2

TISSUES

INTRODUCTION

In the unicellular organisms all the life processes are carried out by the single cell. But in multicellular organisms different groups of cells perform different functions. Thus there is division of labour. Groups of cells having a common origin and performing similar functions are called **tissues**.

The microscopic study of tissue structure is called **histology**. Knowledge of tissue structure and function is important in understanding how individual cells are organized to form tissue and how tissues are organized to form organs, organ systems, and the complete organism. There is a relationship between the tissues in an organ and the organ's function.

As plants are fixed or stationary, most of their tissues are of supportive type. Animals move around in search of food, mate & shelter so they consume more energy as compared to plants.

Plant tissues are basically of two types : (1) Meristematic tissues and (2) Permanent tissues

While animal tissues are four types : (1) Epithelial (2) connective (3) Muscular and (4) Nervous

PLANT TISSUES

If you were to design your dream house, what would be the critical considerations? You would need to include not only the materials that make up the building as well as consider energy sources/ thermal regulation, security, size, light absorption, waste disposal and many more.

Plants also need to consider the same factors before they 'build' their bodily structure.

Tissue type	Functional roles
Meristematic	division of new cells for new growth or repair
Ground tissue	bulk tissue; storage, processing, physical support
Dermal tissue	protection and sometimes nutrient absorption
Vascular tissue	movement of fluids/food and physical support

General classification of Plant Tissues :

Plant Tissue
- **Meristematic**
  - Apical
  - Lateral
  - Intercalary
- **Permanent**
  - Simple - Dermal (Epidermis)
    - Ground
      - Parenchyma
      - Collenchyma
      - Sclerenchyma
  - Complex-(Vascular)
    - **Phloem**
      1. Sieve tube
      2. Companion cell
    - **Xylem**
      1. Xylem vessels
      2. Tracheids

Similar to the other organs of a plant, a leaf is comprised of three basic tissue systems, including the dermal, vascular, and ground tissue systems. These three motifs are continuous throughout an entire plant, but their properties vary significantly based upon the organ type in which they are located. All three tissue systems are illustrated in Figure, which is a cutaway drawing of a typical leaf.

KEY POINT **Leaves contain all three tissue systems found in plants: the dermal tissue system, represented by the upper and lower epidermis; the ground tissue system, represented by the mesophyll; and the vascular tissue system, represented by the xylem and phloem in the veins.**

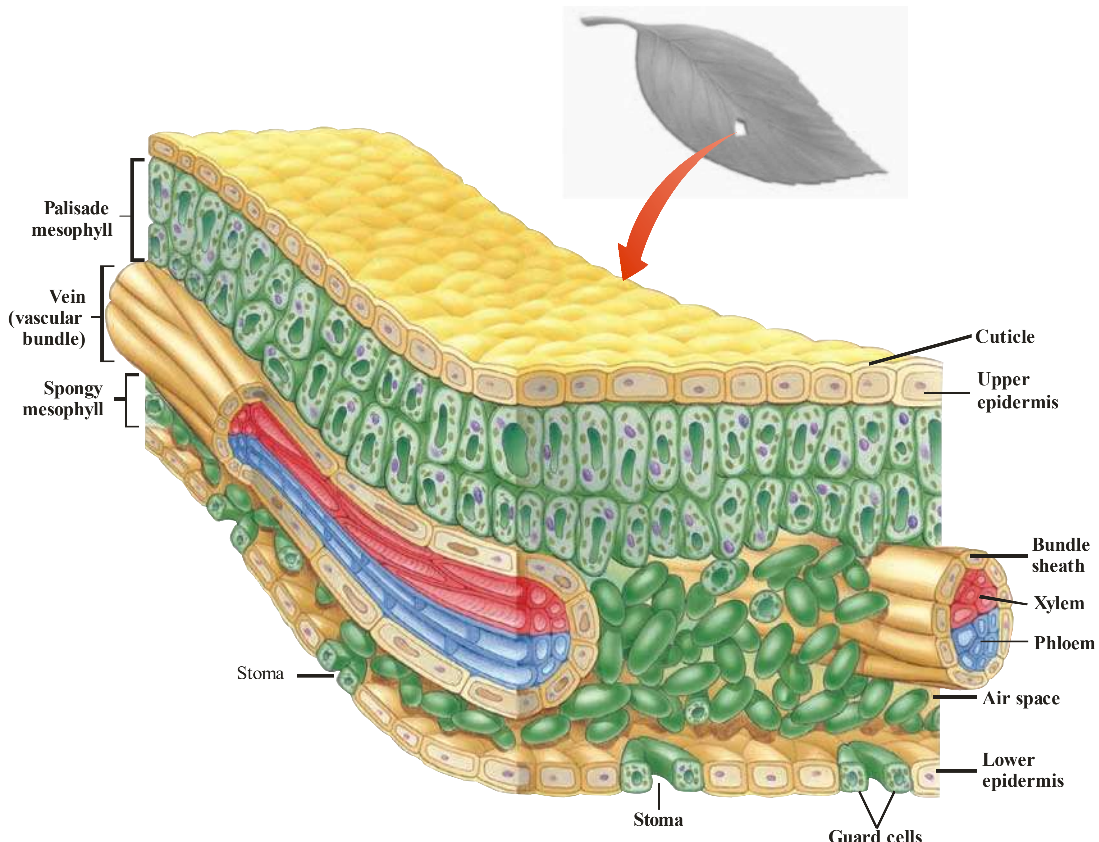


Figure : Tissues in a typical leaf blade

An upper epidermis and lower epidermis cover the blade. The photosynthetic ground tissue, called mesophyll, is often arranged into palisade and spongy layers. Veins branch throughout the mesophyll.

Meristematic tissue :

It adds new cells and enables a plant to grow and specialize. Dermal tissue covers and protects the plant, thus controlling gas exchange between the plant and the environment. Ground tissue makes up the bulk of the plant and stores nutrients or photosynthesizes. Vascular tissues, including xylem and phloem, conduct water and dissolved nutrients, respectively.

The primary body of a flowering plant is an axis consisting of a root (usually belowground) and a shoot (aboveground). The extensive shoot and root systems of many plants increase the surface area available for the chemical reactions of life. Shoots and roots support one another. Shoots, through photosynthesis, provide carbohydrates to the roots below. Roots gather water and minerals and transport them to the shoots.

Unlike an animal, which grows explosively very early in its development, a plant has parts-roots, shoots, and buds-that enable it to grow rapidly during what may be a very long life time. Meristems may be thought of as embryonic tissue that persists throughout the life of the plant.

Meristems are localized regions that undergo cell division and are the ultimate source of all the cells of a plant.

Some cell types descended from meristems can themselves divide. The cells farthest from meristems are the most mature and differentiated, and they may be many times larger than the meristematic cells that gave rise to them. Meristems function throughout a plant's life, because of them, plants never stop growing.

Apical meristems occur near the tips of roots and shoots in all plants. Cells in these regions are small and unspecialized. When these meristematic cells divide, the plant lengthens in what is called primary growth. Apical meristems produce three primary meristems, which form the other three primary tissues-ground, dermal, and vascular tissues.

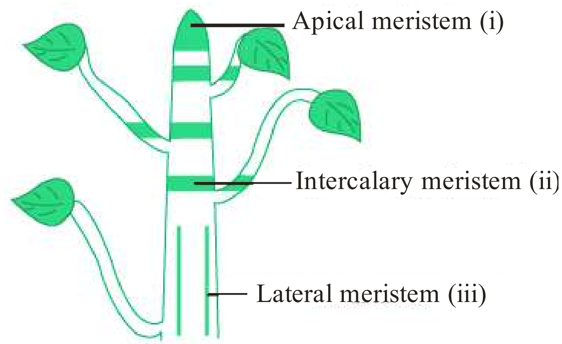


Figure : Various Meristamatic Tissue

Lateral meristems grow outward, thickening the plant, in a process called secondary growth. Wood forms from secondary growth. Unlike primary growth, secondary growth does not occur in all flowering plants.

Intercalary meristem is the meristem at the base of the leaves or internodes (on either side of the node) on twigs. Intercalary meristem is an unusual type of dividing tissue found in grass blades. If the tip of a stem or leaf is torn off by a lawn mower, for example-intercalary meristems re-form the structure of the plant from that point up. This is why grass blades grow back so quickly after a lawn is mowed. Intercalary meristems enable grasses to survive the constant munching of herbivores.

The **vascular cambium** is a layer of meristematic cells that forms a long, thin, continuous cylinder within the stem and root. It is located between the wood and bark of a woody plant. Division of cells of the vascular cambium adds more cells to the wood (secondary xylem) and inner bark (secondary phloem).

The **cork cambium**, located in the outer bark, is composed of a thin cylinder or irregular arrangement of meristematic cells. Cells of the cork cambium divide and form cork cells toward the outside and one or more underlying layers of cork parenchyma cells that function in storage. Collectively, cork cells, cork cambium, and cork parenchyma make up the periderm.

Summarizes Meristem Types

Type	Function
Apical meristem	Growth at root and shoot tips.
Lateral meristem	Growth outward, thickening plant
Intercalary meristem	In grass stems, allows rapid regrowth

PERMANENT TISSUE

The permanent tissues are composed of those cells which have lost their capability to divide. They have definite shape, size and thickness. The permanent cells may be dead or living.

The division & differentiation of the cells of meristematic tissues give rise to permanent tissues in cell differentiation developing tissues and organs change from simple to more complex forms to become specialized for specific functions. The cells of permanent tissue lose the capacity to divide and attain a permanent shape, size and function.

Permanent tissue can be divided into two parts simple permanent and complex permanent (vascular) further simple permanent is divided into two parts supporting (ground) and protective (epidermis).

Ground Tissue :

Ground tissue makes up most of the primary body of a flowering plant, filling much of the interior of roots, stems, and leaves. These cells have many function, including storage, support, and basic metabolism. Ground tissue consists of three cell types : parenchyma, collenchyma, and sclerenchyma.

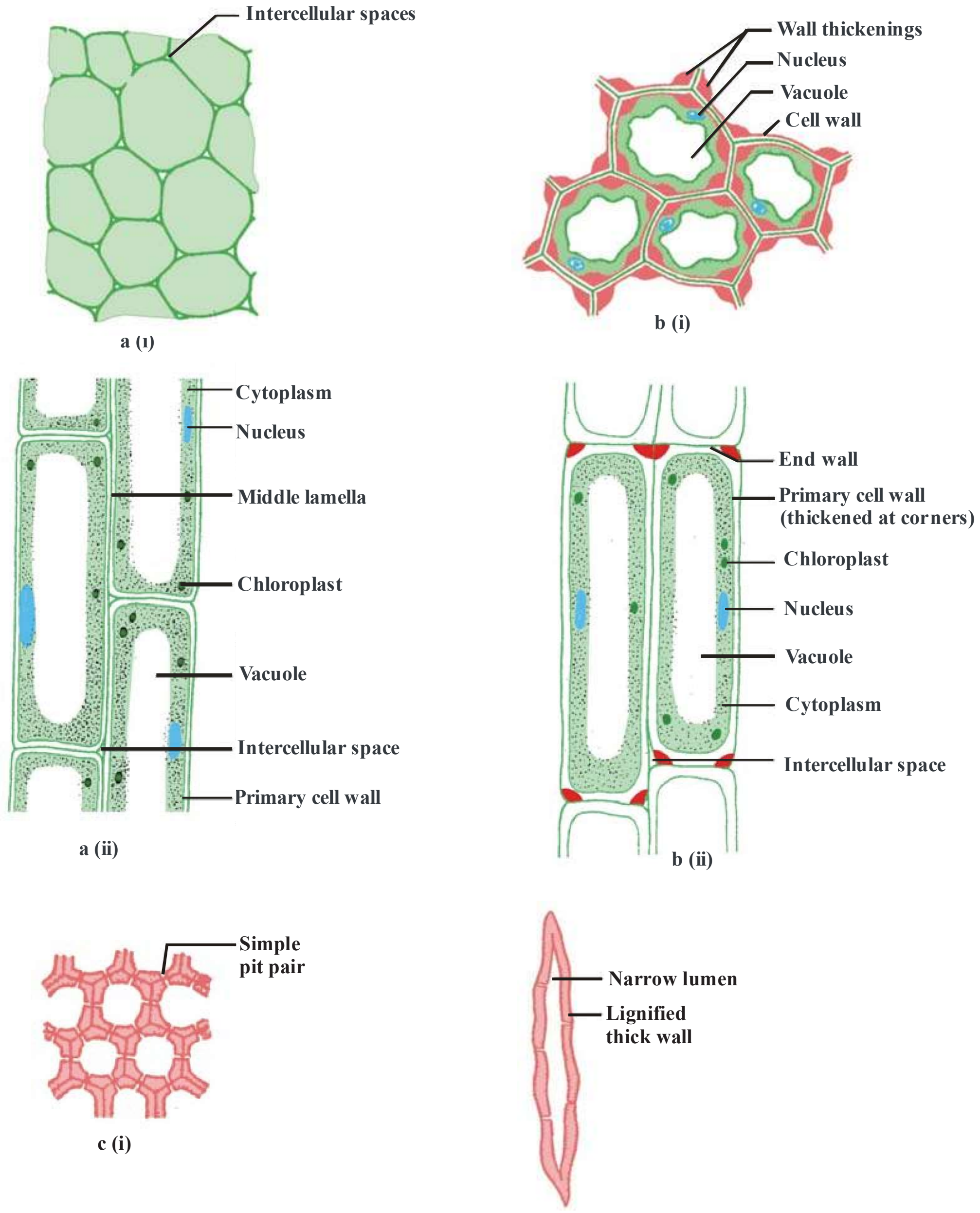


Figure :
Various types of simple tissues: (a) Parenchyma (i) transverse section, (ii) longitudinal section; (b) Collenchyma (i) transverse section, (ii) longitudinal section; (c) Sclerenchyma (i) transverse section, (ii) longitudinal section.

Parenchyma cells are the most abundant plant cells. They keep the plant erect when it is filled with water. Parenchyma cells are relatively unspecialized and in an evolutionary sense likely gave rise to more specialized cell types. Mature parenchyma cells are alive and can divide which enables the tissue to specialize in response to a changing situation. For example, parenchyma cells can help a plant survive injury or adapt to a new environmental condition. These cells can also return to an unspecialized state.
Parenchyma cells store the biochemicals that give plants their familiar edible parts, such as the carbohydrates in a potato or an ear of corn. These cells also store fragrant oils, salts, pigments, and organic acids. Parenchyma cells of oranges and lemons, for example, store citric acid, which gives them their tart taste. These cells also conduct vital function, such as photosynthesis, cellular respiration, and protein synthesis.

Collenchyma cells form strands or continuous cylinders beneath the epidermis of stems or leaf stalks and along veins in leaves. Their distinguishing feature is their unevenly thickened primary walls. Collenchyma cells are usually elongated and alive at maturity. Strands of collenchyma provide much of the support for stems in which secondary growth has not taken place. The part of celery that we eat is the petiole, or leaf stalk, and the "strings" in celery consist mainly of collenchyma. Collenchyma supports without interfering with growth of young stems or expanding leaves.
The collenchyma is the typical supporting tissue of the primary plant body and growing plant parts, though it is kept with unaltered structure and function even in outgrown organs like stems, petioles, laminae or roots. In cross-sections of stems, the collenchyma commonly appears as discrete strands or as a peripheral cylinder that lies, depending on the species, either directly beneath the epidermis or is separated from it by several layers of parenchyma. The cylinder is usually composed of several layers. Collenchyma is also found bordering the veins of dicot leaves. It forms fibres in edgy stems that run along the edges or ribs. Often either phloem or xylem of the vascular bundles is associated with collenchyma cells.

Sclerenchyma : The husk of a coconut is made of sclerenchymatous tissue.
Sclerenchyma cells have tough, thick secondary walls; they may lack living protoplasts when they are mature. Their secondary cell walls are often impregnated with lignin, a highly-branched macromolecule that makes the walls in which it is deposited more rigid. Cell walls containing lignin are said to be lignified. Lignin is common in walls of plant cells that have a supporting or mechanical function. Some kinds of cells have lignin deposited in primary as well as secondary walls. These cells support parts of plants that are no longer growing and are usually dead at maturity.
Two types of sclerenchyma: fibers, which are long, slender cells that usually form strands, and sclereids, which are variable in shape but often branched. Both of these tough, thick-walled cell types serve to strengthen the tissues in which they occur. For example, linen is woven from strands of sclerenchyma fibers that occur in association with the phloem of flax.
Sclereids, on the other hand, may occur singly or in groups; they are not elongate, but may have various forms, including star shaped. The gritty texture of pears is caused by groups of sclereids that occur among the soft flesh of the fruit.

Dermal Tissue :

Dermal tissue covers the plant. The epidermis, usually only one cell thick, covers the primary plant body. Epidermal cells are flat, transparent, and tightly packed. Special features of the epidermis provide a variety of functions.
The cuticle is a covering over all but the roots of a plant that protects the plant and conserves water. The cuticle consists primarily of cutin, a fatty material epidermal cells produce.
This covering retains water and prevents desiccation as a result, plants can maintain a watery internal environment–a prerequisite to survival on dry land.

The cuticle and underlying epidermal layer also are a first line of defense against predators and infectious agents. In many plants, a smooth white layer of wax covers the cuticle; when it is thick, it is visible on leaves and fruits. The layer on the undersides of wax palm leaves may be more than 5 millimeters thick. It is harvested and used to manufacture polishes and lipstick.

Since an impermeable cuticle covers the tightly packed epidermal cells, how do plants exchange water and gases with the atmosphere ? **Stomata** are pores that solve this problem **Guard cells** control the opening and closing of the pores, which regulate gas and water exchange.

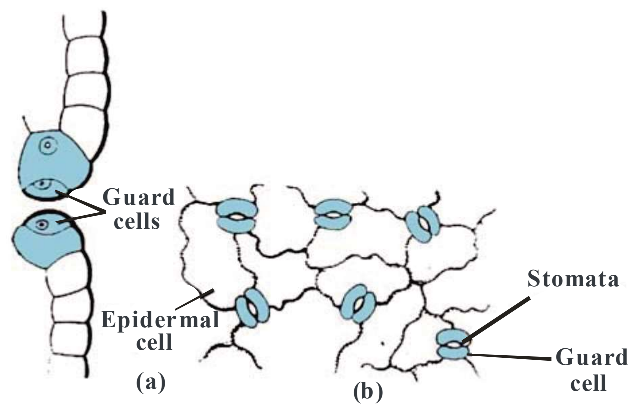


Figure : Guard cells and epidermal cells: (a) lateral view, (b) surface view

Stomata control the amount of carbon dioxide that diffuses into a leaf for photosynthesis and the amount of water that evaporates from leaves, a process called transpiration. Stomata may be very numerous. The underside of a black oak leaf, for example, has 100,000 or so stomata per square centimeter! Because stomata help plants conserve water, they are an essential adaptation for life on land.

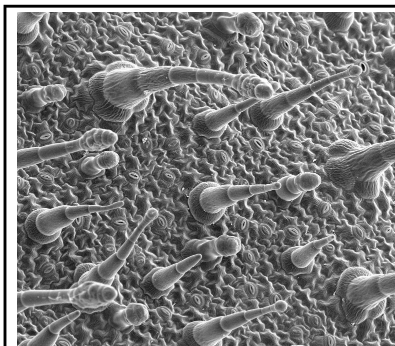


Figure : Trichomes

Trichomes are outgrowths of epidermal cells in almost all plants, These structures deter predators in interesting ways. Hookshaped trichomes may impale marauding animals. In other plants, predators may inadvertently break off the tips of trichomes, releasing a sticky substance that traps the invading animal. Stinging nettle trichomes have spherical tips that break off and penetrate a predator's body, injecting their poisonous contents into the wounds. Trichomes of carnivorous plants such as the Venus's flytrap secrete enzymes to digest trapped animals.

These trichomes then absorb the digested prey. Many trichomes are economically important. Cotton fibers, for example, are trichomes from the epidermis of cotton seeds. Menthol comes from peppermint trichomes, and hashish, a powerful narcotic, is purified resin from Cannabis trichomes.

Vascular Tissues (Complex Tissues)

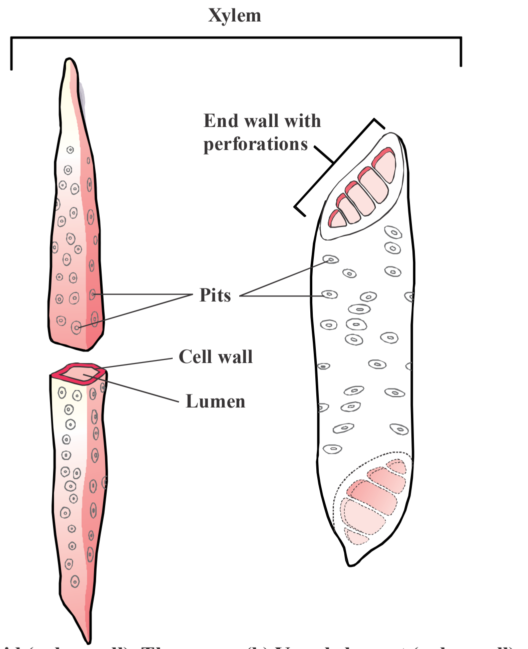
Vascular tissues are specialized conducting tissues that form the veins in leaves. The two types of plant vascular tissues, xylem and phloem, each form during both primary and secondary growth.

Vascular tissue evolved as an adaptation to increasing plant size and to existence on land, an event that occurred about 400 million years ago. In the unicellular algae that were the probable ancestors of plants, diffusion was sufficient to transport materials in and out of the cell. Dissolved nutrients could easily enter from the aquatic environment, and wastes leave. Multicellular life particularly one dry land, requires a more elaborate transport system plus ways to replace the tremendous amounts of water lost through transpiration.

A plant's epidermis and stomata are adaptations to conserve water; vascular tissue is an adaptation to transport water and dissolved nutrients. Water is vital to the plant for several reasons: to synthesize biochemicals; as a solvent for nutrients; and to create turgor pressure, which physically supports the plant body.
Leaves have many spaces that provide a tremendous surface area from which water evaporates. A corn plant, for example, loses approximately 110 gallons (500 liters) of water to transpiration in its 4-month growing season. Veins carrying vascular tissues permeate leaves and distribute water to these surfaces.

Xylem :

Xylem, the principal water-conducting tissue of plants, consists of dead, hollow, tubular cells arranged end to end. It supplies support as well as provides for the conduction of water and dissolved minerals throughout the plant body. Within the xylem, water passes from the roots up through the shoot in an unbroken stream. Dissolved minerals, inorganic ions such as nitrates and phosphates, are taken up through the roots in the water stream. When the water reaches the leaves, it passes into the air as water vapor, mainly through the stomata. Primary xylem is derived from procambium, which in turn comes from the apical meristem. Secondary xylem is formed by vascular cambium, a lateral meristem that develops later. Wood consists of accumulated secondary xylem.
The two principal types of conducting elements in the xylem are tracheids and vessel elements. Both of these cell types resemble fibers. They are elongate with thick, lignified secondary walls, and have no living protoplasts at maturity. The continuous stream of water in a plant flows from tracheid to tracheid through small, thin openings called pits in their secondary walls.



(a) Tracheid (xylem cell). The tracheid is opened to reveal the cell's appearance in cross section. At maturity, tracheids are usually dead.

(b) Vessel element (xylem cell). The end walls of vessel elements are perforated. Vessel elements are joined end to end, from roots to leaves and other shoot parts.

The pits occur in pairs, separated from one another by the common primary walls of the tracheids. In contrast to tracheids, which have only pit-pairs in their common walls, vessel elements are joined end on end by perforations in their end walls. Such a vertical series row of vessel elements is called a vessel.
The greater width of vessel elements and the fact that water can pass directly from one cell to another accounts for its more efficient water conduction.

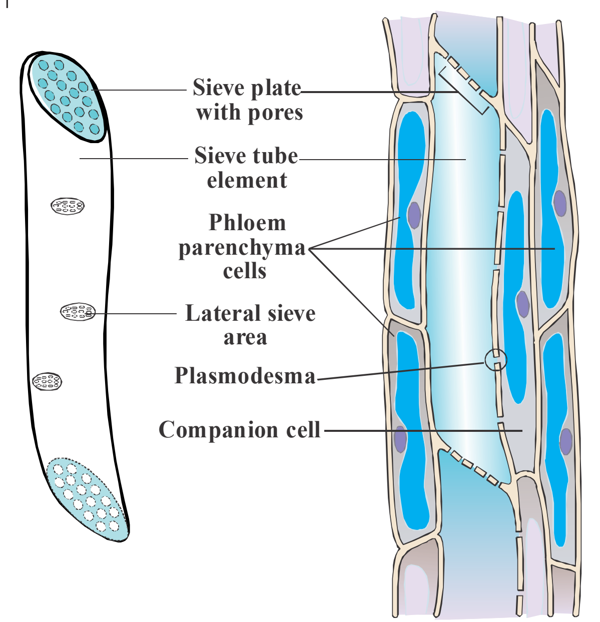
Phloem :

Phloem transports primarily dissolved carbohydrates throughout a plant. In some plants phloem is so sugary that it forms a thick sap. Phloem also transports hormones, alkaloids, viruses, and inorganic ions. Unlike xylem, which transports water upward under negative pressure, like a drinking straw, phloem transports substances under positive pressure, which is like water flowing through a hose when the spigot is turned on.
Thus, water and dissolved sugars can move through phloem in all directions. Also, the conducting cells of phloem, unlike those of xylem, are alive at maturity.
Their cell walls have thin areas perforated by many sieve pores, and solutes move through these pores from cell to cell.
Phloem has two kinds of conducting cells: sieve cells and sieve tube members. Sieve cells are the more primitive (that is, less specialized) conducting cells.

They are elongated with tapered, overlapping ends. Sieve pores permeate all sieve cell walls. Sieve tube members are more complex, shorter, and winder than sieve cells, and they lie end to end, forming long sieve tubes.

The pores of individual cells cluster on contacting end walls and form an area called a sieve plate. This organization allows faster, more efficient nutrient transport. Mature sieve tube members lack nuclei but contain living protoplasm–a unique feature among plant cells. Near sieve tube members are companion cells, which help transfer carbohydrates into and out of the sieve tube members. Companion cells move sugars and amino acids into and out of the sieve elements. In "source" tissue, such as a leaf, the companion cells use transmembrane proteins to take up - by active transport - sugars and amino acids from the cells manufacturing them. Water follows by osmosis.

Phloem



(a) Sieve tube element, showing the sieve plate. Sieve tube elements are joined end to end to form sieve tubes.

(b) Longitudinal section of phloem tissue. Sieve tube elements, companion cells, and phloem parenchyma cells. Fiber cells are not shown.

These materials then move into adjacent sieve elements by diffusion through plasmodesmata. The pressure created by osmosis drives the flow of materials through the sieve tubes.

In "sink" tissue, the sugars and amino acids leave the sieve tubes by diffusion through plasmodesmata connecting the sieve elements to the cells of their destination. Again, water follows by osmosis where it may leave the plant by transpiration or increase the volume of the cells or move into the xylem for recycling through the plant.

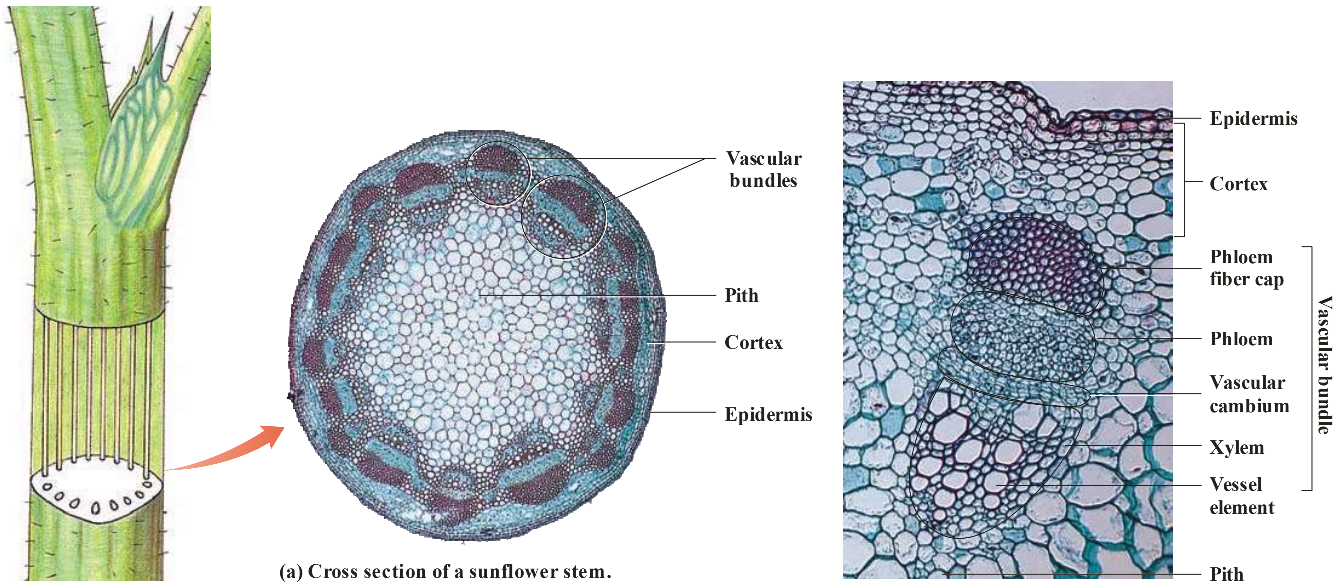
Major Plant Cell Types

Cell	Tissue Type	Function
Parenchyma	Ground	Storage, division, metabolism
Collenchyma	Ground	Support
Sclerenchyma	Ground	Support
Tracheids	Vascular (xylem)	Water transport
Vessel elements	Vascular (xylem)	Water transport
Sieve cells	Vascular (phloem)	Water and nutrient transport
Sieve tube	Vascular (phloem)	Water and nutrient transport

STEM GROWTH AND STRUCTURE

All plants have primary growth; some plants have both primary and secondary growth. Stems with only primary growth are herbaceous, whereas those with both primary and secondary growth are generally woody. (Certain herbaceous stems, such as geranium and sunflower, also have a limited amount of secondary growth.)

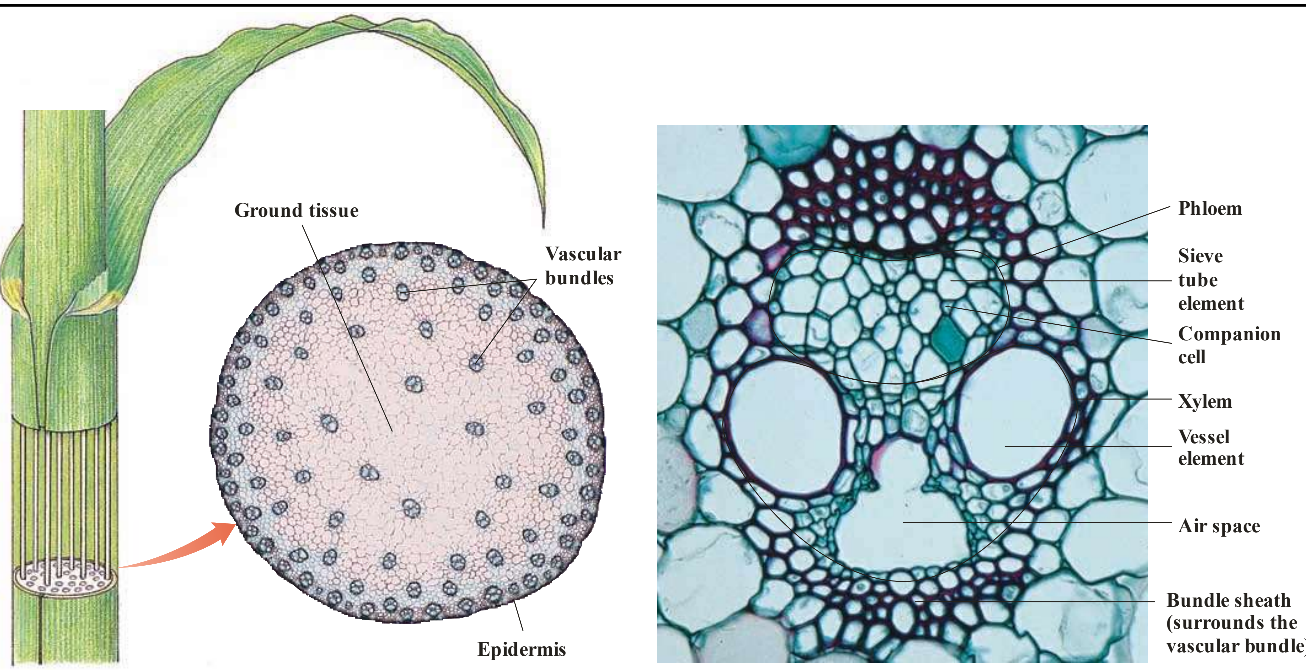
A woody plant increases in length by primary growth at the tips of its stems and roots, whereas its older stems and roots farther back from the tips increase in girth by secondary growth. In other words, at the same time that primary growth is increasing the length of the stem, secondary growth is adding wood and bark, thereby causing the stem to thicken.



(a) Cross section of a sunflower stem. Note the vascular bundles arranged in a circle around a central core of pith.

(b) Close-up of a vascular bundle. In each bundle, xylem is located toward the stem's interior, and phloem toward the exterior. Each vascular bundle is "capped" by a batch of fibers for additional support.

Figure : Cross section of a sunflower stem.



(a) Cross section of a corn stem shows vascular bundles scattered throughout ground tissue.

(b) Close-up of a vascular bundle. The air space is the site where the first xylem elements were formed and later disintegrated. The entire bundle is enclosed in a bundle sheath of sclerenchyma for additional support.

Figure : Cross Section of a Corn Stem

ANIMAL TISSUE

In complex animals, tissues build organs, and organs connect and function coordinately, forming organ systems. A human body consists of about 200 different types of specialized cells that form four basic tissue types :

* **Epithelial tissue** covers and lines organs.
* **Connective tissue** provides support and other functions.
* **Nervous tissue** forms rapid communication networks between cells.
* **Muscular tissue** contracts, powering the movements of life.

Epithelial Tissue

Epithelium or epithelial tissue, is found throughout the body where it covers internal and external surfaces. It also forms most glands. Surfaces of the body include the skin on the outside of the body and the lining of cavities such as the digestive tract, respiratory passages, and blood vessels. Epithelium consists almost entirely of cells with very little extracellular matrix between them. Although there are same exceptions, most epithelia have a free surface, composed of a layer of epithelial cells with one surface which is not in contact with other cells, and a basement membrane, which attaches the epithelial cells to underlying tissues. The basement membrane is made up of carbohydrates and proteins that are secreted by epithelial cells and cells of the underlying tissue. Blood vessels do not extend from the underlying tissues into epithelium, so gases and nutrients that reach the epithelium must diffuse across the basement membrane from the underlying tissues, where blood vessels are abundant. Waste products produced by the epithelial cells diffuse across the basement membrane to blood vessels.

Functions of Epithelia : The major functions of epithelia include :

1. Protecting underlying structures. Examples include the skin and the epithelium of the oral cavity, which protect the underlying structures from abrasion.
2. Acting as barriers. Epithelium prevents the movement of many substances through the epithelial layer. For example, the skin acts as a barrier to water and prevents water loss from the body. The skin is also a barrier that prevents the entry of many toxic molecules and microorganisms into the body.
3. Permitting the passage of substances. Epithelium allows the movements of many substances through the epithelial layer. For example, oxygen and carbon dioxide are exchanged between the air and blood by diffusion through the epithelium in the lungs.
4. Secreting substances. Examples include the sweat glands, mucous glands, and the enzyme-secreting portion of the pancreas.
5. Absorbing substances. The cell membranes of certain epithelial tissues contain carrier molecules that regulate the absorption of materials. For example, the epithelial cells of the intestine absorb digested food molecules, vitamins, and ions.

Classification of Epithelia :

Epithelia are classified according to the number of cell layers and the shape of the cells. Simple epithelium consists of a single layer of cells. Stratified epithelium consists of more than one layer of epithelial cells, with some cells sitting on top of other cells. Categories of epithelium based on cell shape are squamous (flat), cuboidal (cubelike), and columnar (tall and thin). In most cases, each epithelium is given two names. Examples include simple squamous, simple columnar, and stratified squamous epithelia. When epithelium is stratified, it is named according to the shape of the cells at the free surface.

Simple squamous epithelium is a single layer of thin, flat cells. Because substances easily pass through this thin layer of tissue, it is often found where diffusion or filtration take place. For example, the respiratory passages and as small sacs called alveoli. The alveoli consist of simple squamous epithelium that allows oxygen from the air to diffuse into the body and carbon dioxide to diffuse out of the body into the air. Simple squamous epithelial tissue in the filtration membranes of the kidneys forms thin barriers through which small molecules, but not large ones, can pass.

Small molecules and water from blood are filtered through these barriers as a major step in urine formation. Large molecules, such as proteins and blood cells, remain in the blood vessels of the kidneys.

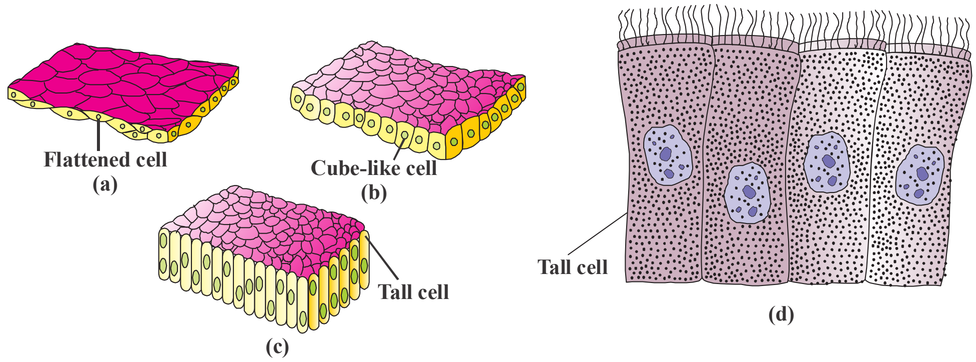


Figure : Simple Epithelium : (a) Squamous (b) Cuboidal (c) Columnar (d) Columnar cells bearing cilia.

Simple cuboidal epithelium is a single layer of cubelike cells. These cells have a greater volume than simple squamous epithelial cells and contain more cell organelles. The organelles of simple cuboidal cells that actively transport molecules into and out of the cells include mitochondria, which produce energy and organelles needed to synthesize the transport proteins. Transport of molecules across a layer of simple cuboidal epithelium can also be regulated by the amount of energy produced or by the type of transport molecules synthesized. The many kidney tubules, all having large portions of their wall composed of simple cuboidal epithelium.

Simple columnar epithelium is a single layer of tall, thin cells. These large cells contain organelles that enable them to perform complex function. For example, the simple columnar epithelium of the small intestine produces and releases digestive enzymes that complete the process of digesting food. The columnar cells then absorb the digested foods by active transport, facilitated diffusion, or simple diffusion. Stratified squamous epithelium forms a thick epithelium because it consists of many layers of cells.

One type of stratified squamous epithelium forms the outer layer of the skin and is called keratinized stratified squamous epithelium. The outer layers consist of dead stratified epithelial cells tightly bound to one another. They provide protection against abrasion, form a barrier that prevents microorganisms and toxic chemicals from entering the body, and prevent the loss of water from the body. In contrast, stratified squamous epithelium of the mouth is composed of living cells with a moist surface. It also provides protection against abrasion and acts as a mechanical barrier, preventing the entry of microorganisms into the body. Water, however, can move a cross it more readily than across the skin.

Transitional epithelium is a special types of stratified epithelium that can be greatly stretched

Transitional epithelium is found lining cavities that can expand greatly, such as the urinary bladder. It also protects underlying structures from the caustic effects of urine.

Classification of Epithelia

Number of layers	Cell shape
Simple (one layer)	Squamous
	Cuboidal
	Columnar
Pseudostratified (a modified form of simple epithelium)	Columnar
Stratified (more than one layer)	Squamous
	Moist
	Keratinized
Transitional (a type of stratified epithelium)	Roughly cubodial or many-surfaces

Connective Tissues :

Connective tissues are derived from embryonic mesoderm and occur in many different forms. These various forms are divided into two major classes: connective tissue proper, which is further divided into **loose and dense connective tissues**; and special connective tissues such as **cartilage, bone, and blood**. At first glance, it may seem odd that such diverse tissues are placed in the same category. Yet all connective tissues do share a common structural feature: they all have abundant extracellular material because their cells are spaced widely apart. This extracellular material is generically known as the matrix of the tissue. In bone, the extracellular matrix contains crystals that make the bones hard; in blood, the extracellular matrix is the fluid portion of the blood.

Connective tissue cells are named according to their functions. **Blast cells** produce the matrix, cyte cells maintain it, and clast cells break it down for remodeling. For example, osteoblasts (osteo means bone) form bone, osteocytes maintain bone, and osteoclasts break down bone. Cells associated with the immune system are also found in connective tissue. Macrophages are large cells that are capable of moving about and ingesting foreign substances, including microorganisms that are found in the connective tissue. Mast cells are nonmotile cells that release chemicals that promote inflammation.

A fibroblast is a common type of connective tissue cell. Fibroblasts manufacture two types of protein fibers that become part of the matrix–collagen, a flexible white protein that resists stretching, and elastin, a yellowish protein that stretches readily, like a rubber band. The matrix also includes a thin gel of proteoglycans. which are complex carbohydrates linked to proteins.

The major types of connective tissues in the human body are loose connective tissue (glue of the body) dense connective tissue, adipose tissue, blood, cartilage, and bone. Matrix composition, types of fibers, cell specializations, and the proportion of cells to matrix distinguish each type of connective tissue.

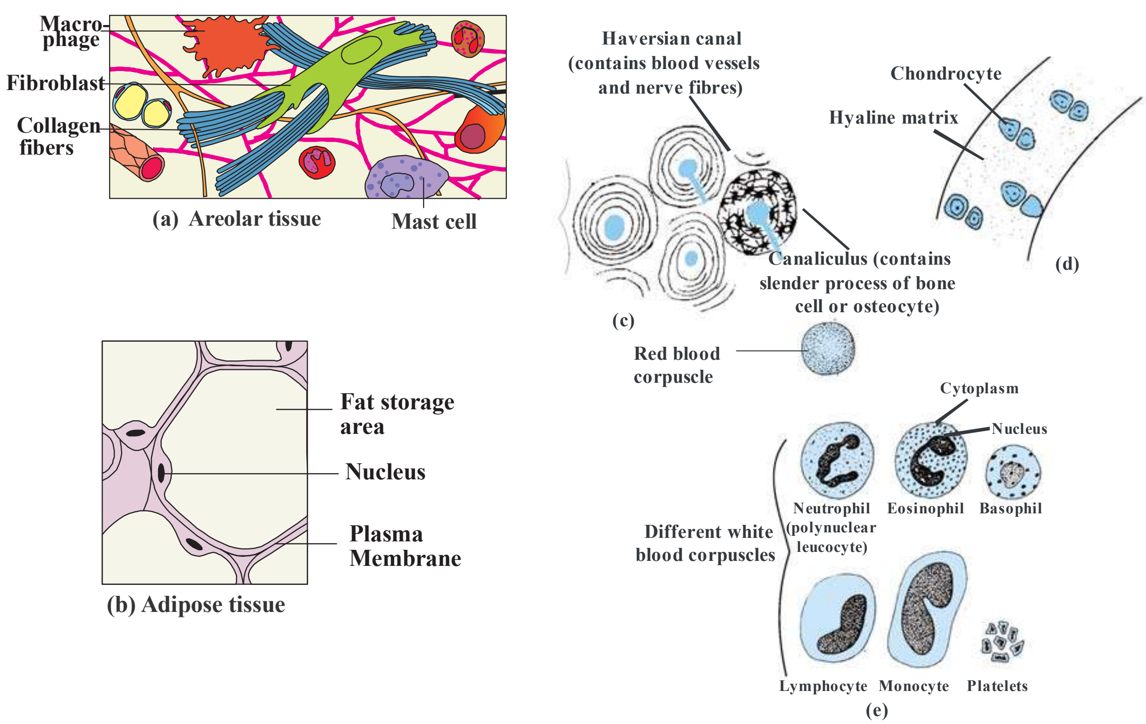


Figure : Types of connective tissues: (a) Areolar tissue, (b) Adipose tissue, (c) Compact bone, (d) Hyaline cartilage, (e) Types of blood cells.

Functions of Connective Tissue :

Connective tissues perform the following major categories of functions :

1. Enclosing and separating. Sheets of connective tissues form capsules around organs such as the live and kidneys. Connective tissue also forms layers that separate tissues and organs. For example, connective tissues separate muscles, arteries, veins, and nerves from one another.
2. Connecting tissues to one another. For example, tendons are strong cables, or bands, of connective tissue that attach muscles to bone, and ligaments are connective tissue bands that hold bones together.
3. Supporting and moving. Bones of the skeletal system provide rigid support for the body, and the semirigid cartilage supports structures such as the nose, ears, and surface of joints. Joints between bones allow one part of the body to move relative to other parts.
4. Storing. Adipose tissues (fat) stores high-energy molecules, and bones store minerals such as calcium and phosphate.
5. Cusbioning and insulating. Adipose tissue (fat).
   Cushions and protects the tissues it surrounds and provides an insulating layer beneath the skin that helps conserve heat.
6. Transporting. Blood transports substances throughout the body, such as gases, nutrients, enzymes, hormones, and cells of the immune system.
7. Protecting. Cells of the immune system and blood provide protection against toxins and tissue injury, as well as from microorganisms. Bones protect underlying structures from injury.

Cartilage : Cartilage cushions organs and forms a structural framework that keeps tubular organs from collapsing, such as in the ear, nose, and respiratory passages. In joints, cartilage can sustain weight while allowing bones to move against one another. Cartilage consists of a single cell type, the chondrocyte. These cells lodge within oblong spaces called lacunae that are embedded in a collagen matrix. Cartilage grows as chondrocytes secrete collagen. Some cartilage also contains elastin. Chondrocytes have large nuclei and extensive endoplasmic reticula, a sign of their high protein secretion.

Hyaline cartilage : Hyaline cartilage is semi-transparent and appears bluish-white in colour. It is extremely strong, but very flexible and elastic. Hyaline cartilage consists of living cells, chondrocytes, which are situated far apart in fluid-filled spaces, the lacunae. There is an extensive amount of rubbery matrix between the cells and the matrix contains a number of collagenous fibres. Hyaline cartilage occurs in trachea, the larynx, the tip of the nose, in the connection between the ribs and the breastbone and also the ends of bone where they form joints. Temporary cartilage in mammalian embryos also consists of hyaline cartilage.

Functions :

- Reduces friction at joints : By virtue of the smooth surface of hyaline cartilage, it provides a sliding area which reduces friction, thus facilitating bone movement.
- Movement : Hyaline cartilage joins bones firmly together in such a way that a certain amount of movement is still possible between them.
- Support : The c-shaped cartilagenous rings in the windpipes (trachea and bronchi) assist in keeping those tubes open.
- Growth : Hyaline cartilage is responsible for the longitudinal growth of bone in the neck regions of the long bones.

White Fibrocartilage : White fibrocartilage is an extremely tough tissue. The orientation of the bundles depends upon the stresses acting on the cartilage. The collagenous bundles take up a direction parallel to the cartilage. Fibrocartilage is found as discs between the vertebrae between the pubic bones in front of the pelvic girdle and around the edges of the articular cavities such as the glenoid cavity in the shoulder joint.

Functions :

- Shock absorbers : The cartilage between the adjacent vertebrae absorbs the shocks that will otherwise damage and jar the bones while we run or walk.
- Provides sturdiness without impeding movement.
The white fibrocartilage forms a firm joint between bones but still allows for a reasonable degree of movement.
- Deepens sockets : In articular cavities (such as the ball-and-socket joints in the hip and shoulder regions) white fibrocartilage deepens the sockets to make dislocation less possible.

Elastic cartilage :

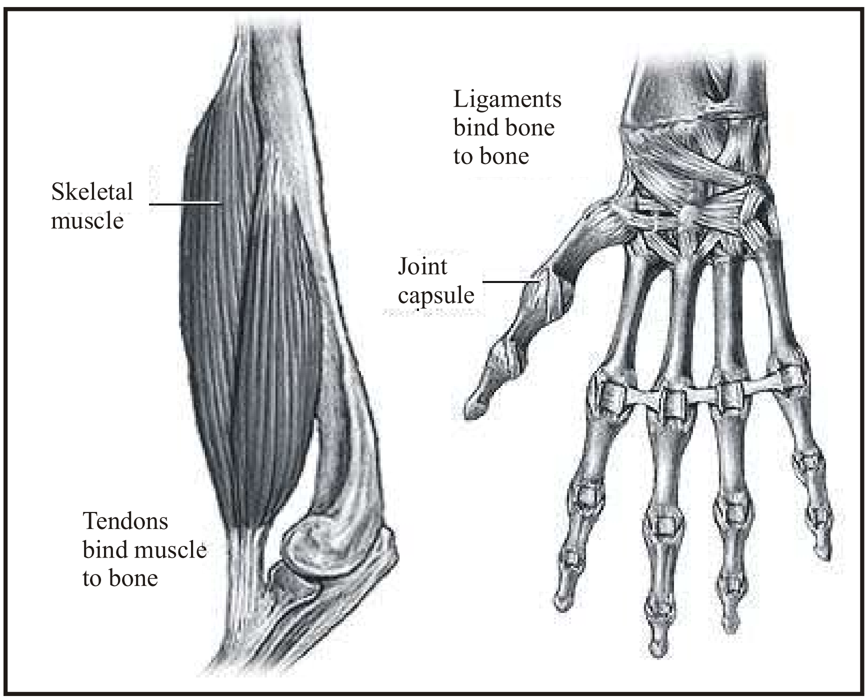
Basically elastic cartilage is similar to hyaline cartilage, but in addition to the collagenous fibres, the matrix of the elastic also contains an abundant network of branched yellow elastic fibres. They run through the matrix in all directions. This type of cartilage is found in the lobe of the ear, the epiglottis and in parts of the larynx.

Functions : Maintain shape : In the ear, for example, elastic cartilage helps to maintain the shape and flexibility of the organ.

- **Support :** Elastic cartilage also strengthens and supports these structures.

Tendon and Ligaments :

Tendons and ligaments are thick network of fibres. The fibres are loose and very elastic in nature. These fibres are secreted by the surrounding connective tissue cells. The tendons are strong and connect the muscle to bone. The ligaments are elastic and connect bone to bone. There are other examples of connective tissue such as areolar tissue, which forms a packing tissue between organs lying in the body cavity.



Differences between Tendon and Ligament

S.N.	Tendons	Ligaments
1.	Inelastic in nature.	Elastic in nature.
2.	Join muscle to bone.	Connect bone to bone.
3.	Made up of white collagen fibres.	Made up of bundles of elastic fibres and few collagen fibres.

Bone :
When cartilage becomes hardened by calcification, the chondrocytes are cut off from their source of oxygen and nutrients and die. The dying and degenerating cartilage is replaced by living bone. This is what happens to the cartilaginous skeleton of a fetus. Bone has a special structure that enables the bone cells, or osteoblasts, to remain alive even though the extracellular matrix becomes hardened with crystals of calcium phosphate. Though bone is the hardest tissue in the body, there are places where it is organized into a delicate latticework.

Blood :
Blood (special connective tissue) is a complex mixture of different cell types suspended in a liquid matrix called plasma. Blood cells circulate through the body, whereas other connective tissue cells do not migrate. Red blood cells (erythrocytes) transport oxygen and constitute the bulk of the blood cells. White blood cells (Leukopoietic) are less numerous than red blood cells and are of several varieties. White blood cells protect against infection and help clear the body of cells that have worn out or become abnormal. Blood also contains cell fragments called platelets, which release chemicals that promote blood clotting. In a healthy individual, the different types of blood cells are present in specific proportions. Alterations in blood composition can signify illness.

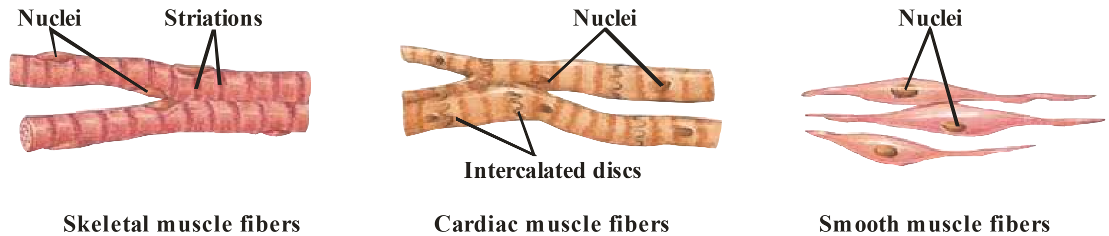
White blood cells : There are several different types of white cells in the blood in differing amounts. They all play a part in the immune response. This is the response of the body to infection, or anything else the body recognises as 'foreign'. These blood cells can be made very quickly and generally have a short life. Some only live for a few hours, others for days.
There isn't an exact 'normal' figure for blood counts. 'Normal' for a large man wouldn't be the same as for a small woman. But generally the normal white cell count is between about 4,000 and 11,000 per cubic millimeter of blood. If you have surgery or an infection, your white blood cell counts will go up within a day or two.
The most numerous of the white blood cells are the neutrophils. There are between 2,000 and 7,500 of these per cubic millimeter of blood. They are important for fighting infection. If you have chemotherapy, particularly high dose, your doctors will probably talk about your neutrophil count.
The next most numerous are the lymphocytes. A normal lymphocyte count is between 1,300 and 4,000 per cubic millimeter of blood. Lymphocytes are involved in making antibodies as part of the immune response.

Red blood cells : Red blood cells give the blood its red colour. There are more than 4 or 5 million of them in every cubic millimeter of blood. A red blood cell can live for up to 120 days.
Red blood cells are able to attach to oxygen to carry it within the circulation to the tissues. When they get to an area where the oxygen is needed, they give it up and pick up carbon dioxide which they carry back to the lungs. A shortage of red blood cells is called anaemia. The role of the red blood cell in carrying oxygen explains why very anaemic people usually feel breathless.

Platelets : Platelets are really bits of much bigger cells called megakaryocytes. A normal platelet count is between 150,000 and 440,000 per cubic millimeter of blood.
Platelets are very important in blood clotting. They clump together to form a plug if bleeding occurs. Then they release other chemicals that help the blood to clot and the blood vessel to be repaired.
All the different types of blood cells develop from one type of cell called a 'blood stem cell'. In adults, blood stem cells are normally found in the red bone marrow inside the bones. Blood cells are made in the bone marrow in the skull, ribs, sternum (breast bone), spine and pelvis.

MUSCULAR TISSUE

The main characteristic of muscle tissue is its ability to contract, or shorten, making movement possible. The characteristic that makes them unique is the relative abundance and organization of actin and myosin filaments within them. Although these filaments are present as a fine network in all eukaryotic cells, where they contribute to cellular movements, they are far more common in muscle cells, which are specialized for contraction. The three types of muscle tissue are skeletal (striated) cardiac, and smooth (unstriated) skeletal muscle is what normally is though of as "muscle". It is the meat of animals and constitutes about 40% of a person's body weight. As the name in plies, skeletal muscle attaches to the skeleton and enables body movement. Skeletal muscle cell tend to be long, cylindrical cells with several nuclei per cell. The nuclei of these cells are located near the periphery of the cell. Some skeletal muscle cells extend the length of an entire muscle.



Cardiac muscle is the muscle of the heart and is responsible for pumping blood. It is under involuntary (unconscious) control. Cardiac muscle cells are cylindrical in shape but much shorter in length than skeletal muscle Cells. Cardiac muscle cells are striated and usually have one nucleus per cell.

Cardiac muscle is composed of smaller, interconnected cells, each with a single nucleus. The interconnections between adjacent cells appear under the microscope as dark lines called intercalated discs. In reality, these lines are regions where adjacent cells are linked by gap junctions. Gap junctions have openings that permit the movement of small substances and electrical charges from one cell to another. These interconnections enable the cardiac muscle cells to form a single, functioning unit known as a myocardium. Certain cardiac muscle cells generate electrical impulses spontaneously, and these impulses spread across the gap junctions from cell to cell, causing all of the cells in the myocardium to contract. Each contraction represents one heartbeat.

Smooth muscle forms the walls of hollow organs (except the heart) and also is found in the skin and the eyes It is responsible for a number of functions, such as movement of food through the digestive tract and emptying of the urinary bladder. Smooth muscle is controlled involuntarily. Smooth muscle cells are tapered at each end, have a single nucleus, and are not striated.

Types of Muscle Tissue

Characteristics	Skeletal	Cardiac	Smooth
Microscopic appearance	Striated, multiple nuclei, cells not branched	Striated, single nucleus, cells branched	Nonstriated, single nucleus, cells spindle-shaped
Organ systems	Muscular system	Circulatory system	Digestive and urinary systems
Location	Most attached to bone; some to skin and muscles	Heart	Walls of digestive organs, blood vessels, and hair follicles
Nervous control	Voluntary	Involuntary	Involuntary
Contraction speed	Fast	Moderate	Slow

Nervous Tissue :

Nervous tissue forms the brain, spinal cord, and nerves. It is responsible for coordinating and controlling many bodily activities. For example, the conscious control of skeletal muscles and the unconscious regulation of cardiac muscle are accomplished by nervous tissue. Awareness of ourselves and the external environment, emotions, reasoning skills, and memory are other functions performed by nervous tissue. Many of these functions depend on the ability of nervous tissue cells to communicate with one another and with the cells of other tissues by electrical signals called action potentials.

Nervous tissue consists of neurons and support cells.

Neurons can be quite long, with intricate branches. A typical neuron consists of an enlarged portion called the cell body (which contains the nucleus), a thick branch called the axon, and several thinner branches called dendrites. Most dendrites receive information from other neurons in the form of chemical neurotransmitters. Environmental stimuli such as light, heat or pressure may activate neurons specialized as sensory receptors, located in the skin and in sense organs. Arrival of a neurotransmitter or sensory stimulation alters the permeability of the dendrite's cell membrane and triggers an electrochemical impulse that then passes to another neuron or to a muscle or gland cell.

Neurons impinge upon one another to form intricate nerve networks. A single neuron in the human brain, for example, might receive thousands of incoming messages from other neurons at any one time.

Several types of neuroglia, as well as connective tissue, are found around and between neurons. One abundant type of neuroglia, Schwann cells, have very fatty cell membranes that warp around axon and form insulating sheaths of the lipid myelin, which speeds nerve impulse conduction. Other neuroglia form scaffoldings that support highly branched neurons, and some supply nutrients and growth factors to neurons or remove ions and neurotransmitters that accumulate in synapses.

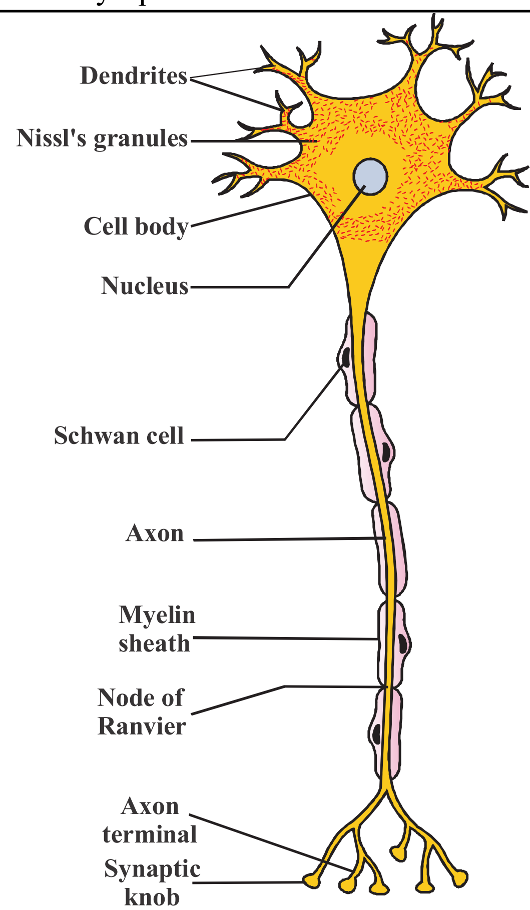


Figure : Structure of a Neuron

CONCEPT MAP

TISSUES

1. Tissue system

Tissue System and Its Functions	Component Tissues
Dermal Tissue System • protection • prevention of water loss	Epidermis Periderm (in older stems and roots)
Ground Tissue System • photosynthesis • food storage • regeneration • support • protection	Parenchyma tissue Collenchyma tissue Sclerenchyma tissue
Vascular Tissue System • transport of water and minerals • transport of food	Xylem tissue Phloem tissue

2. Types of Meristems

S.N.	Apical meristem	Intercalary meristem	Lateral meristem
1	Occurs at the tips of roots and shoots.	Occurs between mature tissues.	Occurs in the mature regions of roots and shoots.
2	Primary meristem.	Primary meristem.	Secondary meristem.
3	Increase the length of plant.	Capable of forming branch and flower.	Appears later than primary meristem and responsible for secondary growth.

3. Simple Tissues :

Ground Tissue	Parenchyma Tissue	Collenchyma Tissue	Sclerenchyma Tissue
Function	• Photosynthesis • Food storage • Healing and tissue regeneration	• Support in young stems, roots, and petioles	• Rigid support • Protection
Cell	Parenchyma cells Thin walled cells, with intercellular spaces, cell wall is made up of cellulose.	Collenchyma cells closely packed cells which are thickened at the corners due to deposition of cellulose, hemicelluloses and pectin.	Sclereid cells & fiber cells dead cells with thick and lignified cell walls with pits.

4. Complex Tissues :

(a) Xylem : Xylem consists of tracheids, vessels, xylem fibres and xylem parenchyma. It conducts water and minerals from roots to other parts of plant.

Protoxylem : The first formed primary xylem elements.

Metaxylem: The later formed primary xylem.

(b) Phloem : Phloem consists of sieve tube elements, companion cells, phloem fibres and phloem parenchyma. Phloem transports the food material from leaves to various parts of the plant.

ANIMAL TISSUE

5. Animal tissues can be epithelial, connective, muscular and nervous tissue.
6. Depending on shape and function, epithelial tissue is classified as squamous, cuboidal, columnar, ciliated and glandular.
7. **Simple squamous epithelium:** It consists 8of a single layer of flat cells with irregular boundaries. It is found in the walls of the blood vessels and in the lining of alveoli.
8. **Simple cuboidal epithelium:** It consists of a single layer of cube-like cells. It is present in regions where secretion and absorption of substances takes place such as the proximal convoluted tubule region of the nephron.
9. **Simple columnar epithelium:** It consists of a single layer of tall, slender cells with their nuclei present at the base of the cells. They may bear micro-villi on the free surfaces. Columnar epithelium forms the lining of the stomach and intestines, and is involved in the function of secretion and absorption.
10. **Ciliated epithelium:** It consists of columnar or cuboidal cells with cilia on their free surfaces. They are present in bronchioles and oviducts from where they direct mucus and eggs in specific directions.
11. **Glandular epithelium:** It consists of columnar or cuboidal cells involved in the secretion of substances. Glands are of two types, unicellular glands (goblet cells of the alimentary canal) and multicellular glands (salivary glands). They can be classified as exocrine (ductless glands) and endocrine glands (duct glands) by the method through which they release enzymes.
12. The different types of connective tissues in our body include areolar tissue, adipose tissue, bone, tendon, ligament, cartilage and blood.
13. **Cardiac muscle and striated muscle:** Cardiac muscle fibres are branched, while striated muscle fibres are unbranched. Cardiac muscles continuously contract and relax throughout the life, while striated muscles show movement as and when required.
14. **Dense regular and dense irregular connective tissues:** The cells and fibres are loosely arranged in a semi-fluid matrix; in loose connective tissue. The cells and fibres are compactly packed in dense connective tissue. Areolar tissue is an example of loose connective tissue, while tendon and ligament are examples of dense connective tissue.
15. **Adipose and blood tissue :** Adipose tissue is an example of loose connective tissue, while blood tissue is a specialized connective tissue. Adipose tissue is usually located beneath the skin. The cells of the adipose tissue are specialized to store fat.
16. Nervous tissue is made of neurons that receive and conduct impulses.