *Gorgonia* (Sea-fan) and *Meandrina* (Brain coral).

### 4.2.3 Phylum – Ctenophora

Ctenophores, commonly known as **sea walnuts** or **comb jellies** are exclusively marine, radially symmetrical, diploblastic organisms with tissue level of organisation. The body bears eight external rows of ciliated **comb plates**, which help in locomotion (Figure 4.8). Digestion is both extracellular and intracellular. **Bioluminescence** (the property of a living organism to emit light) is well-marked in ctenophores. Sexes are not separate. Reproduction takes place only by sexual means. Fertilisation is external with indirect development.

Examples: *Pleurobrachia* and *Ctenoplana*.

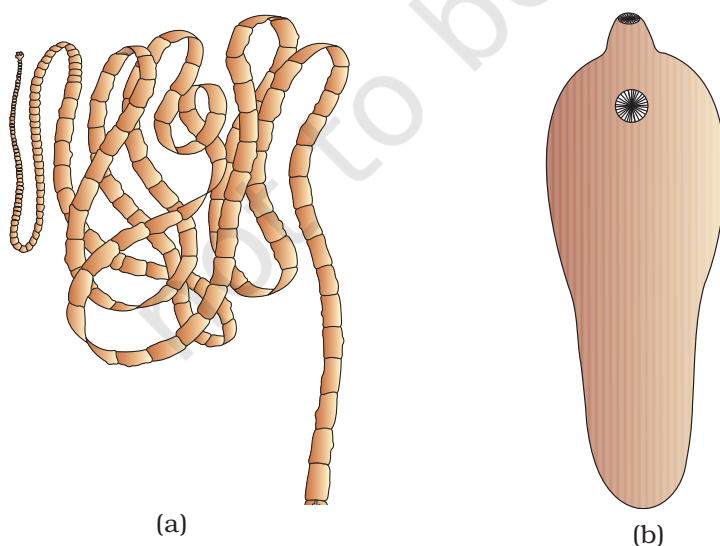
### 4.2.4 Phylum – Platyhelminthes

They have dorso-ventrally flattened body, hence are called **flatworms** (Figure 4.9). These are mostly endoparasites found in animals including human beings. Flatworms are bilaterally symmetrical, triploblastic and acoelomate animals with organ level of organisation. Hooks and suckers are present in the parasitic forms. Some of them absorb nutrients from the host directly through their body surface. Specialised cells called flame cells help in osmoregulation and excretion. Sexes are not separate. Fertilisation is internal and development is through many larval stages. Some members like *Planaria* possess high regeneration capacity.

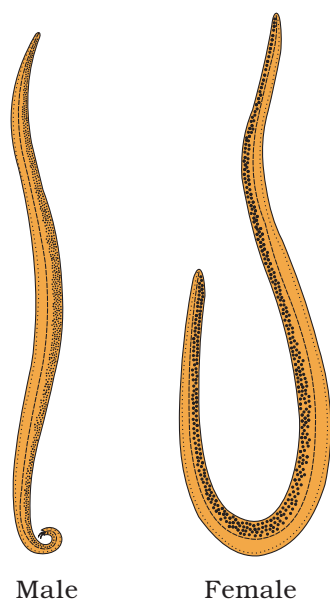
Examples: *Taenia* (Tapeworm), *Fasciola* (Liver fluke).



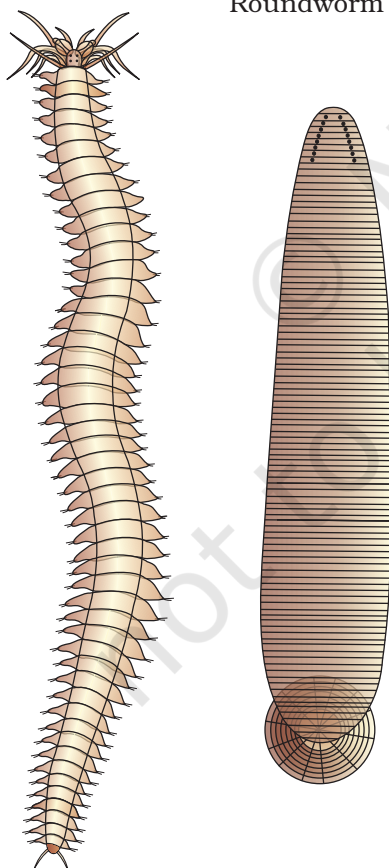
**Figure 4.8** Example of Ctenophora (*Pleurobrachia*)



**Figure 4.9** Examples of Platyhelminthes : (a) Tape worm (b) Liver fluke



**Figure 4.10** Examples of Aschelminthes Roundworm



**Figure 4.11** Examples of Annelida : (a) *Nereis*  
(b) *Hirudinaria*

#### 4.2.5 Phylum – Aschelminthes

The body of the aschelminthes is circular in cross-section, hence, the name **roundworms** (Figure 4.10). They may be freeliving, aquatic and terrestrial or parasitic in plants and animals. Roundworms have organ-system level of body organisation. They are bilaterally symmetrical, triploblastic and pseudocoelomate animals. Alimentary canal is complete with a well-developed **muscular pharynx**. An excretory tube removes body wastes from the body cavity through the excretory pore. Sexes are separate (**dioecious**), i.e., males and females are distinct. Often females are longer than males. Fertilisation is internal and development may be direct (the young ones resemble the adult) or indirect.

Examples : *Ascaris* (Round Worm), *Wuchereria* (Filaria worm), *Ancylostoma* (Hookworm).

#### 4.2.6 Phylum – Annelida

They may be aquatic (marine and fresh water) or terrestrial; free-living, and sometimes parasitic. They exhibit organ-system level of body organisation and bilateral symmetry. They are triploblastic, metamerically segmented and coelomate animals. Their body surface is distinctly marked out into **segments** or **metameres** and, hence, the phylum name Annelida (Latin, *annulus* : little ring) (Figure 4.11). They possess longitudinal and circular muscles which help in locomotion. Aquatic annelids like *Nereis* possess lateral appendages, **parapodia**, which help in swimming. A closed circulatory system is present. **Nephridia** (sing. nephridium) help in osmoregulation and excretion. Neural system consists of paired ganglia (sing. ganglion) connected by lateral nerves to a double ventral nerve cord. *Nereis*, an aquatic form, is dioecious, but earthworms and leeches are monoecious. Reproduction is sexual.

Examples : *Nereis*, *Pheretima* (Earthworm) and *Hirudinaria* (Blood sucking leech).

### 4.2.7 Phylum – Arthropoda

This is the **largest phylum** of Animalia which includes insects. Over two-thirds of all named species on earth are arthropods (Figure 4.12). They have organ-system level of organisation. They are bilaterally symmetrical, triploblastic, segmented and coelomate animals. The body of arthropods is covered by chitinous exoskeleton. The body consists of **head, thorax** and **abdomen**. They have **jointed appendages** (arthros-joint, poda-appendages). Respiratory organs are gills, book gills, book lungs or tracheal system. Circulatory system is of open type. Sensory organs like antennae, eyes (compound and simple), statocysts or balancing organs are present. Excretion takes place through **malpighian tubules**. They are mostly dioecious. Fertilisation is usually internal. They are mostly oviparous. Development may be direct or indirect.

Examples: Economically important insects – *Apis* (Honey bee), *Bombyx* (Silkworm), *Laccifer* (Lac insect)

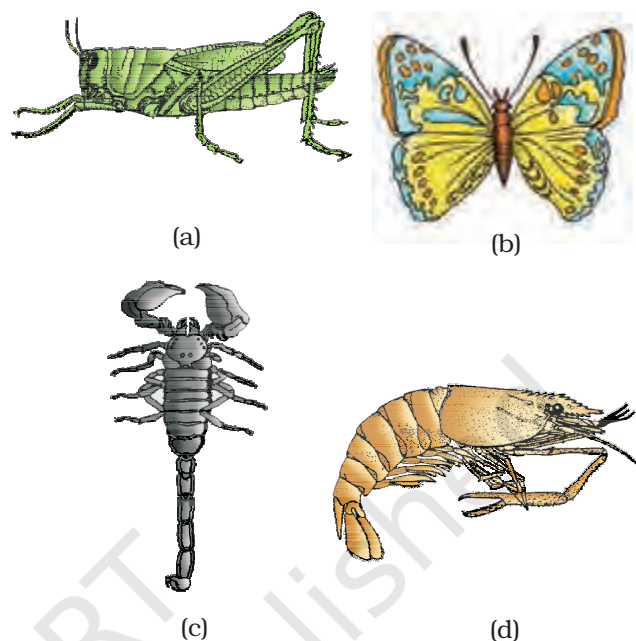
Vectors – *Anopheles*, *Culex* and *Aedes* (Mosquitoes)

Gregarious pest – *Locusta* (Locust)

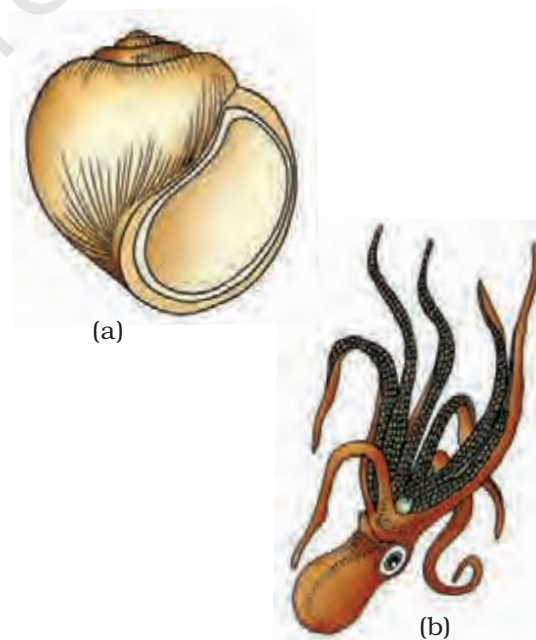
Living fossil – *Limulus* (King crab).

### 4.2.8 Phylum – Mollusca

This is the **second largest** animal phylum (Figure 4.13). Molluscs are terrestrial or aquatic (marine or fresh water) having an organ-system level of organisation. They are bilaterally symmetrical, triploblastic and coelomate animals. Body is covered by a calcareous shell and is unsegmented with a distinct **head, muscular foot** and **visceral hump**. A soft and spongy layer of skin forms a mantle over the visceral hump. The space between the hump and the mantle is called the mantle cavity in which feather like gills are present. They have respiratory and excretory functions. The anterior head region has sensory tentacles. The mouth contains a file-like rasping organ for feeding, called **radula**.

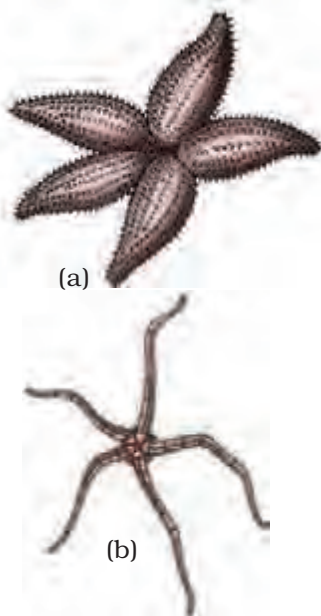


**Figure 4.12** Examples of Arthropoda :  
(a) Locust (b) Butterfly  
(c) Scorpion (d) Prawn



**Figure 4.13** Examples of Mollusca :  
(a) *Pila* (b) *Octopus*





**Figure 4.14** Examples of Echinodermata :  
(a) *Asterias*  
(b) *Ophiura*

They are usually dioecious and oviparous with indirect development.

Examples: *Pila* (Apple snail), *Pinctada* (Pearl oyster), *Sepia* (Cuttlefish), *Loligo* (Squid), *Octopus* (Devil fish), *Aplysia* (Sea-hare), *Dentalium* (Tusk shell) and *Chaetopleura* (Chiton).

#### 4.2.9 Phylum – Echinodermata

These animals have an endoskeleton of calcareous ossicles and, hence, the name Echinodermata (Spiny bodied, Figure 4.14). All are marine with organ-system level of organisation. The adult echinoderms are radially symmetrical but larvae are bilaterally symmetrical. They are triploblastic and coelomate animals. Digestive system is complete with mouth on the lower (ventral) side and anus on the upper (dorsal) side. The most distinctive feature of echinoderms is the presence of **water vascular system** which helps in locomotion, capture and transport of food and respiration. An excretory system is absent. Sexes are separate. Reproduction is sexual. Fertilisation is usually external. Development is indirect with free-swimming larva.

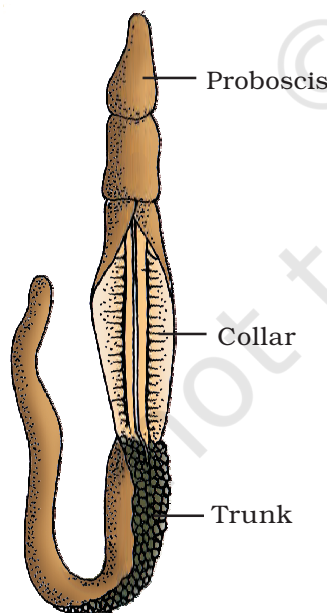
Examples: *Asterias* (Star fish), *Echinus* (Sea urchin), *Antedon* (Sea lily), *Cucumaria* (Sea cucumber) and *Ophiura* (Brittle star).

#### 4.2.10 Phylum – Hemichordata

Hemichordata was earlier considered as a sub-phylum under phylum Chordata. But now it is placed as a separate phylum under non-chordata. Hemichordata have a rudimentary structure in the collar region called stomochord, a structure similar to notochord.

This phylum consists of a small group of **worm-like** marine animals with organ-system level of organisation. They are bilaterally symmetrical, triploblastic and coelomate animals. The body is cylindrical and is composed of an anterior **proboscis**, a **collar** and a long **trunk** (Figure 4.15). Circulatory system is of open type. Respiration takes place through gills. Excretory organ is proboscis gland. Sexes are separate. Fertilisation is external. Development is indirect.

Examples: *Balanoglossus* and *Saccoglossus*.



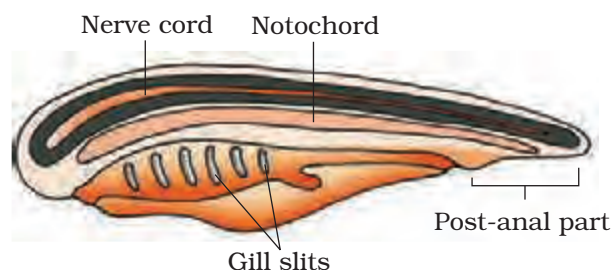
**Figure 4.15** *Balanoglossus*

#### 4.2.11 Phylum – Chordata

Animals belonging to phylum Chordata are fundamentally characterised by the presence of a **notochord**, a **dorsal**

**hollow nerve cord** and **paired pharyngeal gill slits** (Figure 4.16). These are bilaterally symmetrical, triploblastic, coelomate with organ-system level of organisation. They possess a post anal tail and a closed circulatory system.

Table 4.1 presents a comparison of salient features of chordates and non-chordates.



**Figure 4.16** Chordata characteristics

**TABLE 4.1 Comparison of Chordates and Non-chordates**

S.No.	Chordates	Non-chordates
1.	Notochord present.	Notochord absent.
2.	Central nervous system is dorsal, hollow and single.	Central nervous system is ventral, solid and double.
3.	Pharynx perforated by gill slits.	Gill slits are absent.
4.	Heart is ventral.	Heart is dorsal (if present).
5.	A post-anal part (tail) is present.	Post-anal tail is absent.

Phylum Chordata is divided into three subphyla: **Urochordata** or **Tunicata**, **Cephalochordata** and **Vertebrata**.

Subphyla Urochordata and Cephalochordata are often referred to as **protochordates** (Figure 4.17) and are exclusively marine. In Urochordata, notochord is present only in larval tail, while in Cephalochordata, it extends from head to tail region and is persistent throughout their life.

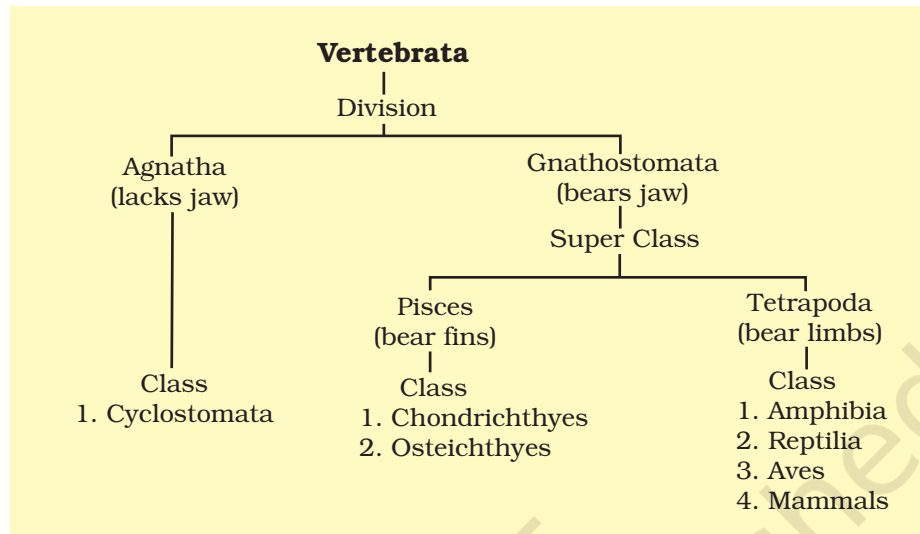
Examples: Urochordata – *Ascidia*, *Salpa*, *Doliolum*; Cephalochordata – *Branchiostoma* (Amphioxus or Lancelet).

The members of subphylum Vertebrata possess notochord during the embryonic period. The notochord is replaced by a cartilaginous or bony **vertebral column** in the adult. Thus all vertebrates are chordates but all chordates are not vertebrates. Besides the basic chordate characters, vertebrates have a ventral muscular heart with two, three or four chambers, kidneys for excretion and osmoregulation and paired appendages which may be fins or limbs.



**Figure 4.17** *Ascidia*

The subphylum Vertebrata is further divided as follows:



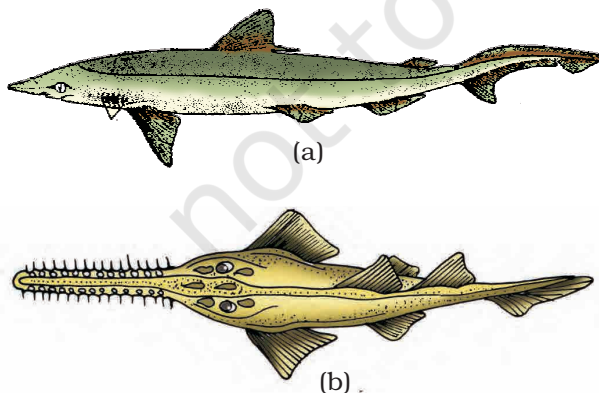
#### 4.2.11.1 Class - Cyclostomata

All living members of the class Cyclostomata are ectoparasites on some fishes. They have an elongated body bearing 6-15 pairs of **gill slits** for respiration. Cyclostomes have a sucking and circular mouth without jaws (Fig. 4.18). Their body is devoid of scales and paired fins. Cranium and vertebral column are cartilaginous. Circulation is of closed type. Cyclostomes are marine but migrate for spawning to fresh water. After spawning, within a few days, they die. Their larvae, after metamorphosis, return to the ocean.

Examples: *Petromyzon* (Lamprey) and *Myxine* (Hagfish).



**Figure 4.18** A jawless vertebrate - *Petromyzon*



**Figure 4.19** Example of Cartilaginous fishes :  
(a) *Scoliodon* (b) *Pristis*

#### 4.2.11.2 Class - Chondrichthyes

They are marine animals with streamlined body and have cartilaginous endoskeleton (Figure 4.19). Mouth is located ventrally. **Notochord** is **persistent** throughout life. Gill slits are separate and without **operculum** (gill cover). The skin is tough, containing minute **placoid scales**. Teeth are modified placoid scales which are backwardly directed. Their jaws are very powerful. These animals are predaceous. Due to the absence of air bladder, they have to swim constantly to avoid sinking.

Heart is two-chambered (one auricle and one ventricle). Some of them have **electric organs** (e.g., *Torpedo*) and some possess **poison sting** (e.g., *Trygon*). They are cold-blooded (**poikilothermous**) animals, i.e., they lack the capacity to regulate their body temperature. Sexes are separate. In males pelvic fins bear claspers. They have internal fertilisation and many of them are viviparous.

Examples: *Scoliodon* (Dog fish), *Pristis* (Saw fish), *Carcharodon* (Great white shark), *Trygon* (Sting ray).

#### 4.2.11.3 Class - Osteichthyes

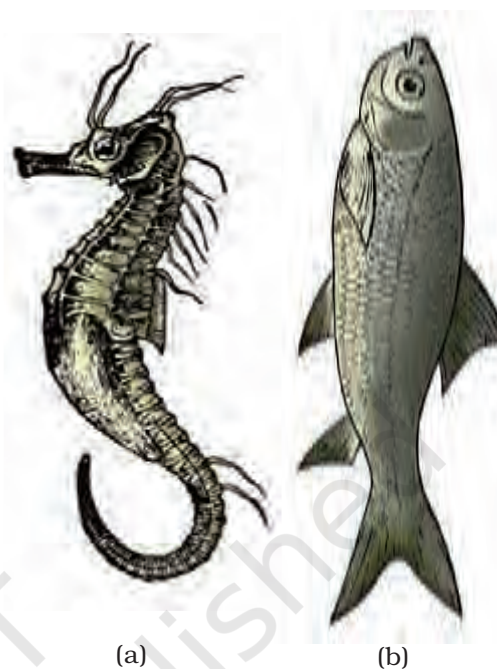
It includes both marine and fresh water fishes with bony endoskeleton. Their body is streamlined. Mouth is mostly terminal (Figure 4.20). They have four pairs of gills which are covered by an **operculum** on each side. Skin is covered with cycloid/ctenoid scales. **Air bladder** is present which regulates buoyancy. Heart is two-chambered (one auricle and one ventricle). They are cold-blooded animals. Sexes are separate. Fertilisation is usually external. They are mostly oviparous and development is direct.

Examples: Marine - *Exocoetus* (Flying fish), *Hippocampus* (Sea horse); Freshwater - *Labeo* (Rohu), *Catla* (Katla), *Clarias* (Magur); Aquarium - *Betta* (Fighting fish), *Pterophyllum* (Angel fish).

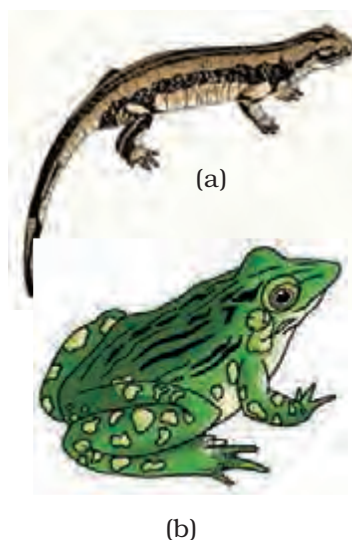
#### 4.2.11.4 Class - Amphibia

As the name indicates (*Gr.*, *Amphi* : dual, *bios*, life), amphibians can live in aquatic as well as terrestrial habitats (Figure 4.21). Most of them have two pairs of limbs. Body is divisible into **head** and **trunk**. Tail may be present in some. The amphibian skin is moist (without scales). The eyes have eyelids. A **tympanum** represents the ear. Alimentary canal, urinary and reproductive tracts open into a common chamber called **cloaca** which opens to the exterior. Respiration is by gills, lungs and through skin. The heart is three-chambered (two auricles and one ventricle). These are cold-blooded animals. Sexes are separate. Fertilisation is external. They are oviparous and development is indirect.

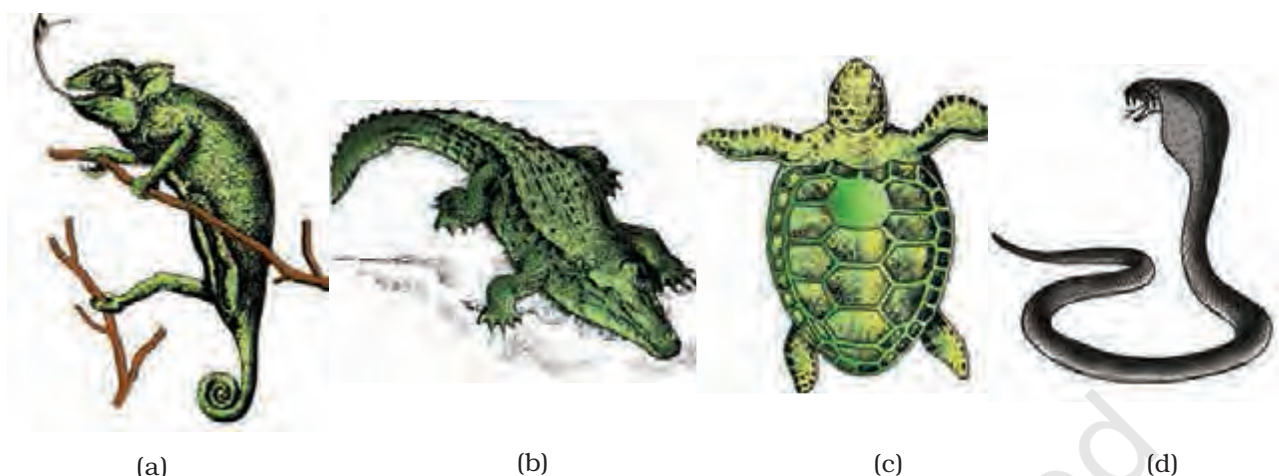
Examples: *Bufo* (Toad), *Rana* (Frog), *Hyla* (Tree frog), *Salamandra* (Salamander), *Ichthyophis* (Limbless amphibia).



**Figure 4.20** Examples of Bony fishes :  
(a) *Hippocampus* (b) *Catla*



**Figure 4.21** Examples of Amphibia :  
(a) *Salamandra*  
(b) *Rana*



**Figure 4.22** Reptiles: (a) *Chameleon* (b) *Crocodylus* (c) *Chelone* (d) *Naja*

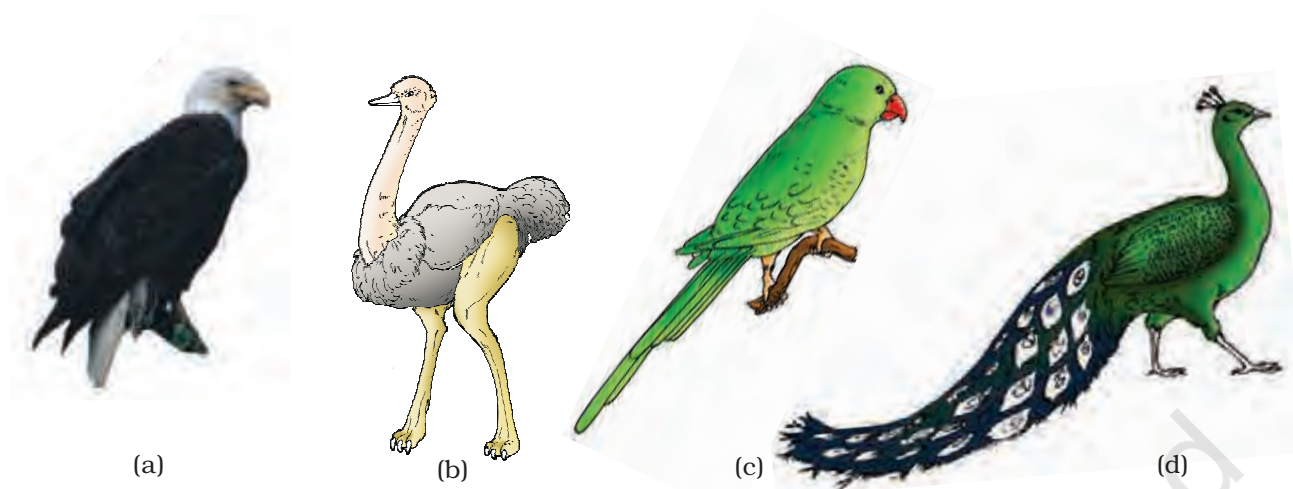
#### 4.2.11.5 Class – Reptilia

The class name refers to their creeping or crawling mode of locomotion (*Latin, repere* or *reptum*, to creep or crawl). They are mostly terrestrial animals and their body is covered by dry and cornified skin, epidermal **scales** or **scutes** (Fig. 4.22). They do not have external ear openings. Tympanum represents ear. Limbs, when present, are two pairs. Heart is usually three-chambered, but four-chambered in crocodiles. Reptiles are poikilotherms. Snakes and lizards shed their scales as skin cast. Sexes are separate. Fertilisation is internal. They are oviparous and development is direct.

Examples: *Chelone* (Turtle), *Testudo* (Tortoise), *Chameleon* (Tree lizard), *Calotes* (Garden lizard), *Crocodylus* (Crocodile), *Alligator* (Alligator), *Hemidactylus* (Wall lizard), Poisonous snakes – *Naja* (Cobra), *Bangarus* (Krait), *Vipera* (Viper).

#### 4.2.11.6 Class – Aves

The characteristic features of Aves (birds) are the presence of **feathers** and most of them can fly except flightless birds (e.g., Ostrich). They possess **beak** (Figure 4.23). The forelimbs are modified into **wings**. The hind limbs generally have scales and are modified for walking, swimming or clasp the tree branches. Skin is dry without glands except the oil gland at the base of the tail. Endoskeleton is fully ossified (bony) and the long bones are hollow with **air cavities** (pneumatic). The digestive tract of birds has additional chambers, the crop and gizzard. Heart is completely four-chambered. They are warm-blooded (**homiothermous**) animals, i.e., they are able to maintain a constant body temperature. Respiration is by



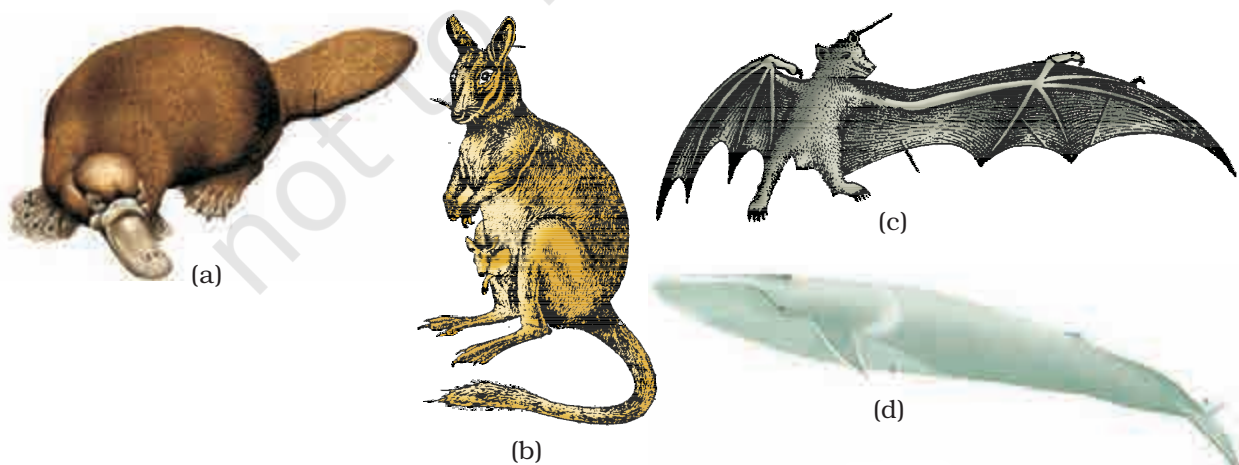
**Figure 4.23** Some birds : (a) *Neophron* (b) *Struthio* (c) *Psittacula* (d) *Pavo*

lungs. Air sacs connected to lungs supplement respiration. Sexes are separate. Fertilisation is internal. They are oviparous and development is direct.

Examples : *Corvus* (Crow), *Columba* (Pigeon), *Psittacula* (Parrot), *Struthio* (Ostrich), *Pavo* (Peacock), *Aptenodytes* (Penguin), *Neophron* (Vulture).

#### 4.2.11.7 Class - Mammalia

They are found in a variety of habitats – polar ice caps, deserts, mountains, forests, grasslands and dark caves. Some of them have adapted to fly or live in water. The most unique mammalian characteristic is the presence of milk producing glands (**mammary glands**) by which the young ones are nourished. They have two pairs of limbs, adapted for walking, running, climbing, burrowing, swimming or flying (Figure 4.24). The skin of



**Figure 4.24** Some mammals : (a) *Ornithorhynchus* (b) *Macropus* (c) *Pteropus* (d) *Balaenoptera*

mammals is unique in possessing **hair**. External ears or **pinnae** are present. Different types of teeth are present in the jaw. Heart is four-chambered. They are homoiothermous. Respiration is by lungs. Sexes are separate and fertilisation is internal. They are viviparous with few exceptions and development is direct.

Examples: Oviparous-*Ornithorhynchus* (Platypus); Viviparous - *Macropus* (Kangaroo), *Pteropus* (Flying fox), *Camelus* (Camel), *Macaca* (Monkey), *Rattus* (Rat), *Canis* (Dog), *Felis* (Cat), *Elephas* (Elephant), *Equus* (Horse), *Delphinus* (Common dolphin), *Balaenoptera* (Blue whale), *Panthera tigris* (Tiger), *Panthera leo* (Lion).

The salient distinguishing features of all phyla under animal kingdom is comprehensively given in the Table 4.2.

**TABLE 4.2 Salient Features of Different Phyla in the Animal Kingdom**

Phylum	Level of Organisation	Symmetry	Coelom	Segmentation	Digestive System	Circulatory System	Respiratory System	Distinctive Features
Porifera	Cellular	Various	Absent	Absent	Absent	Absent	Absent	Body with pores and canals in walls.
Coelenterata (Cnidaria)	Tissue	Radial	Absent	Absent	Incomplete	Absent	Absent	Cnidoblasts present.
Ctenophora	Tissue	Radial	Absent	Absent	Incomplete	Absent	Absent	Comb plates for locomotion.
Platyhelminthes	Organ & Organ-system	Bilateral	Absent	Absent	Incomplete	Absent	Absent	Flat body, suckers.
Aschelminthes	Organ-system	Bilateral	Pseudo coelomate	Absent	Complete	Absent	Absent	Often worm-shaped, elongated.
Annelida	Organ-system	Bilateral	Coelomate	Present	Complete	Present	Absent	Body segmentation like rings.
Arthropoda	Organ-system	Bilateral	Coelomate	Present	Complete	Present	Present	Exoskeleton of cuticle, jointed appendages.
Mollusca	Organ-system	Bilateral	Coelomate	Absent	Complete	Present	Present	External skeleton of shell usually present.
Echinodermata	Organ-system	Radial	Coelomate	Absent	Complete	Present	Present	Water vascular system, radial symmetry.
Hemichordata	Organ-system	Bilateral	Coelomate	Absent	Complete	Present	Present	Worm-like with proboscis, collar and trunk.
Chordata	Organ-system	Bilateral	Coelomate	Present	Complete	Present	Present	Notochord, dorsal hollow nerve cord, gill slits with limbs or fins.

## SUMMARY

The basic fundamental features such as level of organisation, symmetry, cell organisation, coelom, segmentation, notochord, etc., have enabled us to broadly classify the animal kingdom. Besides the fundamental features, there are many other distinctive characters which are specific for each phyla or class.

Porifera includes multicellular animals which exhibit cellular level of organisation and have characteristic flagellated choanocytes. The coelenterates have tentacles and bear cnidoblasts. They are mostly aquatic, sessile or free-floating. The ctenophores are marine animals with comb plates. The platyhelminths have flat body and exhibit bilateral symmetry. The parasitic forms show distinct suckers and hooks. Aschelminthes are pseudocoelomates and include parasitic as well as non-parasitic roundworms.

Annelids are metamerically segmented animals with a true coelom. The arthropods are the most abundant group of animals characterised by the presence of jointed appendages. The molluscs have a soft body surrounded by an external calcareous shell. The body is covered with external skeleton made of chitin. The echinoderms possess a spiny skin. Their most distinctive feature is the presence of water vascular system. The hemichordates are a small group of worm-like marine animals. They have a cylindrical body with proboscis, collar and trunk.

Phylum Chordata includes animals which possess a notochord either throughout or during early embryonic life. Other common features observed in the chordates are the dorsal, hollow nerve cord and paired pharyngeal gill slits. Some of the vertebrates do not possess jaws (Agnatha) whereas most of them possess jaws (Gnathostomata). Agnatha is represented by the class, Cyclostomata. They are the most primitive chordates and are ectoparasites on fishes. Gnathostomata has two super classes, Pisces and Tetrapoda. Classes Chondrichthyes and Osteichthyes bear fins for locomotion and are grouped under Pisces. The Chondrichthyes are fishes with cartilaginous endoskeleton and are marine. Classes, Amphibia, Reptilia, Aves and Mammalia have two pairs of limbs and are thus grouped under Tetrapoda. The amphibians have adapted to live both on land and water. Reptiles are characterised by the presence of dry and cornified skin. Limbs are absent in snakes. Fishes, amphibians and reptiles are poikilothermous (cold-blooded). Aves are warm-blooded animals with feathers on their bodies and forelimbs modified into wings for flying. Hind limbs are adapted for walking, swimming, perching or claspings. The unique features of mammals are the presence of mammary glands and hairs on the skin. They commonly exhibit viviparity.



**EXERCISES**

1. What are the difficulties that you would face in classification of animals, if common fundamental features are not taken into account?
2. If you are given a specimen, what are the steps that you would follow to classify it?
3. How useful is the study of the nature of body cavity and coelom in the classification of animals?
4. Distinguish between intracellular and extracellular digestion?
5. What is the difference between direct and indirect development?
6. What are the peculiar features that you find in parasitic platyhelminthes?
7. What are the reasons that you can think of for the arthropods to constitute the largest group of the animal kingdom?
8. Water vascular system is the characteristic of which group of the following:  
(a) Porifera (b) Ctenophora (c) Echinodermata (d) Chordata
9. "All vertebrates are chordates but all chordates are not vertebrates". Justify the statement.
10. How important is the presence of air bladder in Pisces?
11. What are the modifications that are observed in birds that help them fly?
12. Could the number of eggs or young ones produced by an oviparous and viviparous mother be equal? Why?
13. Segmentation in the body is first observed in which of the following:  
(a) Platyhelminthes (b) Aschelminthes (c) Annelida (d) Arthropoda
14. Match the following:

(a) Operculum	(i) Ctenophora
(b) Parapodia	(ii) Mollusca
(c) Scales	(iii) Porifera
(d) Comb plates	(iv) Reptilia
(e) Radula	(v) Annelida
(f) Hairs	(vi) Cyclostomata and Chondrichthyes
(g) Choanocytes	(vii) Mammalia
(h) Gill slits	(viii) Osteichthyes
15. Prepare a list of some animals that are found parasitic on human beings.



# UNIT 2

## STRUCTURAL ORGANISATION IN PLANTS AND ANIMALS

**Chapter 5**  
Morphology of  
Flowering Plants

**Chapter 6**  
Anatomy of Flowering  
Plants

**Chapter 7**  
Structural Organisation in  
Animals

The description of the diverse forms of life on earth was made only by observation – through naked eyes or later through magnifying lenses and microscopes. This description is mainly of gross structural features, both external and internal. In addition, observable and perceivable living phenomena were also recorded as part of this description. Before experimental biology or more specifically, physiology, was established as a part of biology, naturalists described only biology. Hence, biology remained as a natural history for a long time. The description, by itself, was amazing in terms of detail. While the initial reaction of a student could be boredom, one should keep in mind that the detailed description, was utilised in the later day reductionist biology where living processes drew more attention from scientists than the description of life forms and their structure. Hence, this description became meaningful and helpful in framing research questions in physiology or evolutionary biology. In the following chapters of this unit, the structural organisation of plants and animals, including the structural basis of physiological or behavioural phenomena, is described. For convenience, this description of morphological and anatomical features is presented separately for plants and animals.



**Katherine Esau**  
(1898 – 1997)

KATHERINE ESAU was born in Ukraine in 1898. She studied agriculture in Russia and Germany and received her doctorate in 1931 in United States. She reported in her early publications that the curly top virus spreads through a plant via the food-conducting or phloem tissue. Dr Esau's *Plant Anatomy* published in 1954 took a dynamic, developmental approach designed to enhance one's understanding of plant structure and an enormous impact worldwide, literally bringing about a revival of the discipline. The *Anatomy of Seed Plants* by Katherine Esau was published in 1960. It was referred to as Webster's of plant biology – it is encyclopediac. In 1957 she was elected to the National Academy of Sciences, becoming the sixth woman to receive that honour. In addition to this prestigious award, she received the National Medal of Science from President George Bush in 1989.

When Katherine Esau died in the year 1997, Peter Raven, director of Anatomy and Morphology, Missouri Botanical Garden, remembered that she 'absolutely dominated' the field of plant biology even at the age of 99.

## CHAPTER 5

# MORPHOLOGY OF FLOWERING PLANTS

### 5.1 The Root

### 5.2 The Stem

### 5.3 The Leaf

### 5.4 The Inflorescence

### 5.5 The Flower

### 5.6 The Fruit

### 5.7 The Seed

### 5.8 *Semi-technical Description of a Typical Flowering Plant*

### 5.9 *Description of Some Important Families*

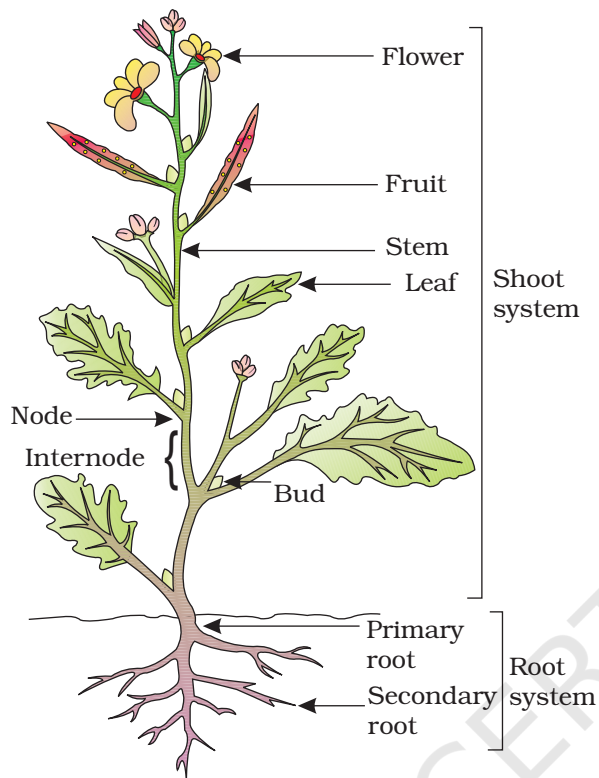
The wide range in the structure of higher plants will never fail to fascinate us. Even though the angiosperms show such a large diversity in external structure or **morphology**, they are all characterised by presence of roots, stems, leaves, flowers and fruits.

In chapters 2 and 3, we talked about classification of plants based on morphological and other characteristics. For any successful attempt at classification and at understanding any higher plant (or for that matter any living organism) we need to know standard technical terms and standard definitions. We also need to know about the possible variations in different parts, found as adaptations of the plants to their environment, e.g., adaptations to various habitats, for protection, climbing, storage, etc.

If you pull out any weed you will see that all of them have roots, stems and leaves. They may be bearing flowers and fruits. The underground part of the flowering plant is the root system while the portion above the ground forms the shoot system (Figure 5.1).

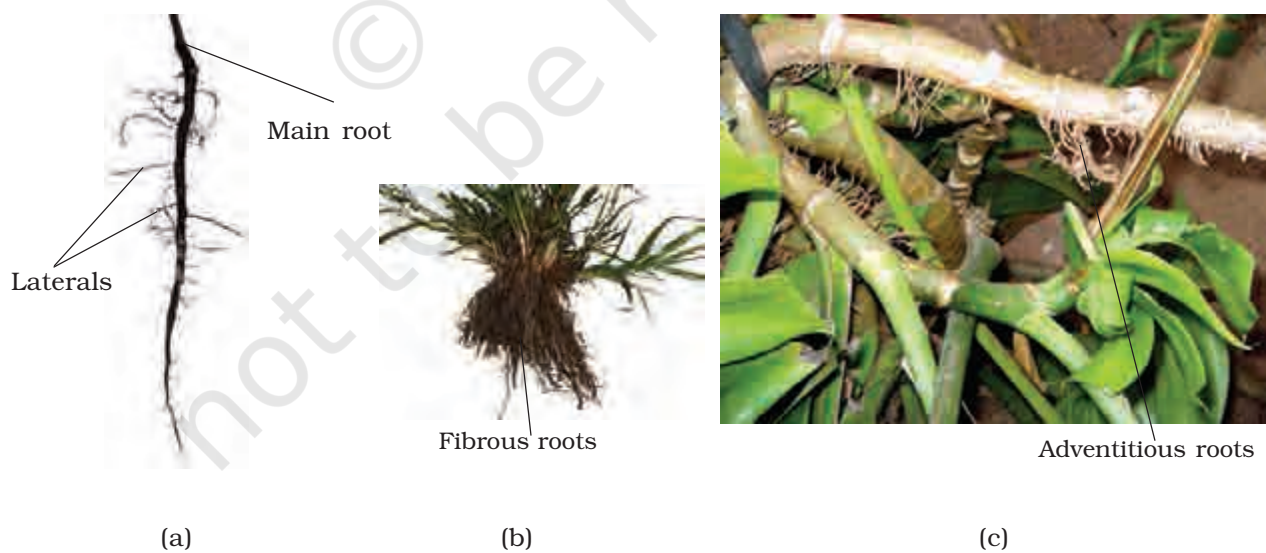
## 5.1 THE ROOT

In majority of the dicotyledonous plants, the direct elongation of the radicle leads to the formation of **primary root** which grows inside the soil. It bears lateral roots of several orders that are referred to as **secondary**, **tertiary**, etc. **roots**. The primary roots and its branches constitute the



**Figure 5.1** Parts of a flowering plant

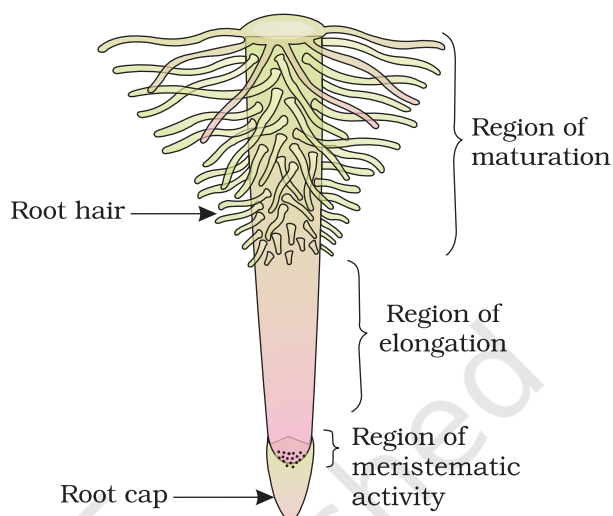
**tap root system**, as seen in the mustard plant (Figure 5.2a). In monocotyledonous plants, the primary root is short lived and is replaced by a large number of roots. These roots originate from the base of the stem and constitute the **fibrous root system**, as seen in the wheat plant (Figure 5.2b). In some plants, like grass, *Monstera* and the banyan tree, roots arise from parts of the plant other than the radicle and are called **adventitious roots** (Figure 5.2c). The main functions of the root system are absorption of water and minerals from the soil, providing a proper anchorage to the plant parts, storing reserve food material and synthesis of plant growth regulators.



**Figure 5.2** Different types of roots : (a) Tap (b) Fibrous (c) Adventitious

### 5.1.1 Regions of the Root

The root is covered at the apex by a thimble-like structure called the **root cap** (Figure 5.3). It protects the tender apex of the root as it makes its way through the soil. A few millimetres above the root cap is the **region of meristematic activity**. The cells of this region are very small, thin-walled and with dense protoplasm. They divide repeatedly. The cells proximal to this region undergo rapid elongation and enlargement and are responsible for the growth of the root in length. This region is called the **region of elongation**. The cells of the elongation zone gradually differentiate and mature. Hence, this zone, proximal to region of elongation, is called the **region of maturation**. From this region some of the epidermal cells form very fine and delicate, thread-like structures called **root hairs**. These root hairs absorb water and minerals from the soil.



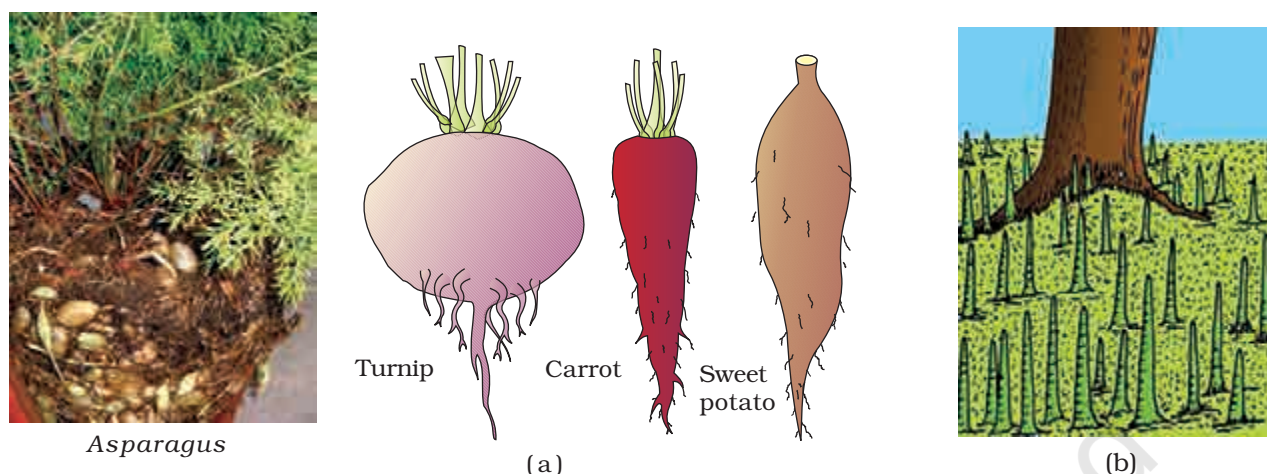
**Figure 5.3** The regions of the root-tip

### 5.1.2 Modifications of Root

Roots in some plants change their shape and structure and become modified to perform functions other than absorption and conduction of water and minerals. They are modified for support, storage of food and respiration (Figure 5.4 and 5.5). Tap roots of carrot, turnip and adventitious roots of sweet potato, get swollen and store food. Can you give some more such examples? Have you ever wondered what those hanging structures that support a banyan tree are? These are called **prop roots**. Similarly, the stems of maize and sugarcane have supporting roots coming out of the lower nodes of the stem. These are called **stilt roots**. In some plants such as *Rhizophora* growing in swampy areas, many roots come out of the ground and grow vertically upwards. Such roots, called **pneumatophores**, help to get oxygen for respiration (Figure 5.5b).



**Figure 5.4** Modification of root for support: Banyan tree



**Figure 5.5** Modification of root for : (a) storage (b) respiration: pneumatophore in *Rhizophora*

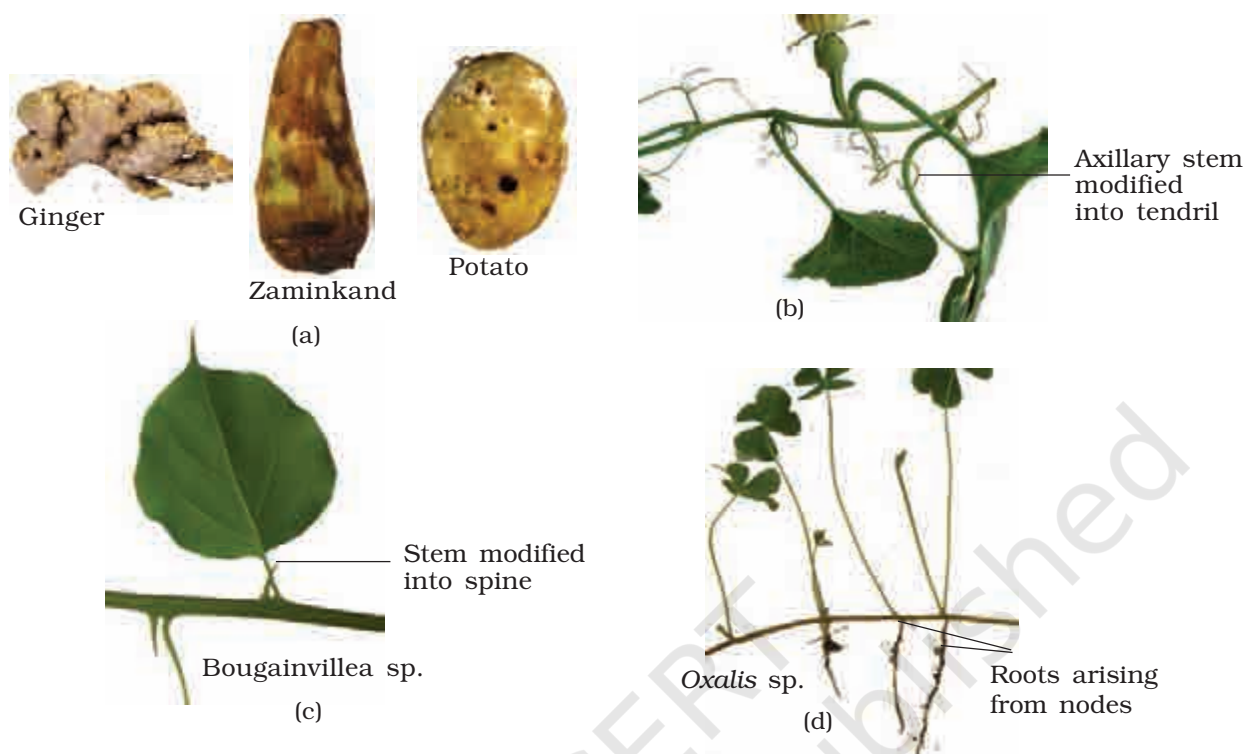
## 5.2 THE STEM

What are the features that distinguish a stem from a root? The stem is the ascending part of the axis bearing branches, leaves, flowers and fruits. It develops from the plumule of the embryo of a germinating seed. The stem bears **nodes** and **internodes**. The region of the stem where leaves are born are called nodes while internodes are the portions between two nodes. The stem bears buds, which may be terminal or axillary. Stem is generally green when young and later often become woody and dark brown.

The main function of the stem is spreading out branches bearing leaves, flowers and fruits. It conducts water, minerals and photosynthates. Some stems perform the function of storage of food, support, protection and of vegetative propagation.

### 5.2.1 Modifications of Stem

The stem may not always be typically like what they are expected to be. They are modified to perform different functions (Figure 5.6). Underground stems of potato, ginger, turmeric, *zaminkand*, *Colocasia* are modified to store food in them. They also act as organs of perennation to tide over conditions unfavourable for growth. Stem **tendrils** which develop from axillary buds, are slender and spirally coiled and help plants to climb such as in gourds (cucumber, pumpkins, watermelon) and grapevines. Axillary buds of stems may also get modified into woody, straight and pointed **thorns**. Thorns are found in many plants such as *Citrus*, *Bougainvillea*. They protect plants from browsing animals. Some plants of arid regions modify their stems into flattened (*Opuntia*), or fleshy cylindrical (*Euphorbia*) structures. They contain chlorophyll and carry



**Figure 5.6** Modifications of stem for: (a) storage (b) support (c) protection (d) spread and vegetative propagation

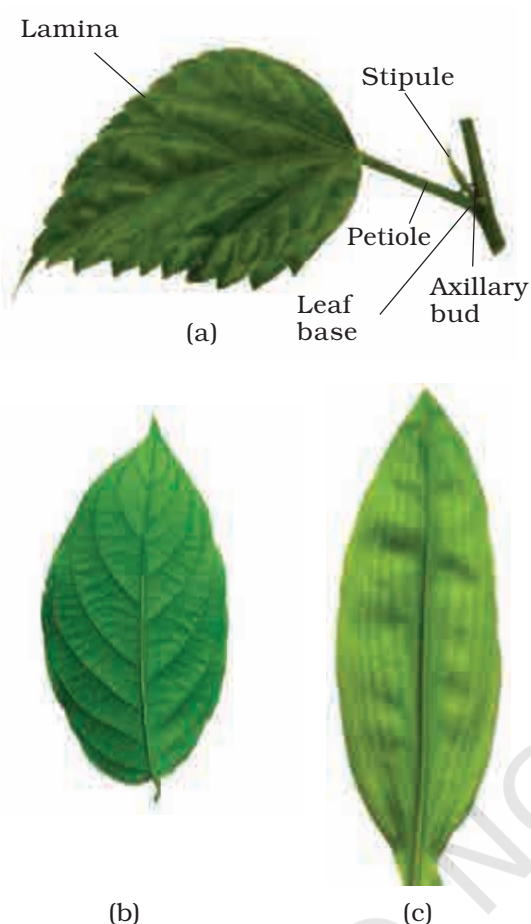
out photosynthesis. Underground stems of some plants such as grass and strawberry, etc., spread to new niches and when older parts die new plants are formed. In plants like mint and jasmine a slender lateral branch arises from the base of the main axis and after growing aurally for some time arch downwards to touch the ground. A lateral branch with short internodes and each node bearing a rosette of leaves and a tuft of roots is found in aquatic plants like *Pistia* and *Eichhornia*. In banana, pineapple and *Chrysanthemum*, the lateral branches originate from the basal and underground portion of the main stem, grow horizontally beneath the soil and then come out obliquely upward giving rise to leafy shoots.

### 5.3 THE LEAF

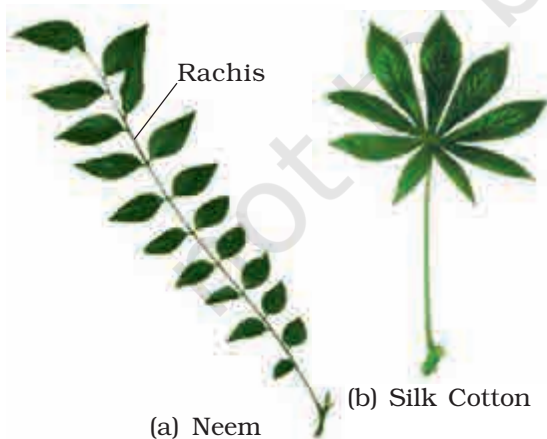
The leaf is a lateral, generally flattened structure borne on the stem. It develops at the node and bears a bud in its axil. The **axillary bud** later develops into a branch. Leaves originate from shoot apical meristems and are arranged in an acropetal order. They are the most important vegetative organs for photosynthesis.

A typical leaf consists of three main parts: leaf base, petiole and lamina (Figure 5.7 a). The leaf is attached to the stem by the **leaf base** and may





**Figure 5.7** Structure of a leaf :  
 (a) Parts of a leaf  
 (b) Reticulate venation  
 (c) Parallel venation



**Figure 5.8** Compound leaves :  
 (a) pinnately compound leaf  
 (b) palmately compound leaf

bear two lateral small leaf like structures called stipules. In monocotyledons, the leaf base expands into a sheath covering the stem partially or wholly. In some leguminous plants the leafbase may become swollen, which is called the **pulvinus**. The **petiole** help hold the blade to light. Long thin flexible petioles allow leaf blades to flutter in wind, thereby cooling the leaf and bringing fresh air to leaf surface. The **lamina** or the **leaf blade** is the green expanded part of the leaf with veins and veinlets. There is, usually, a middle prominent vein, which is known as the midrib. Veins provide rigidity to the leaf blade and act as channels of transport for water, minerals and food materials. The shape, margin, apex, surface and extent of incision of lamina varies in different leaves.

### 5.3.1 Venation

The arrangement of veins and the veinlets in the lamina of leaf is termed as **venation**. When the veinlets form a network, the venation is termed as **reticulate** (Figure 5.7 b). When the veins run parallel to each other within a lamina, the venation is termed as **parallel** (Figure 5.7 c). Leaves of dicotyledonous plants generally possess reticulate venation, while parallel venation is the characteristic of most monocotyledons.

### 5.3.2 Types of Leaves

A leaf is said to be **simple**, when its lamina is entire or when incised, the incisions do not touch the midrib. When the incisions of the lamina reach up to the midrib breaking it into a number of leaflets, the leaf is called **compound**. A bud is present in the axil of petiole in both simple and compound leaves, but not in the axil of leaflets of the compound leaf.

The compound leaves may be of two types (Figure 5.8). In a **pinnately compound leaf** a number of leaflets are present on a common axis, the **rachis**, which represents the midrib of the leaf as in neem.

In **palmately compound leaves**, the leaflets are attached at a common point, i.e., at the tip of petiole, as in silk cotton.

### 5.3.3 Phyllotaxy

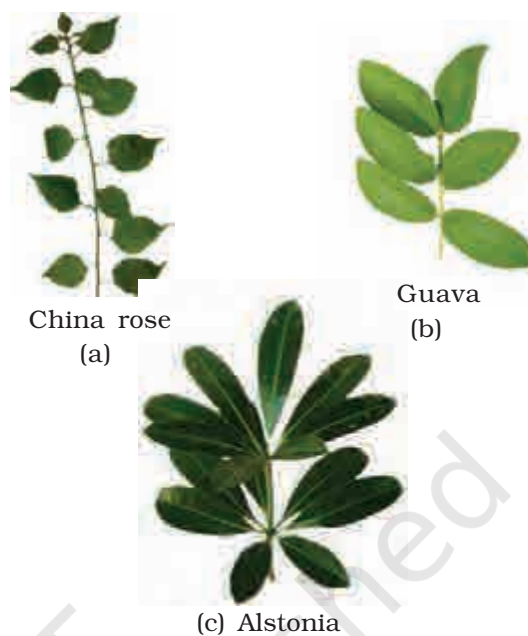
Phyllotaxy is the pattern of arrangement of leaves on the stem or branch. This is usually of three types – alternate, opposite and whorled (Figure 5.9). In **alternate** type of phyllotaxy, a single leaf arises at each node in alternate manner, as in china rose, mustard and sun flower plants. In **opposite** type, a pair of leaves arise at each node and lie opposite to each other as in *Calotropis* and guava plants. If more than two leaves arise at a node and form a whorl, it is called **whorled**, as in *Alstonia*.

### 5.3.4 Modifications of Leaves

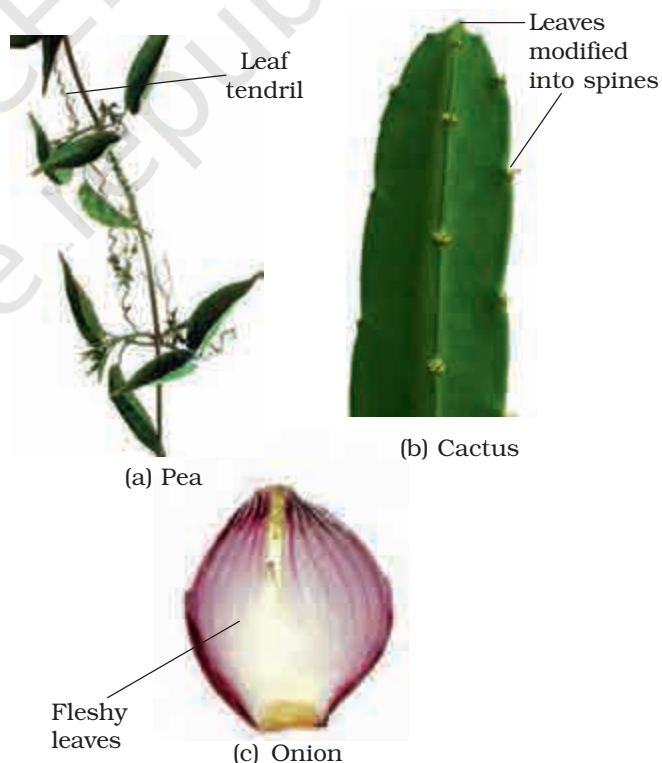
Leaves are often modified to perform functions other than photosynthesis. They are converted into **tendrils** for climbing as in peas or into **spines** for defence as in cacti (Figure 5.10 a, b). The fleshy leaves of onion and garlic store food (Figure 5.10c). In some plants such as Australian acacia, the leaves are small and short-lived. The petioles in these plants expand, become green and synthesise food. Leaves of certain insectivorous plants such as pitcher plant, venus-fly trap are also modified leaves.

## 5.4 THE INFLORESCENCE

A flower is a modified shoot wherein the shoot apical meristem changes to floral meristem. Internodes do not elongate and the axis gets condensed. The apex produces different kinds of floral appendages laterally at successive nodes instead of leaves. When a shoot tip transforms into a flower, it is always solitary. The arrangement of flowers on the



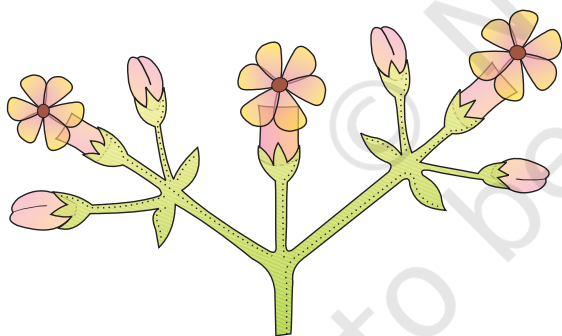
**Figure 5.9** Different types of phyllotaxy :  
(a) Alternate (b) Opposite  
(c) Whorled



**Figure 5.10** Modifications of leaf for :  
(a) support: tendril (b) protection:  
spines (c) storage: fleshy leaves



**Figure 5.11** Racemose inflorescence



**Figure 5.12** Cymose inflorescence

floral axis is termed as **inflorescence**. Depending on whether the apex gets developed into a flower or continues to grow, two major types of inflorescences are defined – racemose and cymose. In **racemose** type of inflorescences the main axis continues to grow, the flowers are borne laterally in an acropetal succession (Figure 5.11).

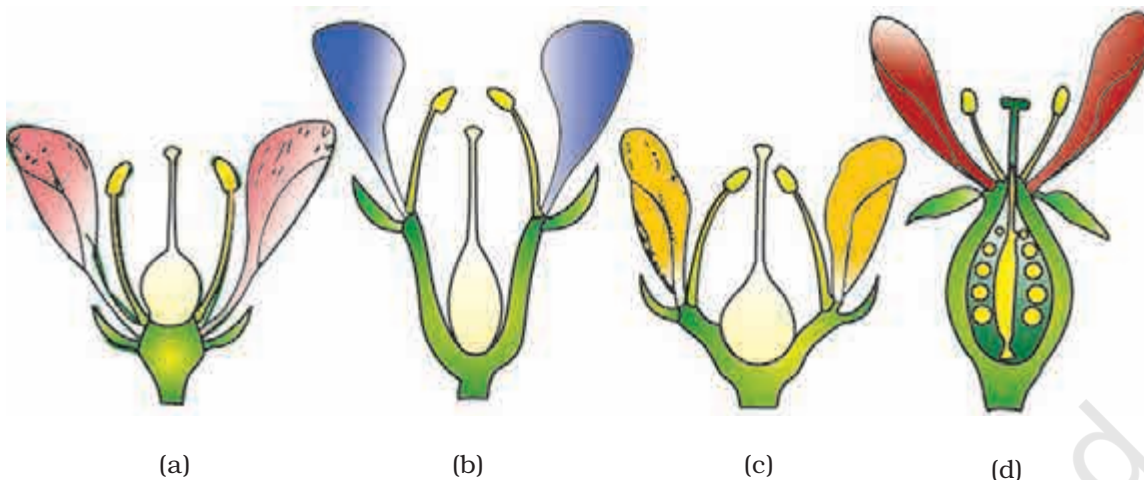
In **cymose** type of inflorescence the main axis terminates in a flower, hence is limited in growth. The flowers are borne in a basipetal order (Figure 5.12).

## 5.5 THE FLOWER

The flower is the reproductive unit in the angiosperms. It is meant for sexual reproduction. A typical flower has four different kinds of whorls arranged successively on the swollen end of the stalk or pedicel, called **thalamus or receptacle**. These are calyx, corolla, androecium and gynoecium. Calyx and corolla are accessory organs, while androecium and gynoecium are reproductive organs. In some flowers like lily, the calyx and corolla are not distinct and are termed as perianth. When a flower has both androecium and gynoecium, it is **bisexual**. A flower having either only stamens or only carpels is **unisexual**.

In symmetry, the flower may be **actinomorphic** (radial symmetry) or **zygomorphic** (bilateral symmetry). When a flower can be divided into two equal radial halves in any radial plane passing through the centre, it is said to be **actinomorphic**, e.g., mustard, *datura*, chilli. When it can be divided into two similar halves only in one particular vertical plane, it is **zygomorphic**, e.g., pea, gulmohur, bean, *Cassia*. A flower is **asymmetric** (irregular) if it cannot be divided into two similar halves by any vertical plane passing through the centre, as in canna.

A flower may be **trimerous**, **tetramerous** or **pentamerous** when the floral appendages are in multiple of 3, 4 or 5, respectively. Flowers with bracts-reduced leaf found at the base of the pedicel- are called **bracteate** and those without bracts, **ebracteate**.



**Figure 5.13** Position of floral parts on thalamus : (a) Hypogynous (b) and (c) Perigynous (d) Epigynous

Based on the position of calyx, corolla and androecium in respect of the ovary on thalamus, the flowers are described as hypogynous, perigynous and epigynous (Figure 5.13). In the **hypogynous** flower the gynoecium occupies the highest position while the other parts are situated below it. The ovary in such flowers is said to be **superior**, e.g., mustard, china rose and brinjal. If gynoecium is situated in the centre and other parts of the flower are located on the rim of the thalamus almost at the same level, it is called **perigynous**. The ovary here is said to be **half inferior**, e.g., plum, rose, peach. In **epigynous flowers**, the margin of thalamus grows upward enclosing the ovary completely and getting fused with it, the other parts of flower arise above the ovary. Hence, the ovary is said to be **inferior** as in flowers of guava and cucumber, and the ray florets of sunflower.

### 5.5.1 Parts of a Flower

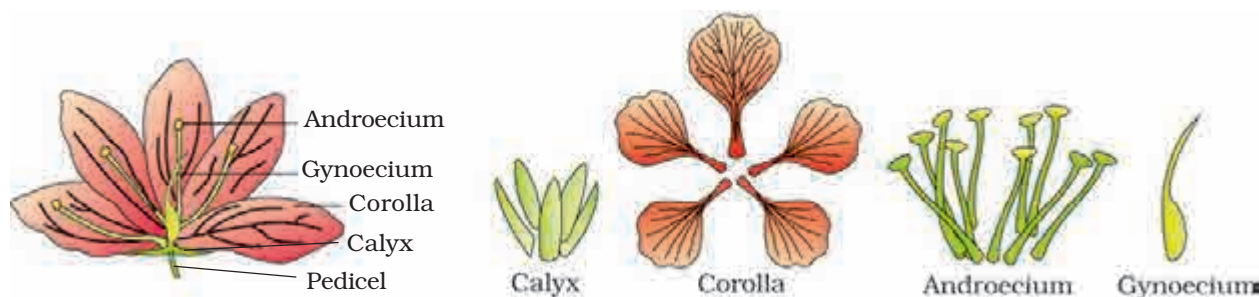
Each flower normally has four floral whorls, viz., calyx, corolla, androecium and gynoecium (Figure 5.14).

#### 5.5.1.1 Calyx

The calyx is the outermost whorl of the flower and the members are called sepals. Generally, sepals are green, leaf like and protect the flower in the bud stage. The calyx may be **gamosepalous** (sepals united) or **polysepalous** (sepals free).

#### 5.5.1.2 Corolla

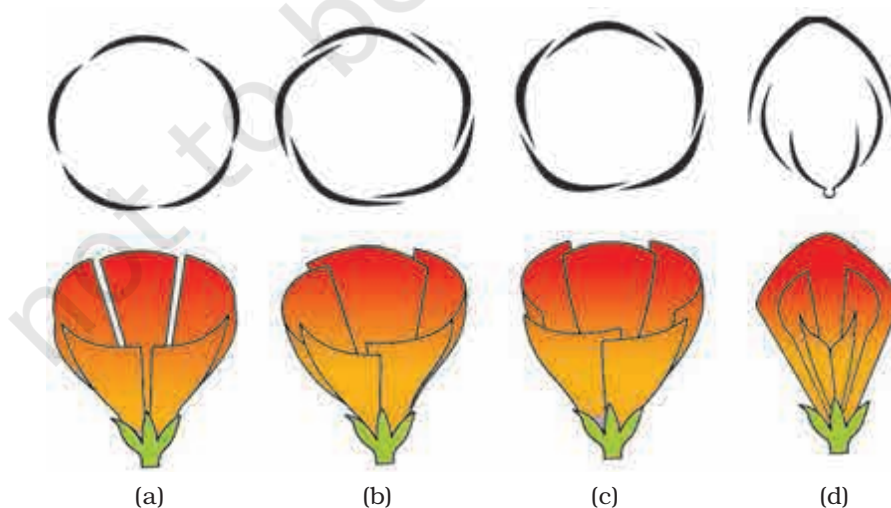
Corolla is composed of petals. Petals are usually brightly coloured to attract insects for pollination. Like calyx, corolla may also be



**Figure 5.14** Parts of a flower

**gamopetalous** (petals united) or **polypetalous** (petals free). The shape and colour of corolla vary greatly in plants. Corolla may be tubular, bell-shaped, funnel-shaped or wheel-shaped.

**Aestivation:** The mode of arrangement of sepals or petals in floral bud with respect to the other members of the same whorl is known as aestivation. The main types of aestivation are valvate, twisted, imbricate and vexillary (Figure 5.15). When sepals or petals in a whorl just touch one another at the margin, without overlapping, as in *Calotropis*, it is said to be **valvate**. If one margin of the appendage overlaps that of the next one and so on as in china rose, lady's finger and cotton, it is called **twisted**. If the margins of sepals or petals overlap one another but not in any particular direction as in *Cassia* and gulmohur, the aestivation is called **imbricate**. In pea and bean flowers, there are five petals, the largest (standard) overlaps the two lateral petals (wings) which in turn overlap the two smallest anterior petals (keel); this type of aestivation is known as **vexillary** or papilionaceous.



**Figure 5.15** Types of aestivation in corolla : (a) Valvate (b) Twisted (c) Imbricate (d) Vexillary

### 5.5.1.3 Androecium

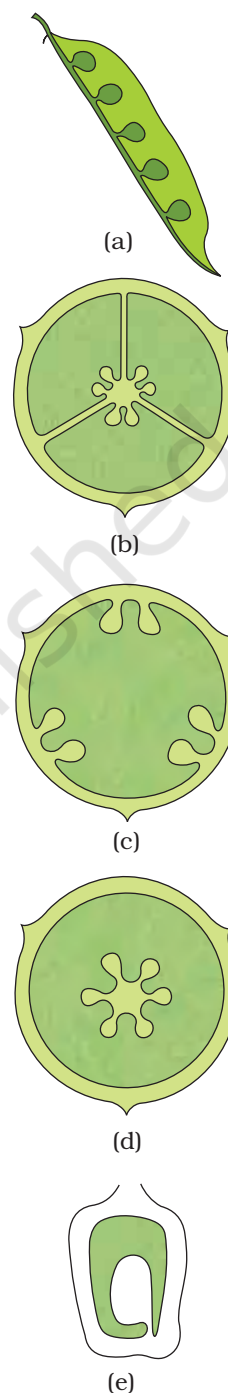
Androecium is composed of stamens. Each stamen which represents the male reproductive organ consists of a stalk or a filament and an anther. Each anther is usually bilobed and each lobe has two chambers, the pollen-sacs. The pollen grains are produced in pollen-sacs. A sterile stamen is called **staminode**.

Stamens of flower may be united with other members such as petals or among themselves. When stamens are attached to the petals, they are **epipetalous** as in brinjal, or **epiphyllous** when attached to the perianth as in the flowers of lily. The stamens in a flower may either remain free (polyandrous) or may be united in varying degrees. The stamens may be united into one bunch or one bundle (**monoadelphous**) as in china rose, or two bundles (**diadelphous**) as in pea, or into more than two bundles (**polyadelphous**) as in citrus. There may be a variation in the length of filaments within a flower, as in *Salvia* and mustard.

### 5.5.1.4 Gynoecium

Gynoecium is the female reproductive part of the flower and is made up of one or more carpels. A carpel consists of three parts namely stigma, style and ovary. **Ovary** is the enlarged basal part, on which lies the elongated tube, the style. The style connects the ovary to the stigma. The **stigma** is usually at the tip of the **style** and is the receptive surface for pollen grains. Each ovary bears one or more ovules attached to a flattened, cushion-like **placenta**. When more than one carpel is present, they may be free (as in lotus and rose) and are called **apocarpous**. They are termed **syncarpous** when carpels are fused, as in mustard and tomato. After fertilisation, the ovules develop into seeds and the ovary matures into a fruit.

**Placentation:** The arrangement of ovules within the ovary is known as placentation. The placentation are of different types namely, marginal, axile, parietal, basal, central and free central (Figure 5.16). In **marginal** placentation the placenta forms a ridge along the ventral suture of the ovary and the ovules are borne on this ridge forming two rows, as in pea. When the placenta is axial and the ovules are attached to it in a multilocular ovary, the placentation is said to be **axile**, as in china rose, tomato and lemon. In **parietal** placentation, the ovules develop on the inner wall of the ovary or on peripheral part. Ovary is one-chambered but it becomes two-chambered due to the formation of the false septum, e.g., mustard and *Argemone*. When the ovules are borne on central axis and septa are absent, as in *Dianthus* and *Primrose* the placentation is



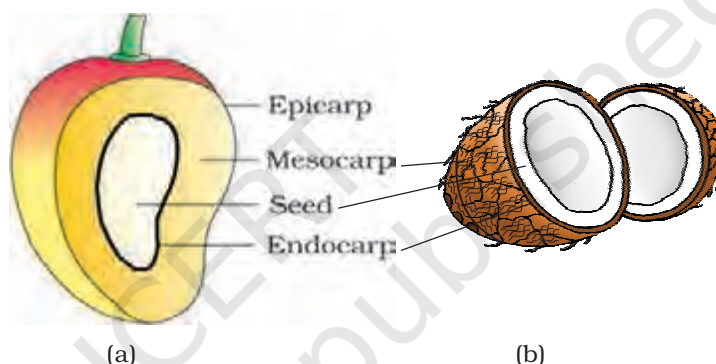
**Figure 5.16** Types of placentation :  
 (a) Marginal  
 (b) Axile  
 (c) Parietal  
 (d) Free central  
 (e) Basal

called **free central**. In **basal** placentation, the placenta develops at the base of ovary and a single ovule is attached to it, as in sunflower, marigold.

## 5.6 THE FRUIT

The fruit is a characteristic feature of the flowering plants. It is a mature or ripened ovary, developed after fertilisation. If a fruit is formed without fertilisation of the ovary, it is called a **parthenocarpic** fruit.

Generally, the fruit consists of a wall or **pericarp** and seeds. The pericarp may be dry or fleshy. When pericarp is thick and fleshy, it is differentiated into the outer **epicarp**, the middle **mesocarp** and the inner **endocarp**.



**Figure 5.17** Parts of a fruit : (a) Mango (b) Coconut

In mango and coconut, the fruit is known as a drupe (Figure 5.17). They develop from monocarpellary superior ovaries and are one seeded. In mango the pericarp is well differentiated into an outer thin epicarp, a middle fleshy edible mesocarp and an inner stony hard endocarp. In coconut which is also a drupe, the mesocarp is fibrous.

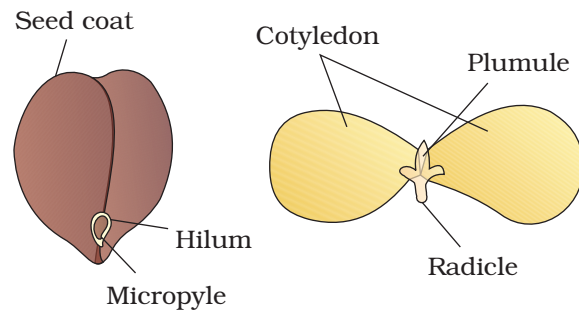
## 5.7 THE SEED

The ovules after fertilisation, develop into seeds. A seed is made up of a seed coat and an embryo. The embryo is made up of a radicle, an embryonal axis and one (as in wheat, maize) or two cotyledons (as in gram and pea).

### 5.7.1 Structure of a Dicotyledonous Seed

The outermost covering of a seed is the seed coat. The seed coat has two layers, the outer **testa** and the inner **tegmen**. The **hilum** is a scar on the seed coat through which the developing seeds were attached to the fruit. Above the hilum is a small pore called the **micropyle**. Within the seed

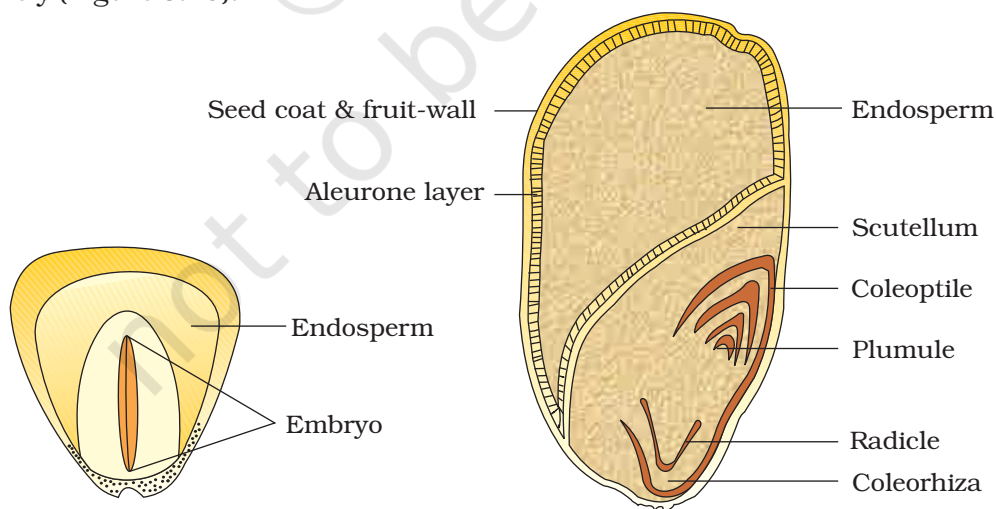
coat is the embryo, consisting of an embryonal axis and two cotyledons. The cotyledons are often fleshy and full of reserve food materials. At the two ends of the embryonal axis are present the radicle and the plumule (Figure 5.18). In some seeds such as castor the **endosperm** formed as a result of double fertilisation, is a food storing tissue and called endospermic seeds. In plants such as bean, gram and pea, the endosperm is not present in mature seeds and such seeds are called non-endospermous.



**Figure 5.18** Structure of dicotyledonous seed

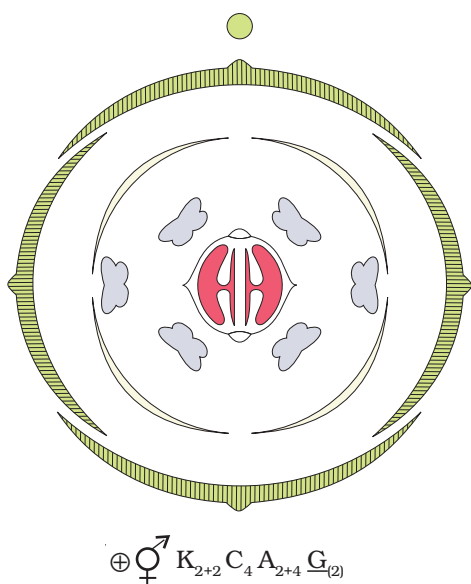
### 5.7.2 Structure of Monocotyledonous Seed

Generally, monocotyledonous seeds are endospermic but some as in orchids are non-endospermic. In the seeds of cereals such as maize the seed coat is membranous and generally fused with the fruit wall. The endosperm is bulky and stores food. The outer covering of endosperm separates the embryo by a proteinous layer called **aleurone layer**. The embryo is small and situated in a groove at one end of the endosperm. It consists of one large and shield shaped cotyledon known as **scutellum** and a short axis with a **plumule** and a **radicle**. The plumule and radicle are enclosed in sheaths which are called **coleoptile** and **coleorhiza** respectively (Figure 5.19).



**Figure 5.19** Structure of a monocotyledonous seed





**Figure 5.20** Floral diagram with floral formula

## 5.8 SEMI-TECHNICAL DESCRIPTION OF A TYPICAL FLOWERING PLANT

Various morphological features are used to describe a flowering plant. The description has to be brief, in a simple and scientific language and presented in a proper sequence. The plant is described beginning with its habit, vegetative characters – roots, stem and leaves and then floral characters inflorescence and flower parts. After describing various parts of plant, a floral diagram and a floral formula are presented. The floral formula is represented by some symbols. In the floral formula, **Br** stands for bracteate **K** stands for calyx, **C** for corolla, **P** for perianth, **A** for androecium and **G** for Gynoecium, **G** for superior ovary and  $\bar{\mathbf{G}}$  for inferior ovary,  $\sigma^7$  for male,  $\rho^7$  for female,  $\sigma^7\rho^7$  for bisexual plants,  $\oplus$  for actinomorphic and  $\%$  for zygomorphic nature of flower. Fusion is indicated by enclosing the figure within bracket and adhesion by a line drawn above the symbols of the floral parts. A floral diagram provides information about the number of parts of a flower, their arrangement and the relation they have with one another (Figure 5.20). The position of the mother axis with respect to the flower is represented by a dot on the top of the floral diagram. Calyx, corolla, androecium and gynoecium are drawn in successive whorls, calyx being the outermost and the gynoecium being in the centre. Floral formula also shows cohesion and adhesion within parts of whorls and between whorls. The floral diagram and floral formula in Figure 5.20 represents the mustard plant (Family: Brassicaceae).

## 5.9 DESCRIPTION OF SOME IMPORTANT FAMILIES

### 5.9.1 Fabaceae

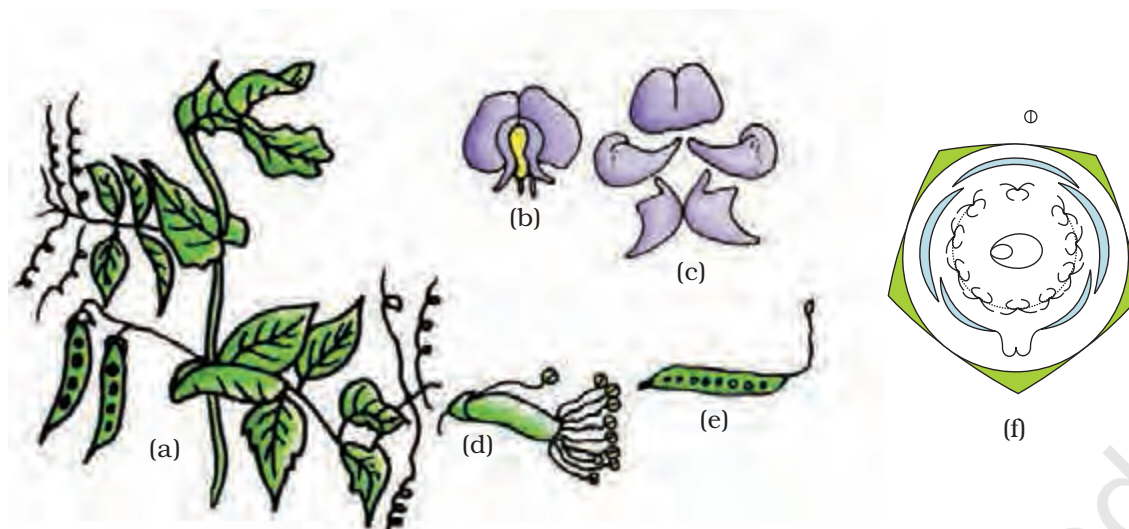
This family was earlier called Papilionoideae, a subfamily of family Leguminosae. It is distributed all over the world (Figure 5.21).

#### Vegetative Characters

Trees, shrubs, herbs; root with root nodules

**Stem:** erect or climber

**Leaves:** alternate, pinnately compound or simple; leaf base, pulvinate; stipulate; venation reticulate.



**Figure 5.21** *Pisum sativum* (pea) plant : (a) Flowering twig (b) Flower (c) Petals (d) Reproductive parts (e) L.S.carpel (f) Floral diagram

### Floral characters

**Inflorescence:** racemose

**Flower:** bisexual, zygomorphic

**Calyx:** sepals five, gamosepalous; valvate/imbricate aestivation

**Corolla:** petals five, polypetalous, papilionaceous, consisting of a posterior standard, two lateral wings, two anterior ones forming a keel (enclosing stamens and pistil), vexillary aestivation

**Androecium:** ten, diadelphous, anther ditheous

**Gynoecium:** ovary superior, mono carpellary, unilocular with many ovules, style single

**Fruit:** legume; seed: one to many, non-endospermic

**Floral Formula:**  $\% \overset{\sigma}{\text{K}}_{(5)} \text{C}_{1+2+(2)} \text{A}_{(9)+1} \underline{\text{G}}_1$

### Economic importance

Many plants belonging to the family are sources of pulses (gram, arhar, sem, moong, soyabean; edible oil (soyabean, groundnut); dye (Indigofera); fibres (sunhemp); fodder (*Sesbania*, *Trifolium*), ornamentals (lupin, sweet pea); medicine (*muliathu*).

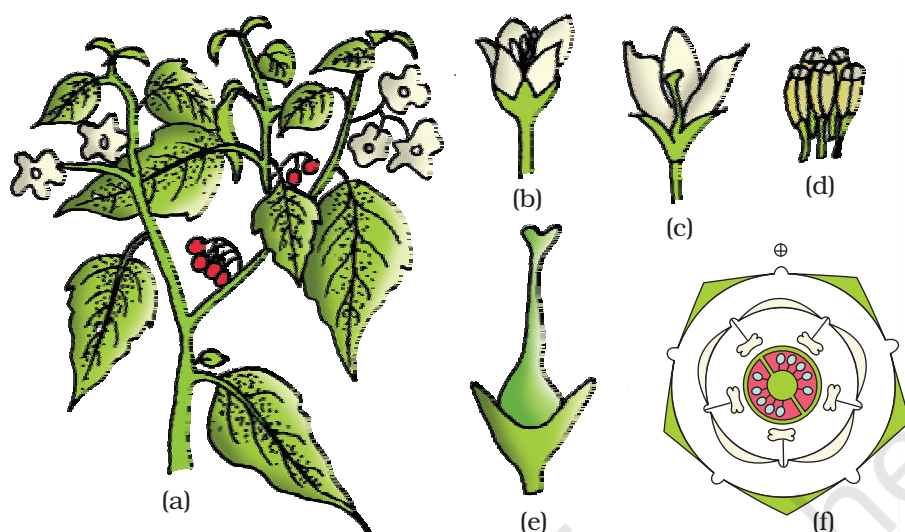
### 5.9.2 Solanaceae

It is a large family, commonly called as the 'potato family'. It is widely distributed in tropics, subtropics and even temperate zones (Figure 5.22).

#### Vegetative Characters

Plants mostly herbs, shrubs and rarely small trees

**Stem:** herbaceous rarely woody, aerial; erect, cylindrical, branched, solid



**Figure 5.22** *Solanum nigrum* (makoi) plant : (a) Flowering twig (b) Flower (c) L.S. of flower (d) Stamens (e) Carpel (f) Floral diagram

or hollow, hairy or glabrous, underground stem in potato (*Solanum tuberosum*)

**Leaves:** alternate, simple, rarely pinnately compound, exstipulate; venation reticulate

#### Floral Characters

**Inflorescence :** Solitary, axillary or cymose as in *Solanum*

**Flower:** bisexual, actinomorphic

**Calyx:** sepals five, united, persistent, valvate aestivation

**Corolla:** petals five, united; valvate aestivation

**Androecium:** stamens five, epipetalous

**Gynoecium:** bicarpellary obligately placed, syncarpous; ovary superior, bilocular, placenta swollen with many ovules, axile

**Fruits:** berry or capsule

**Seeds:** many, endospermous

**Floral Formula:**  $\oplus \overset{\circlearrowleft}{\text{K}}_{(5)} \overset{\circlearrowright}{\text{C}}_{(5)} \text{A}_5 \underline{\text{G}}_{(2)}$

#### Economic Importance

Many plants belonging to this family are source of food (tomato, brinjal, potato), spice (chilli); medicine (belladonna, *ashwagandha*); fumigatory (tobacco); ornamentals (petunia).

### 5.9.3 Liliaceae

Commonly called the 'Lily family' is a characteristic representative of monocotyledonous plants. It is distributed world wide (Figure 5.23).

**Vegetative characters:** Perennial herbs with underground bulbs/corms/ rhizomes

**Leaves** mostly basal, alternate, linear, exstipulate with parallel venation

**Floral characters**

**Inflorescence:** solitary / cymose; often umbellate clusters

**Flower:** bisexual; actinomorphic

**Perianth** tepal six (3+3), often united into tube; valvate aestivation

**Androecium:** stamen six, 3+3, epitepalous

**Gynoecium:** tricarpeal, syncarpous, ovary superior, trilobular with many ovules; axile placentation

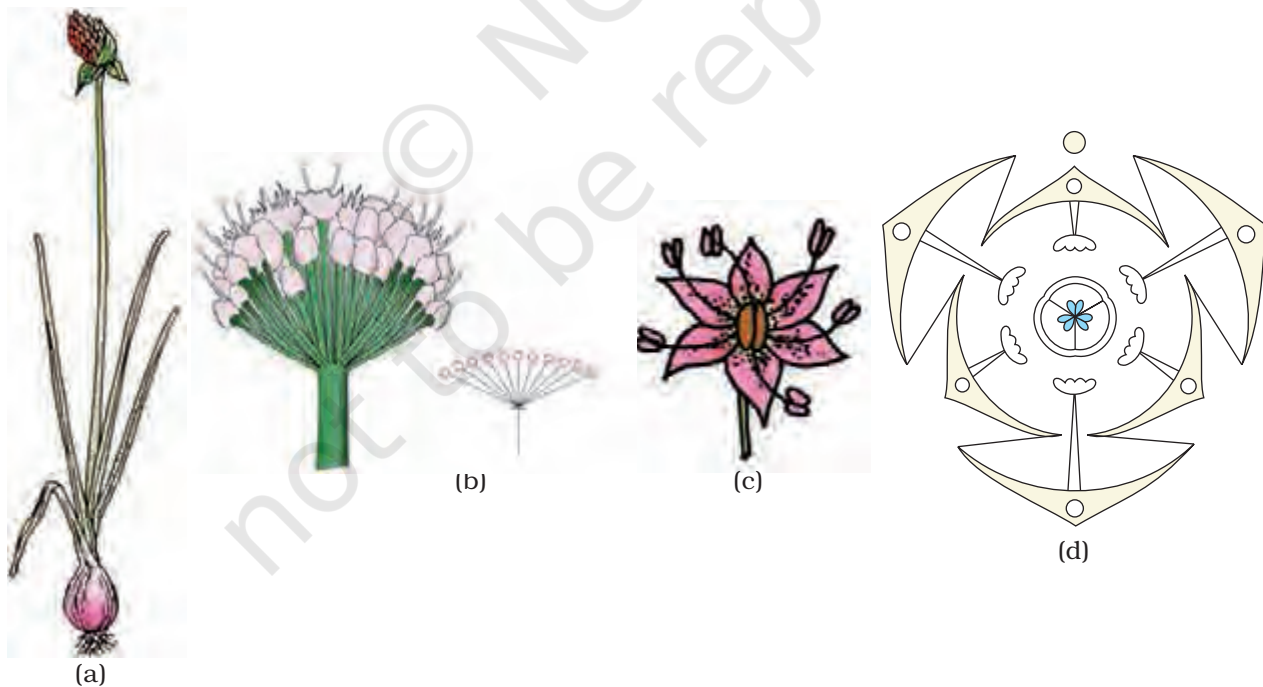
**Fruit:** capsule, rarely berry

**Seed:** endospermous

**Floral Formula:**  $Br \oplus \overset{\text{♂}}{P}_{(3+3)} \overset{\text{♀}}{A}_{3+3} G_{(3)}$

**Economic Importance**

Many plants belonging to this family are good ornamentals (tulip, *Gloriosa*), source of medicine (*Aloe*), vegetables (*Asparagus*), and colchicine (*Colchicum autumnale*).



**Figure 5.23** *Allium cepa* (onion) plant : (a) Plant (b) Inflorescence (c) Flower (d) Floral diagram

### SUMMARY

Flowering plants exhibit enormous variation in shape, size, structure, mode of nutrition, life span, habit and habitat. They have well developed root and shoot systems. Root system is either tap root or fibrous. Generally, dicotyledonous plants have tap roots while monocotyledonous plants have fibrous roots. The roots in some plants get modified for storage of food, mechanical support and respiration. The shoot system is differentiated into stem, leaves, flowers and fruits. The morphological features of stems like the presence of nodes and internodes, multicellular hair and positively phototropic nature help to differentiate the stems from roots. Stems also get modified to perform diverse functions such as storage of food, vegetative propagation and protection under different conditions. Leaf is a lateral outgrowth of stem developed exogeneously at the node. These are green in colour to perform the function of photosynthesis. Leaves exhibit marked variations in their shape, size, margin, apex and extent of incisions of leaf blade (lamina). Like other parts of plants, the leaves also get modified into other structures such as tendrils, spines for climbing and protection respectively.

The flower is a modified shoot, meant for sexual reproduction. The flowers are arranged in different types of inflorescences. They exhibit enormous variation in structure, symmetry, position of ovary in relation to other parts, arrangement of petals, sepals, ovules etc. After fertilisation, the ovary is modified into fruits and ovules into seeds. Seeds either may be monocotyledonous or dicotyledonous. They vary in shape, size and period of viability. The floral characteristics form the basis of classification and identification of flowering plants. This can be illustrated through semi-technical descriptions of families. Hence, a flowering plant is described in a definite sequence by using scientific terms. The floral features are represented in the summarised form as floral diagrams and floral formula.

### EXERCISES

1. What is meant by modification of root? What type of modification of root is found in the:  
(a) Banyan tree (b) Turnip (c) Mangrove trees
2. Justify the following statements on the basis of external features:  
(i) Underground parts of a plant are not always roots.  
(ii) Flower is a modified shoot.
3. How is a pinnately compound leaf different from a palmately compound leaf?
4. Explain with suitable examples the different types of phyllotaxy.

5. Define the following terms:
  - (a) aestivation
  - (b) placentation
  - (c) actinomorphic
  - (d) zygomorphic
  - (e) superior ovary
  - (f) perigynous flower
  - (g) epipetalous stamen
6. Differentiate between
  - (a) Racemose and cymose inflorescence
  - (b) Fibrous root and adventitious root
  - (c) Apocarpous and syncarpous ovary
7. Draw the labelled diagram of the following:
  - (i) gram seed
  - (ii) V.S. of maize seed
8. Describe modifications of stem with suitable examples.
9. Take one flower each of the families Fabaceae and Solanaceae and write its semi-technical description. Also draw their floral diagram after studying them.
10. Describe the various types of placentations found in flowering plants.
11. What is a flower? Describe the parts of a typical angiosperm flower.
12. How do the various leaf modifications help plants?
13. Define the term inflorescence. Explain the basis for the different types inflorescence in flowering plants.
14. Write the floral formula of a actinomorphic, bisexual, hypogynous flower with five united sepals, five free petals, five free stamens and two united carples with superior ovary and axile placentation.
15. Describe the arrangement of floral members in relation to their insertion on thalamus.