



## **TISSUES AND OTHER LEVELS OF ORGANIZATION**

You have just learnt that cell is the fundamental structural and functional unit of organisms and that bodies of organisms are made of cells of various shapes and sizes. Groups of similar cells aggregate to collectively perform a particular function. Such groups of cells are termed “tissues”. This lesson deals with the various kinds of tissues of plants and animals.



### **OBJECTIVES**

After completing this lesson, you will be able to :

- *define tissues;*
- *classify plant tissues;*
- *name the various kinds of plant tissues;*
- *enunciate the tunica corpus theory and histogen theory;*
- *classify animal tissues;*
- *describe the structure and function of various kinds of epithelial tissues;*
- *describe the structure and function of various kinds of connective tissues;*
- *describe the structure and function of muscular tissue;*
- *describe the structure and function of nervous tissue.*

### **5.1 WHAT IS A TISSUE**

Organs such as stem, roots in plants and stomach, heart and lungs in animals are made up of different kinds of tissues. **A tissue is a group of cells with a common origin, structure and function.** Their common origin means they are derived from the same layer (details in lesson No. 20) of cells in the embryo. Being of a common origin, they are similar in structure and hence perform the same function. Many kinds of tissues organise to form an **organ**.

**Example :** Blood, bone, cartilage are some examples of animal tissues whereas parenchyma, collenchyma, xylem and phloem are different tissues in plants. The study of tissues is called **histology**.

A group of cells with similar origin, structure and function is called **tissue**.  
e.g. bone, muscle in animals and meristem in tips of root and shoot in plants

## 5.2 THE PLANT TISSUES

The plant tissues are mainly of two types:

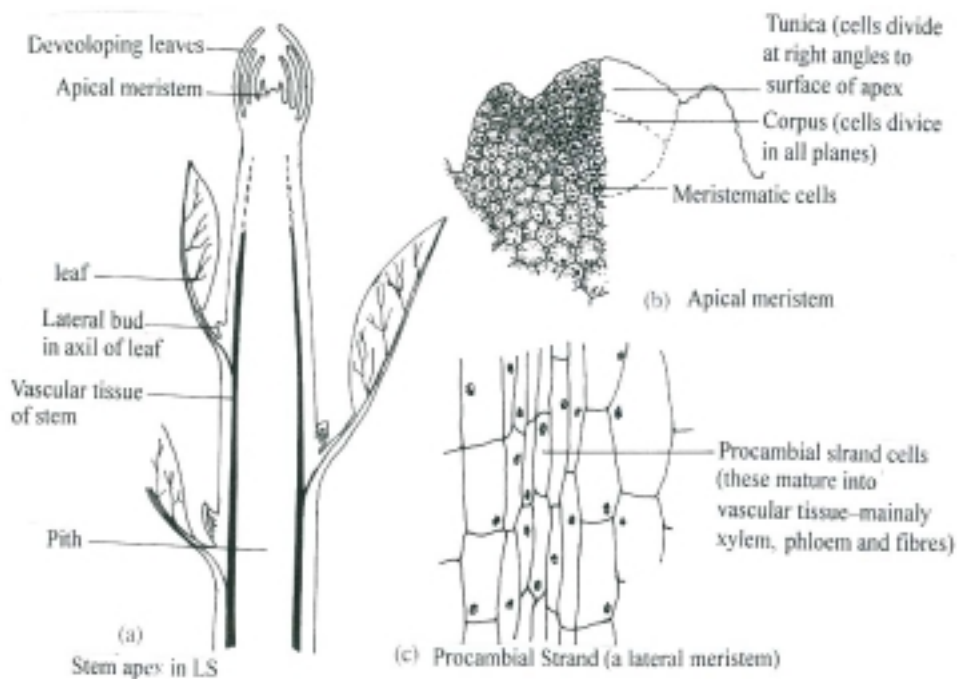
1. Meristematic (Gk. meristos : dividing)
2. Permanent (non-dividing)

### 1. Meristematic tissues

- Composed of immature or undifferentiated cells without intercellular spaces.
- The cells may be rounded, oval or polygonal; always living and thin walled.
- Each cell has abundant cytoplasm and prominent nuclei in it.
- Vacuoles may be small or absent.

**Table 5.1** Types of meristematic tissue

Types	Location	Function
Apical Meristem	Root tip and shoot tip.	Growth in length of plants.
Intercalary Meristem	At the base of leaves or at the base of internodes.	Internodal growth.
Lateral Meristem	Cambium between xylem and phloem and cork cambium in the cortex of dicot plants.	Growth in thickness of the plant body. (secondary growth).



**Fig. 5.1** Location of meristematic tissue



Notes



**Notes**

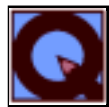
**2. Permanent tissues**

- Permanent tissues are those in which growth has stopped either completely or for the time being.
- Cells of these tissues may be living or dead; and thin walled or thick walled.
- Thin walled permanent tissues are generally living whereas the thick walled tissues may be living or dead.

**Types of permanent tissues**

- (i) **Simple tissues** : Simple tissue is made up of only one type of cells. Common simple tissues are parenchyma, collenchyma and sclerenchyma (Fig. 5.2, 5.3 and 5.4).
- (ii) **Complex tissues** : Complex tissue is made up of more than one type of cells working together as a unit. Common examples are xylem and phloem (Fig. 5.5 and 5.6).

The structure, function and distribution of simple plant tissues is given in table 5.2.



**INTEXT QUESTIONS 5.1**

1. Define tissue.  
.....
2. Give one word equivalent for the following :
  - (i) A plant tissue that consists of cells which continue to divide to produce more cells.  
.....
  - (ii) The meristematic tissue responsible for the increase in thickness of the stem of a tree.  
.....
  - (iii) The kind of plant tissues which consists of all similar cells.  
.....
  - (iv) The category of plant tissues in which the cells do not divide.  
.....
3. What do you mean by “cells of a tissue have similar origin”?  
.....
4. Name that branch of Biology in which tissues studied?  
.....
5. What is a complex tissue?  
.....
6. Mention any **two** special features of meristematic cells.  
.....



Notes

### 5.2.1 Simple Plant Tissues

There are three types of simple plant tissues (Fig. 5.2, 5.3 and 5.4)

1. Parenchyma (Chlorenchyma and Aerenchyma)
2. Collenchyma
3. Sclerenchyma

**Table 5.2** Structure, Function and Distribution of simple tissues

Tissue	Living or Dead	Structure	Function	Distribution
1. Parenchyma	Living	(i) Oval or round, thin walled with sufficient cytoplasm. (ii) Has prominent nucleus and intercellular spaces (iii) Wall made up of cellulose	(a) They make large parts of various organs in most plants. (b) Act as storage cells. (c) Chlorenchyma carries out photosynthesis. (d) Turgid, parenchyma give rigidity to the plant body.	1. Pith and cortex of stem and root. 2. Mesophyll of leaves. 3. Endosperm of seed. 4. Xylem and phloem parenchyma in vascular tissue.
(a) Chlorenchyma	Living	Parenchyma containing chloroplasts.		
(b) Aerenchyma	Living	Parenchyma with large air spaces or intercellular spaces.		
2. Collenchyma (Gk. collen : glue)	Living	(i) Elongated cells with thick primary walls. Thickenings more in the corners of the cells. (ii) Wall material is cellulose and pectin (iii) Intercellular spaces present.	Gives mechanical support to the plant body. Specially in many dicot leaves and green stems	Occur in the peripheral regions of stems and leaves.
3. Sclerenchyma (Gk. scleros = hard)	Dead	Sclerenchyma consists of thick walled cells, walls uniformly thick with lignin.	Sclerenchyma is mainly a supporting tissue, which can withstand strains and protect the inner thin walled cells from damage.	<ul style="list-style-type: none"> <li>● Fibres occur in patches or continuous bands in various parts of stem in many plants.</li> <li>● Sclereids occur commonly in fruit and seed. Present in some leaves in large numbers.</li> </ul>
(a) Fibres	Dead	Elongated cells with pointed ends. Walls are thick with lignin.		
(b) Sclereids	Dead	Irregular in shape. Cell wall very thick making the cell cavity very small.		

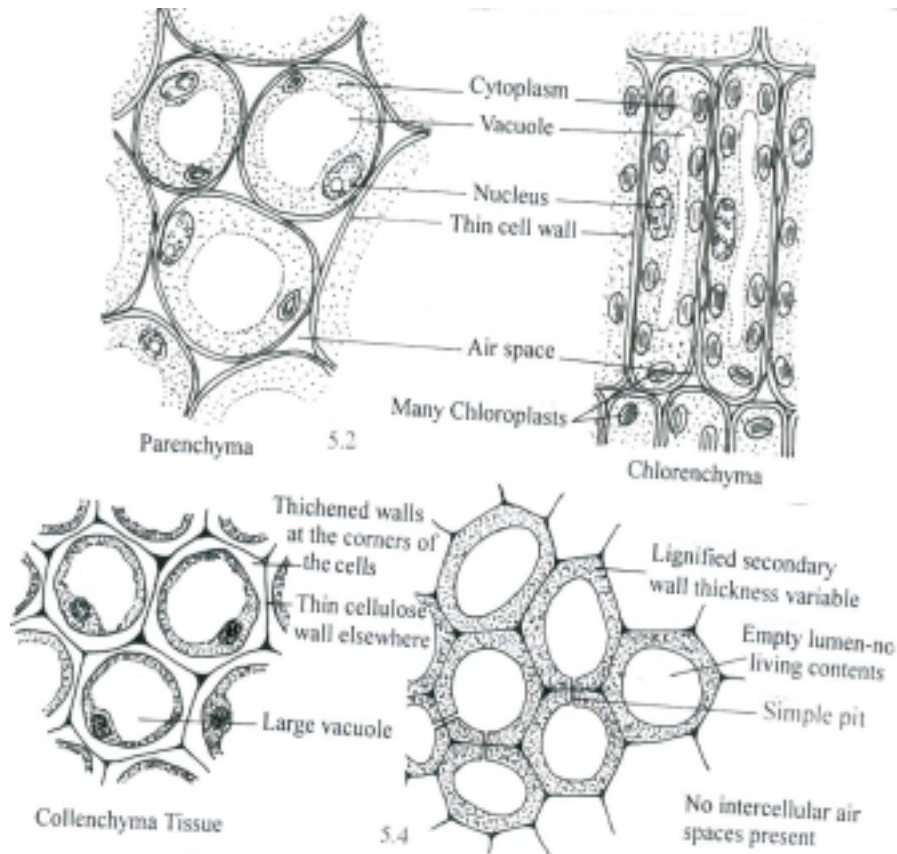


Fig. 5.2, 5.3, 5.4 Various types of simple tissues

### 5.2.2. Complex tissues

Complex tissues are mainly of two types :

(i) Xylem

(ii) Phloem

- Xylem and phloem form a continuous system inside the plants, that is from the roots through the stem and leaves.
- They are known as vascular tissues and form vascular bundles in roots and stems.

**Xylem** (Greek xylo = wood)

- Xylem is a conducting tissue which conducts water and salts upward from roots to leaves.
- Xylem is composed of (a) Tracheids, (b) Vessels (c) Fibres (d) Xylem Parenchyma (Fig. 5.5)

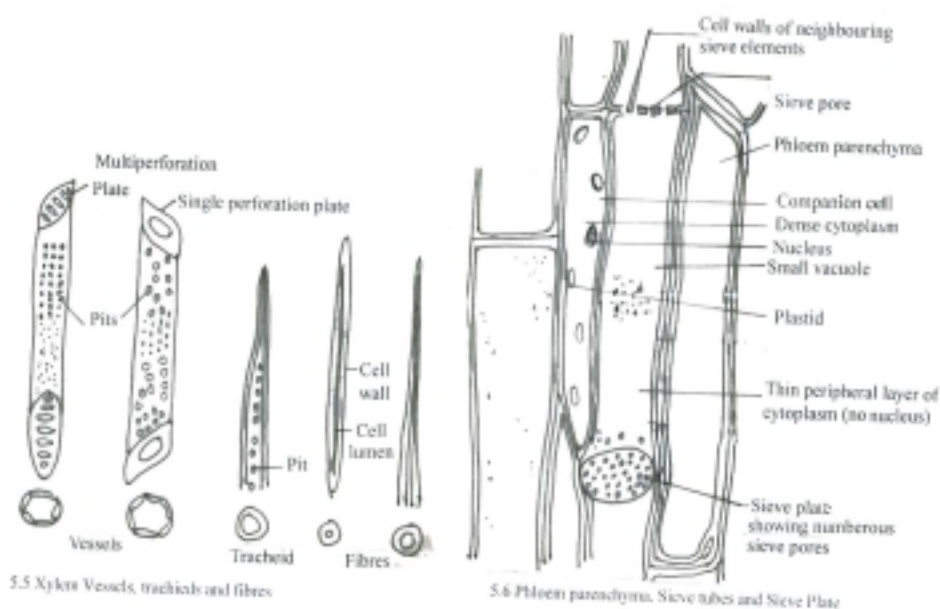
**Phloem**

- Phloem too is a conducting tissue which conducts food synthesised in the leaves to different parts of the plant.
- Phloem is composed of (a) Sieve Tubes (b) Companion Cells (c) Phloem Fibre (d) Phloem Parenchyma (Fig. 5.6)

The structure, function of the complex plant tissues is given in table 5.3.

**Table 5.3 Structure and function of the components of xylem and phloem**

Tissues	Living or Dead	Structure	Function
<b>Xylem</b>			
1. Tracheids	Dead	Long cells with pointed ends. Walls thick with lignin. Have pores on the walls	All of them function as a unit to conduct water upward from root to leaves.
2. Vessel	Dead	Cells shorter and broader than tracheids. Walls thick with lignin and have pores. End walls open and the cells join to form a long tube.	
3. Xylem Fibres	Dead	Long cells with very thick lignin deposition on the walls, no pores on the walls.	
4. Xylem Parenchyma	Living	Small thin walled cells with cellulose walls.	
<b>Phloem</b>			
1. Sieve tube	Living	Elongated sieve cells join to form sieve tubes; cell wall of cellulose. End walls of the cells have holes on them, which give them the name (sieve).	All of them function as a unit to translocate food made in the leaves by photosynthesis to different parts of the plant.
2. Companion cell	Living	Long, rectangular cells associated with sieve cells. Cell wall made of cellulose.	
3. Phloem fibre	Dead	Very long cells with thick lignified walls	
4. Phloem parenchyma	Living	Elongated cells. Cell wall thin and made of cellulose.	

**Notes****Fig. 5.5, 5.6** Various types of complex tissues



Notes

**5.2.3 Theories explaining growth of the plant at its apex and root tip**

There are two important theories that explain the growth of a plant at the extremities of shoot and root. They are (i) Tunica corpus theory and (2) Histogen theory.

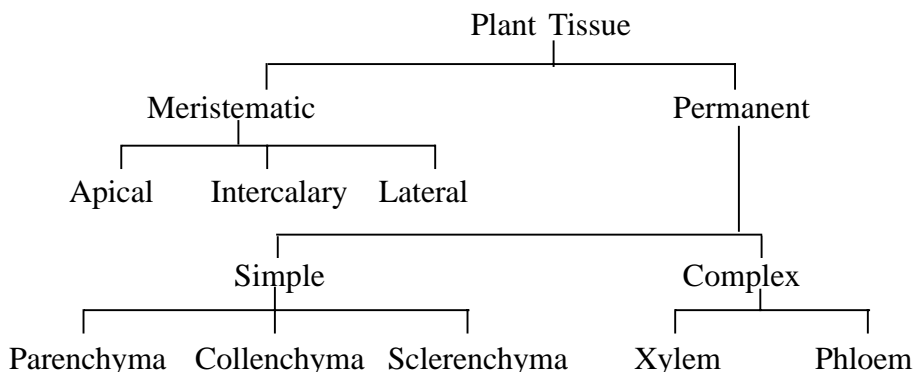
**Tunica Corpus Theory :**

- Tunica corpus theory was developed for vegetative shoot apex.
- According to this theory, there are **two** zones of tissues in the apical meristems **the tunica** (Tunic = cover) consisting of one or more layers of peripheral layers of cells, and the **corpus** (corpus = body) a mass of cells enclosed by the tunica.
- According to the theory, different rates and methods of growth in the apex set apart two regions.
- The layers of tunica show anticlinal (perpendicular to periphery) divisions and bring about surface growth.
- In the corpus, cell division is irregular and at various planes resulting in growth in volume of the mass.
- Tunica gives rise to epidermis and cortex. Corpus gives rise to endodermis, pericycle, pith and vascular tissue.

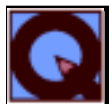
**Histogen Theory**

- According to this theory, apical meristem of stem and root are composed of small mass of cells which are all alike and divide fast (meristematic)
- These meristematic cells form promeristem, which differentiate into three zones **dermatogen, periblem** and **plerome**.
- Every zone consists of a group of initials called a **histogen** (tissue builder).
  - (i) Dermatogen gives rise to epidermis of stems and epiblema of roots.
  - (ii) Periblem (middle layer) gives rise to cortex of stems and roots.
  - (iii) Plerome gives rise to central meristematic region – pericycle, pith and vascular tissue.

**Classification of plant tissues-at a glance**





**INTEXT QUESTIONS 5.2**

1. Give Two characteristics and one example of the location of the given tissues in plants in the following table:

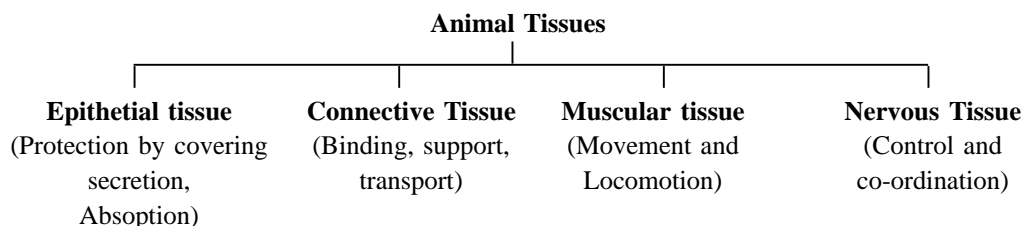
S.No.	Tissue	Characteristics	Example of location
(i)	Parenchyma	.....	.....
(ii)	Collenchyma	.....	.....
(iii)	Sclerenchyma	.....	.....

2. Name plants tissue which

- (i) conduct water .....
- (ii) conduct food. ....

**5.3 ANIMAL TISSUES**

As in plants, tissues in animals are also various types which perform different functions. See the flow chart given below

**5.3.1 Epithelial Tissue**

**Structural Characteristics :** The cells forming epithelial tissue –

- (i) are closely packed with no intercellular space in between.
- (ii) arise from a non-cellular basement membrane.
- (iii) not supplied with blood vessels.

**Function :** line the surfaces, help in absorption, secrete, also bear protoplasmic projections such as the Cilia. (See table 5.4 and Fig. 5.7)

**Table 5.4 : Types of epithelial tissue**

Type	Structure	Location	Function
1. Squamous Epithelium	Flattened cells with a centrally placed nucleus. Have irregular margins.	Lining of air sacs in the lungs.	For exchange of O <sub>2</sub> and CO <sub>2</sub> .
		Lining of Kidney tubules.	For absorption.
		Lining of blood capillaries.	For exchange of materials.



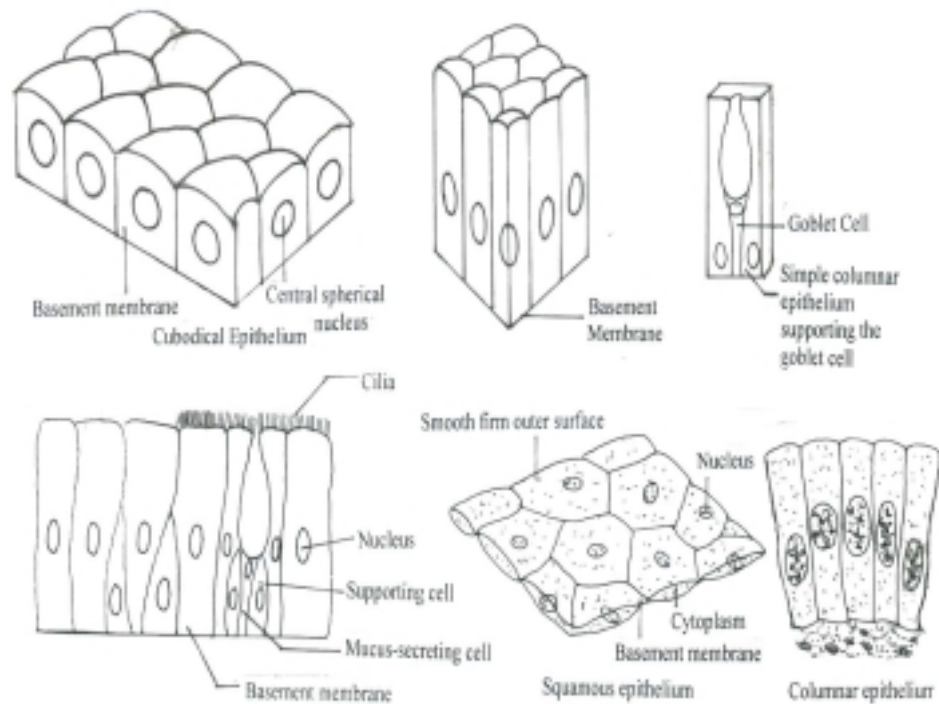
**Notes**





**Notes**

2. Cuboidal Epithelium	Cube like cells with a centrally placed nucleus, Cells appear polygonal.	Lining of salivary and pancreatic ducts.	For absorption.
		Found in sweat, salivary gland.	For secretion
3. Ciliated Epithelium	Have cilia at free ends.	Lining of Kidney tubules.	For flow of nephric filtrate.
4. Columnar epithelium	Tall column like cell, with nucleus at the basal end	Lining of stomach, instestine	Secretion and absorption
5. Ciliated Columnar Epithelium	Cilia at free ends	Lining of trachea	Flow of fluids in a particular direction
6. Brush bordered Columnar Epithelium	Numerous folds at free ends	Lining of intestine	Increasing the surface area for absorption



**Fig. 5.7** The structure of different epithelial tissue

If the epithelial cells are in a single layer, they form simple epithelium. If the epithelial cells are arranged in many layers, they form compound epithelium or stratified epithelium (many layers). Stratified epithelium is present in the body, where there is lot of wear and tear. For example skin, inner lining of cheeks etc.



### INTEXT QUESTIONS 5.3

1. List the different types of animal tissues

.....

2. Match the items in column I with those in column II by writing the corresponding serial number within brackets.

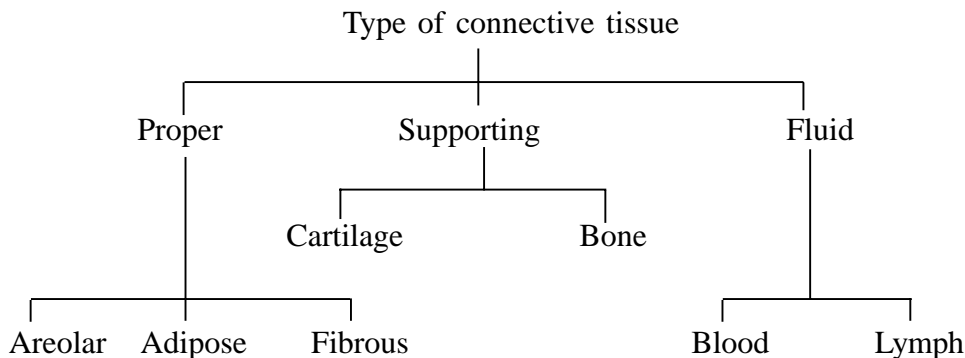
Column I		Column II
(a) Compound Epithelium	( )	(i) Epithelial tissue
(b) Basement membrane	( )	(ii) For increasing the surface area
(c) Brush bordered epithelium	( )	(iii) Lining of trachea
(d) Salivary gland	( )	(iv) Skin
(e) Ciliated Epithelium	( )	(v) Cuboidal epithelium

### 5.3.2 Connective tissue

The connective tissue has two components :

(a) matrix, the ground substance and (b) cells

The matrix and cells are different in different connective tissues (Fig. 5.8). Matrix is the ground substance.



#### A. Proper Connective Tissue

1. **Areolar** : Most widely spread connective tissue.

The cells forming the tissue are :

- (i) **Fibroblasts**-which form the yellow (elastin) and white (collagen) fibres in the matrix.
- (ii) **Macrophages**-which help in engulfing bacteria and micro pathogens.
- (iii) **Mast cell**-which secretes heparin (helps in clotting of blood).



Notes



Notes

**2. Adipose tissue :** It has specialized cells storing fat called **adipose cells**. Help in forming paddings.

**3. Fibrous :** It is mainly made up of fibroblasts. It forms tendons and ligaments.

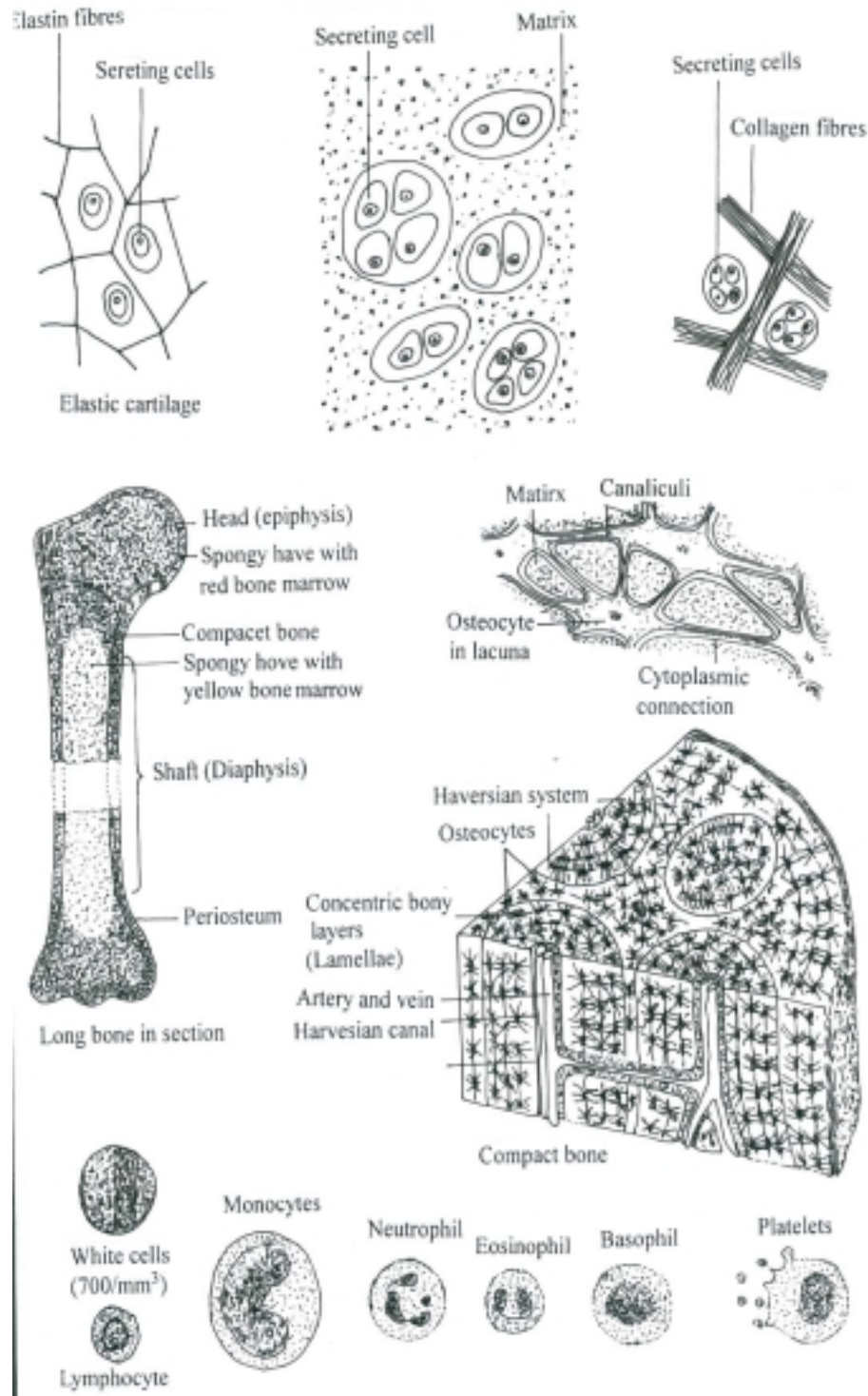
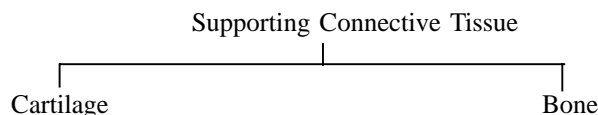


Fig. 5.8 Some representative types of connective tissue.

**B. Supporting Connective Tissue**

- |   |  |
|---|--|
| <ol style="list-style-type: none"> <li>1. Matrix is composed of <b>chondrin</b>. The cells lie in the matrix singly or in groups of two or four surrounded by fluid-filled spaces. The cartilage may be elastic whose matrix has yellow fibres as in pinna of ear.</li> <li>2. The cartilage may be fibrous, whose matrix has white fibres. Fibrous cartilage is present in between vertebrae.</li> <li>3. The cartilage can be calcified where matrix is deposited with calcium salts as in head of long bones.</li> </ol> | <ol style="list-style-type: none"> <li>1. Matrix is composed of <b>ossein</b>. Matrix also contains salts of calcium, phosphorus and magnesium. Matrix in mammalian long bones (such as thigh bone) is arranged in concentric rings. The <b>osteocytes</b> (bone cells) lie on the lamellae (concentric rings in the matrix.) Osteocytes give out branched processes which join with those of the adjoining cells. Some bones have a central cavity which contains a tissue that produces blood cells. The substance contained in the bone cavity is called <b>bone marrow</b>.</li> <li>2. Bones are of two types : <b>Spongy</b> and <b>Compact</b>. In spongy bone, bone cells are irregularly arranged. Such bones are found at the ends of the of long bones.</li> <li>3. In the compact bones, cells are arranged in circles or lamellae around a central canal- the Haversian canal.</li> </ol> |
|---|--|

**C. Fluid connective tissue**

Blood and Lymph are the two forms of the fluid connective tissue.

**Blood :** It is a complex of blood cells and plasma. Plasma forms the matrix.

- The blood cells
1. Red Blood Cells (Erythrocytes)-Transport O<sub>2</sub> and CO<sub>2</sub>
  2. White blood cells (Leucocytes)-Function in defence against bacteria, viruses and other invaders.
  3. Platelets (Thrombocytes)-help in the clotting of blood.

Plasma is the extra cellular fluid of matrix, the ground substance. It contains large number of proteins such as Fibrinogen, Albumin, Globulin to be transported to various parts of the animal body for various purposes.

**5.3.3 Muscle tissue**

Muscle tissue is composed of long excitable cells containing parallel microfilaments of contractile proteins shape. Actin, myosin, troponin and tropomyosin. Because of its elongated shape, muscle cell is called a muscle fibre. The muscle fibres of vertebrates are of three different types (i) Striated (ii) Unstriated (iii) Cardiac (Fig. 5.9) according to shape and functions as mentioned in Table 5.5 and Fig. 5.9.

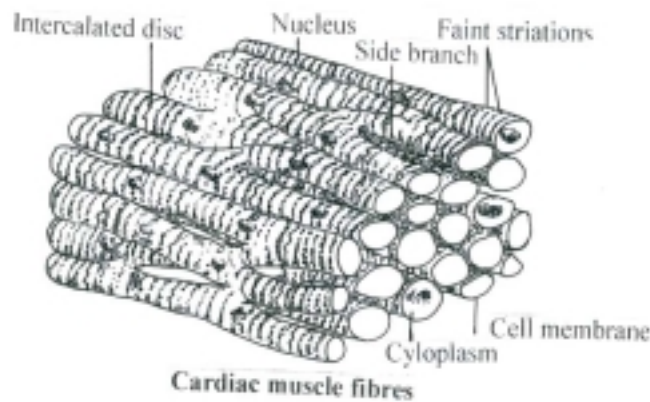
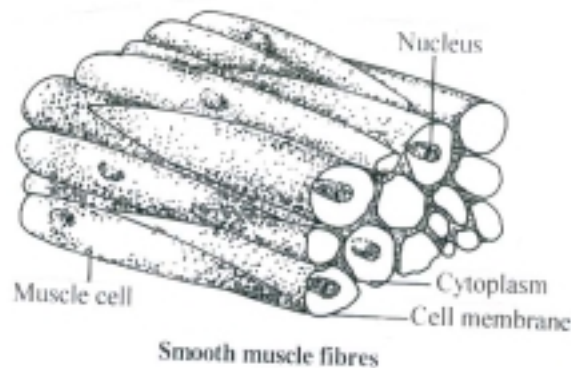
**Notes**



**Notes**

**Table 5.5** Types of Muscle Fibres

Striated/Voluntary/Skeletal	Unstriated/Involuntary	Cardiac
<p><b>Location</b> 1. Attached to the skeleton like head, limbs, face etc.</p>	In the walls of body organs like stomach, intestines.	Walls of heart.
<p><b>Shape</b> Elongated, cylindrical, unbranched fibres Myofibrils so arranged in the cytoplasm, that there are striations seen.</p>	Spindle shaped, tapering.  No such striations seen as myofibrils are not uniformly arranged .	Elongated, cylindrical, branched. Striations (stripes) seen.
<p><b>Sarcolemma</b> Thin and tough membrane sarcolemma of the fibre (cell).</p>	Thin cell membrane, no sarcolemma.	Thin
<p><b>Nucleus</b> Multi nucleated, Peripheral nuclei.</p>	Uninucleated, centrally placed.	One nucleus in each unit, centrally placed.
<p><b>Blood Supply</b> Rich</p>	Poor	Rich
<p><b>Intercalate Discs</b> Absent</p>	Absent	Present
Voluntary (Contracts at will)	Involuntary	Involuntary



**Fig. 5.9** Types of Vertebrate Muscle Tissue

The muscle fibres have the following characteristics:

- (i) Excitability, (respond to stimulus)
- (ii) Extensibility, (stretch)
- (iii) Contractility, (contract)
- (iv) Elasticity, (move back to the original position)



### INTEXT QUESTIONS 5.4

1. Name the different types of cells found in the different types of connective tissue.  
.....
2. Match the item in column I with those in column II, by writing the corresponding serial number within brackets:

Column I	Column II
a. Unstriated muscles	( ) (i) multinucleate
b. Myofibrils	( ) (ii) run parallel to each other in a striped muscle
c. Sarcolemma	( ) (iii) cardiac muscles
d. Striped muscle	( ) (iv) outer tough membrane of a striped muscle fibre
e. Branched myofibrils	( ) (v) involuntary

#### 5.3.4 Nervous Tissues

Nervous tissues has two kinds of cells i.e. **neurons and neuroglia cells**

##### Neurons

Neuron is the functional unit of nervous tissue. Neurons are also called nerve cells. Nervous tissues constitute the brain, spinal cord, nerves and the sensory cells and sense organs.

A single neuron has a generalised appearance as shown in the Fig. 5.10.

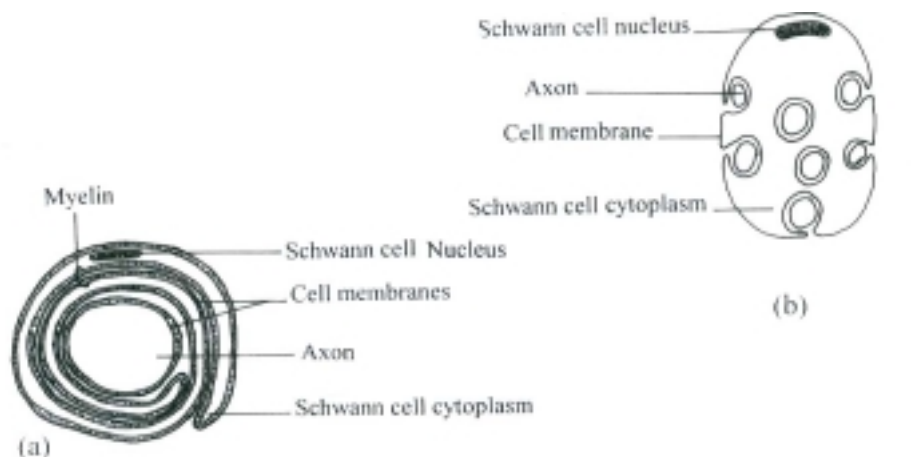


Fig. 5.10 Nerve cell (a) non-myelinated nerve fibre (b) myelinated nerve fibre.



Notes





**Notes**

Like any other cells of the body, it has the main cell body called **cyton** from which project out a varying number of processes –one of which is usually very long. This long fibre is called the **axon**.

The smaller but branching processes of the cyton are called the **dendrites** (GK dendros = tree). The cell bounded by plasma membrane, possesses a nucleus and other organelles like mitochondria etc.

The cyton also contains dark granules called Nissel bodies. These are made of RNA and Protein.

**Transmission of nerve impulse** – The branching dendrites receive the stimulus and transmit through the cyton to the axon, which finally transmits it through its variously branched end into either a muscle (to order it to contract) or to a gland (to order it to secrete). The axon constitutes the nerve fibre. The nerve fibre may or may not be covered by an extra sheath called **medullary sheath** secreted by sheath cells. It is made of **myelin** a lipid like substance. Accordingly, the nerve fibre is termed **medullated** and **non-medullated**. The medullary sheath is not continuous and is broken at **nodes of Ranvier** (Fig. 5.10).



**INTEXT QUESTIONS 5.5**

1. What is the function of the nervous tissue?  
.....
2. What is the direction of the “flow of impulse” within a nerve cell from its dendrites to its axon end or from its axon end toward its dendrites?  
.....
3. What are the following parts in a nerve cell?
  - (i) Cyton .....
  - (ii) Dendrite .....
  - (iii) Axon .....
  - (iv) Medullary sheath .....
  - (v) Node of Ranvier .....

**5.4 LEVELS OF ORGANISATION – CELL TO ORGANISM**

We started the lesson by talking about the smallest unit of life in any living organism i.e. the cell. The cell has a very complex system of its organelles, each organelle concerned with a particular task or activity, and each activity contributing to the total performance of the cell. Thus there is a division of labour at the cellular level. As evolution progressed and larger and larger organism appeared with enormous number of cells in the body, it became necessary that the bodily functions are distributed among different groups of cells or tissues even among groups of tissues. Such higher and higher stages or grouping are known the levels of organization. These levels are as follows:





**Notes**

- (i) **Cellular Level of Organization**– The organization of the activities by different organelles in a single cell. Example, white blood cell or a green cell of a leaf.
- (ii) **Tissue Level**– The aggregates of cells of same origin and having same function, example, the surface epithelium of our skin or the dividing cells at the root cap of a plant.
- (iii) **Tissue System**– Generally seen in plants where two or more different cell types combine to perform a particular activity. Example – Vascular tissue (veins, etc.) of a leaf, consisting of xylem and phloem, for transport of water and food materials.
- (iv) **Organ Level**– A distinct recognizable part of the body, composed of a variety of tissues and performing one or more special functions which contribute to the well being of the organism. Example : Liver in animals and leaf in plants.
- (v) **Organ System**- Combination of a set of organs all of which are usually devoted to one general function. Example : respiratory system (consisting of lungs, trachea, diaphragm, etc. ) in man or the shoot system (consisting of leaves, stem and branches, etc.) in a plant.
- (vi) **Organism**– The complete individual made of different organ system. Examples: man, monkey, or a mustard plant.



**INTEXT QUESTIONS 5.6**

- Rearrange the following levels of organizations in their correct sequences:- tissue, cell, organ, organism, organ system.  
.....
- Complete the following table by giving one example of each of the following in an animal and plant.

Level of Organisation	Examples	
	Animal	Plant
Cell	.....	.....
Tissue	.....	.....
Organ	.....	.....
Organ-system	.....	.....
Organism	.....	.....



**WHAT YOU HAVE LEARNT**

- A tissue is a group of cells which are essentially of the same kind and of same origin and performing similarly function.



## Notes

- In plants there are, first of all two major categories of tissues- meristematic (dividing and undifferentiated) and permanent (specialized) tissues.
- Meristematic tissue is located at all growth points.
- Permanent tissue consists of the simple tissue (parenchyma, collenchyma and sclerenchyma) and complex tissue (xylem and phloem).
- The animal tissues consist of epithelium (closely packed cells usually on surfaces,) connective tissue which primarily support, connect or bind the body parts to together (bones blood etc.), the contractile muscular tissue (different muscles,) and nervous tissue consisting of nerve cells adapted for conducting message (brain cells, etc.)
- The various tissues in both plants and animals are grouped together to form an organ. The different organs together form the organ system and the various organs systems together constitute the organism or the individual. Thus there are different levels of organization with increasing complexity and specialization from cell to organism.



## TERMINAL EXERCISES

1. What is a tissue?
2. State one main structural characteristic and the special activity of the following tissue:  
meristem, sclerenchyma, xylem, phloem, epithelium, muscle, nervous tissue.
3. In what way do the following tissues differ from the one stated:-
  - (i) Connective tissue from epithelial tissue
  - (ii) Bone from blood
  - (iii) Phloem from xylem
  - (iv) Squamous epithelium from columnar epithelium
  - (v) Tracheids from wood fibres
4. Name the different levels of organizations in animals (such as humans) giving one example of each.



## ANSWER TO INTEXT QUESTIONS

- 5.1
1. a group of cells with similar origin, structure and function
  2.
    - (i) Meristematic;
    - (ii) Lateral meristem
    - (iii) Simple
    - (iv) Permanent
  3. arising from same embryonic layer of cells



Notes

4. histology
5. composed of more than one type all cooperating in performing common function

5.2	1.	S.No.	Tissue	Characteristics	Example of location
	1.	1.	Parenchyma	1. Round cells 2. Living	1. Root, stem and leaves
	2.	2.	Collenchyma	1. Polygonal cells with thickening at corners 2. Living	1. Mid rib of leaves
	3.	3.	Sclerenchyma	1. Elongated or irregular in shape 2. Dead and thick walled	1. Stem

2. xylem, phloem

5.3 1. Epithelial, connective, muscular, nervous

2. a-iv, b-i, c-ii, e-iii

5.4	1.	Fibroblasts	-	areolar
		Macrophages	-	areolar
		Mast cells	-	areolar
		Cartilage cells/chondrocyte	-	chondrocyte-cartilage
		Bone cells/osteocyte	-	bone
		Blood cells/WBC RBC	-	blood

2. a (v); (b) (ii); c (iv); d (i); e. (iii)

5.5 1. sensory

2. Dendrite to the axon

3. (i) cell-body (ii) thin processes of cyton (iii) sensory fibre (iv) medullary layer (v) interruptions in medullary sheath

5.6 1. Cell, tissue, organ, organ system, organism

2. refer to text subsection 5.4