UNIT II

Chapter 3

Tissue Level of Organisation

Chapter Outline

A reflective layer of tissue called tapetum lucidum, enhances night time vision in most of the animals like cat.

Learning Objectives:

- *Recognises the types of tissues based on their characteristic features*
- *Understands the description, location, functions and modification of tissues.*
- *Understands the significance of muscles, connective and neural tissues.*

In multicellular organisms, cells do not operate independently, instead, they form tight cell communities that live and work together. Individual body cells are specialized, with each type performing specific functions that helps to maintain homeostasis and benefits the body as a whole. Cell specialization is obvious. How the muscle cell looks and acts differs greatly from skin cells. Cell specialization allows the body to function in co-ordinated ways. Groups of cells that are similar in structure and perform common or related functions are called '**tissues**'.

Tissues are organized in specific proportions and patterns to form **organs** like lungs, heart, stomach, kidneys, ovaries, testes etc; hence the tissues are called the '**living fabrics**'. If two or more organs perform common physical and chemical functions they are called '**organ systems**', Eg: digestive system, respiratory system, circulatory system, excretory system, etc. Most organs contain different types of tissues and their arrangement determines the organs structure and functions. The study of tissues is called **histology** complements the study of gross anatomy. Together they provide the structural basis for understanding organ physiology.

3.1 Animal Tissues

Animal tissues are classified according to the size, shape and function of the cells. There are four primary (basic) tissue types that interweave to form the 'fabric' of the body. They are, the epithelial tissue (covering), the connective tissue (support), the muscle tissue (movement) and the nervous tissue (control) (Figure 3.1).

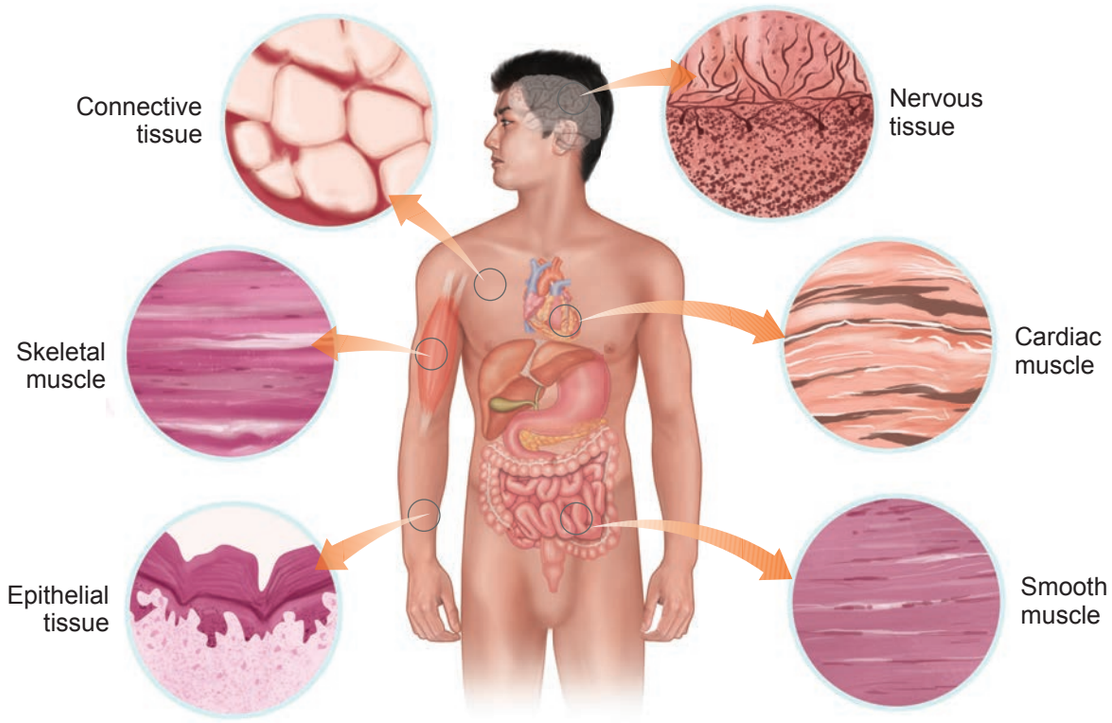


Figure 3.1 Types of Tissues in Human

3.2 Epithelial Tissue

Epithelial tissue is a sheet of cells that covers the body surface or lines the body cavity. It occurs in the body as a **covering, as a lining epithelium and as glandular, epithelium**. The functions of epithelium includes **protection, absorption, filtration, excretion, secretion** and **sensory reception.**

Based on the structural modification of the cells, the epithelial tissues are classified into simple epithelium and compound epithelium or stratified epithelium.

Simple epithelium is composed of a single layer of cells. They are found in the organs of absorption, secretion and filtration. Simple epithelial tissue is further classified

Classification of Animal Tissues

- **Epithelial**
  - **Simple**
    1. Squamous
    2. Cuboidal
    3. Columnar
    4. Ciliated
    5. Pseudostratified
  - **Compound**
    - **Stratified**
      - **Squamous**
        1. Keratinized
        2. Non-Keratinized
      - **Cuboidal**
      - **Columnar**
    - **Transitional**
- **Connective**
- **Muscular**
- **Neural**

into squamous epithelium, cuboidal epithelium, columnar epithelium, ciliated epithelium and pseudostratified epithelium (Figure 3.2). The **squamous epithelium** is made of a single thin layer of flattened cells with irregular boundaries. They are found in the kidney glomeruli, air sacs of lungs, lining of heart, blood vessels and lymphatic vessels and are involved in functions like forming a diffusion boundary and filtration in sites where protection is not important. The **cuboidal epithelium** is made of a single layer of cube like cells. This tissue is commonly found in the kidney tubules, ducts and secretory portions of small glands and surface of the ovary. Its main functions are secretion and absorption. The **columnar epithelium** is composed of single layer of tall cells with round to oval nuclei at the base. It lines the digestive tract from the stomach to the rectum. The two modifications of this lining are the presence of **microvilli** on the apical surface of the absorptive cells and **Goblet cell** which secretes the protective lubricating mucus. The functions of this epithelium include absorption, secretion of mucus, enzymes and other substances. If the columnar cells bear cilia on their free surfaces they are called **ciliated epithelium**. This **ciliated type** propels mucus by ciliary actions and it lines the small bronchioles, fallopian tubes and uterus. **Nonciliated type** lines most of the digestive tract, gall bladder and secretory ducts of glands.

Pseudo-stratified epithelial cells are columnar, but unequal in size. Although the epithelium is single layered yet it appears to be multi-layered because the nuclei lie at different levels in different cells. Hence, it is also called pseudostratified epithelium and

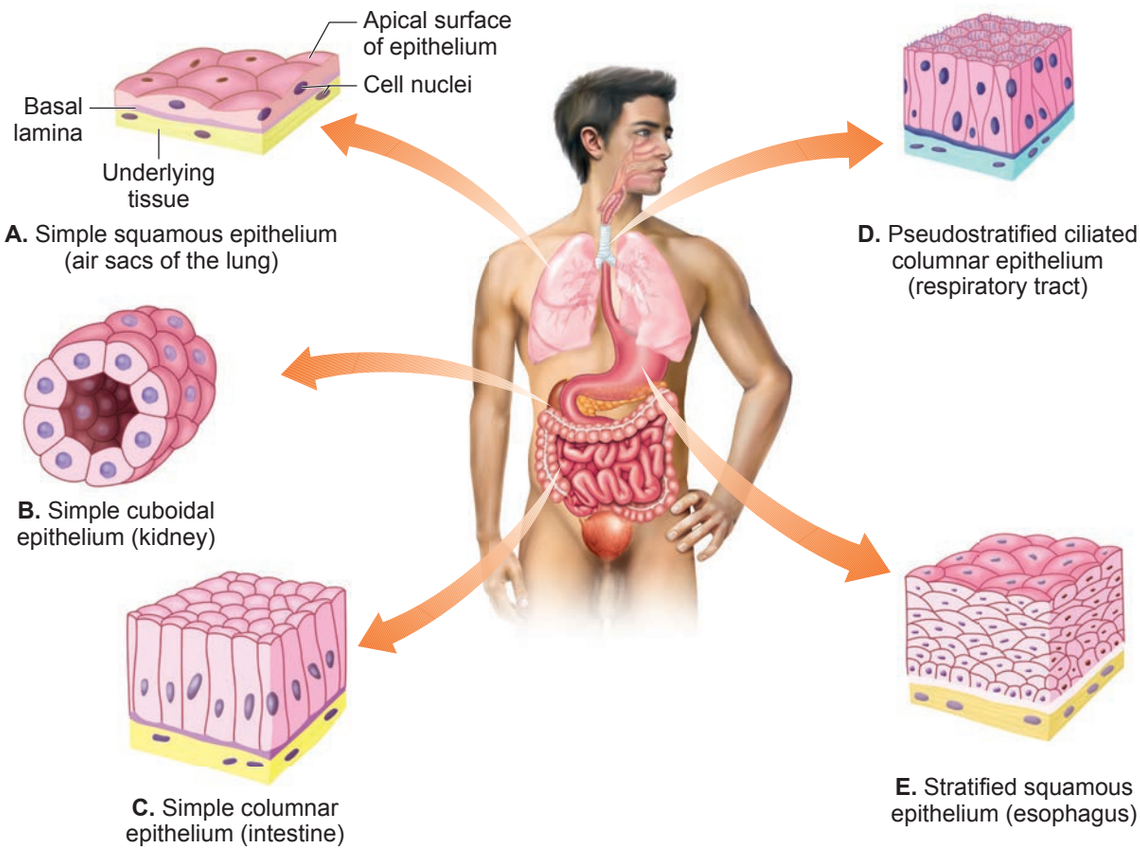


Figure 3.2 Types of Epithelial tissues

its functions are protection, secretion and absorption. Ciliated forms line the trachea and the upper respiratory tract. The non ciliated forms, line the epididymis, large ducts of a glands and tracts of male urethra

Important epithelial tissue disorders:

Eczema, Psoriasis, Epithelial carcinoma and severe asthma

Glandular epithelium

Some of the cuboidal or columnar cells get specialized for secretion and are called **glandular epithelium** (Figure 3.3). They are mainly of two types: unicellular, consisting of isolated glandular cells (goblet cells of the **alimentary canal**), and multicellular, consisting of cluster of cells (**salivary gland**). On the basis of the mode of pouring of their secretions, glands are divided into two categories namely exocrine and endocrine glands. **Exocrine glands** secrete mucus, saliva, earwax, oil, milk, digestive enzymes and other cell products. These products are released through ducts or tubes. In contrast endocrine glands do not have ducts. Their secretions called hormones are secreted directly into the fluid bathing the gland. The exocrine glands are classified as unicellular and multicelluar glands. The multicelluar glands are further classified based on the structure as **simple** and **compound glands,** based on their secretory units as **tubular, alveolar (Acinus)** and **tubulo alveolar**. Based on the mode of secretion exocrine glands are classified as **merocrine, holocrine** and **apocrine**.

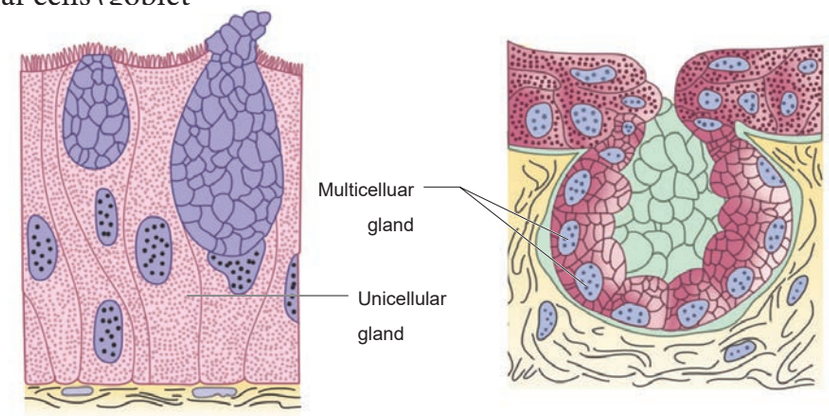
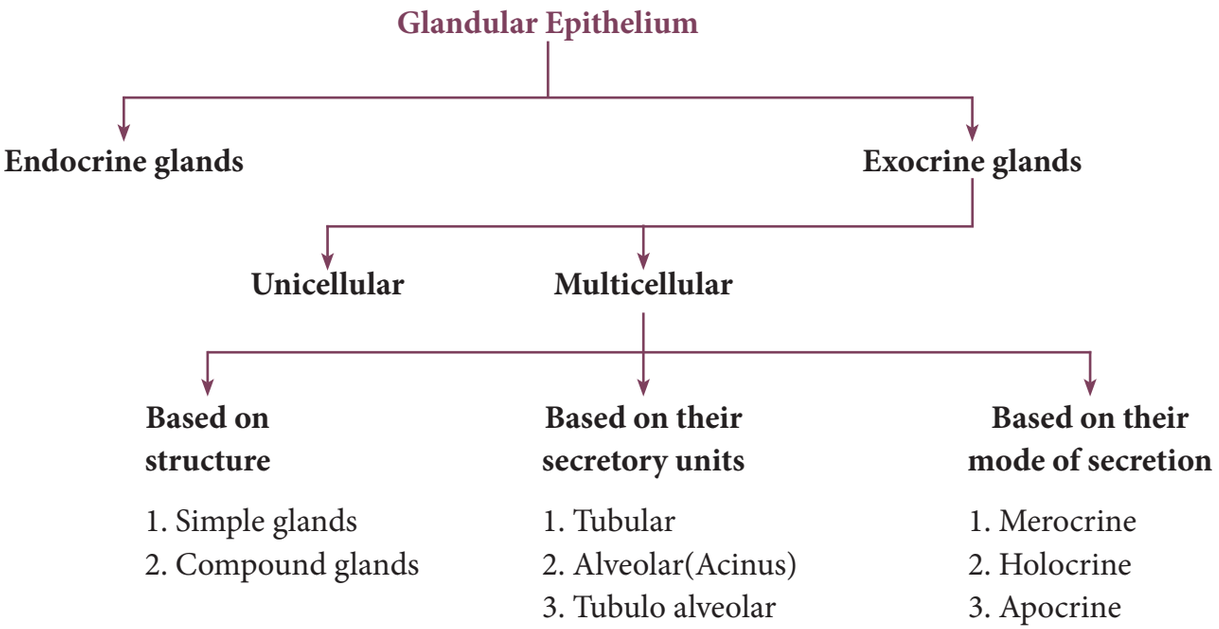


Figure 3.3 Glandular Epithelium



Compound epithelium is made of more than one layer (multi-layered) of cells and thus has a limited role in secretion and absorption(Figure 3.4). The compound epithelia may be stratified and transitional. Their main function is to provide protection against chemical and mechanical stresses. They cover the dry surface of the skin, the moist surface of buccal cavity, pharynx, inner lining of ducts of salivary glands and of pancreatic ducts. There are four types of compound epithelium namely, stratified squamous epithelium, cuboidal epithelium, columnar epithelium and transitional epithelium. **Stratified squamous epithelium** is of two types called **keratinized type** which forms the dry epidermis of the skin and the **non keratinized type** forms the moist lining of the oesophagus, mouth, conjunctiva of the eyes and vagina. **Stratified cuboidal epithelium** mostly found in the ducts of sweat glands and mammary glands. **Stratified columnar epithelium** has limited distribution in the body, found around the lumen of the pharynx, male urethra and lining of some glandular ducts. **Transitional Epithelium** is found lining the ureters, urinary bladder and part of the urethra. This epithelium allows stretching and is protective in function.

All cells of the epithelium are held together with little intercellular material. In most of the animal tissues, specialized junctions provide both structural and functional links between its individual cells. Three types of cell junctions are found in the epithelium and other tissues. These are called as tight, adhering and gap junctions. **Tight junctions** help to stop substances from leaking across a tissue. **Adhering junctions** perform cementing to keep neighbouring cells together. **Gap junctions** facilitate the cells to communicate with each other by connecting the cytoplasm of adjoining cells, for rapid transfer of ions, small molecules and sometimes big molecules.

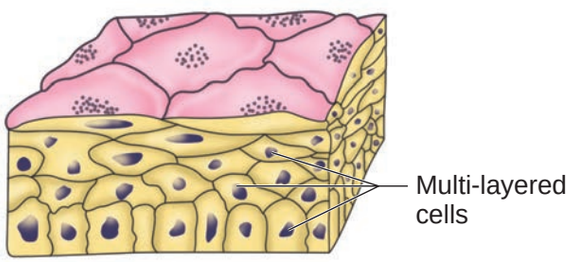
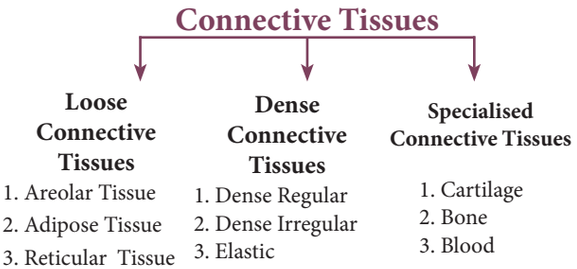


Figure 3.4 Compound Epithelium

Stratified epithelia are "built" for protection or to resist abrasion. What are the simple epithelia better at?

3.3 Connective Tissue

Connective tissue develops from the **mesoderm** and is widely distributed in the body. There are three main classes namely Loose connective tissue, Dense connective tissue and Specialized connective tissue. Major functions of connective tissues are **binding, support, protection, insulation** and **transportation**



1. What type of connective tissue is damaged when one get cut on his index finger accidently?
2. The stored lipids are in the form of adipose tissue. Are they coloured? why?

Components of connective tissue

All connective tissues consist of three main components namely fibres, ground substance and cells. The **'Fibres'** of connective tissue provide support. Three types of fibres are found in the connective tissue matrix. They are **collagen**, **elastic** and **reticular** fibres. Connective tissues are of three types namely, **Loose connective tissues** (Areolar, Adipose and Reticular) and **Dense connective tissues** (dense regular, dense irregular and elastic) and **Specialized connective tissues** (cartilage, bone and blood).

Loose connective tissues

In this tissue the cells and fibres are loosely arranged in a semi fluid ground substances. For example the **Areolar connective tissue** beneath the skin acts as a support framework for epithelium and acts as a reservoir of water and salts for the surrounding body tissues, hence aptly called ***tissue fluid.*** It contains fibroblasts, macrophages, and mast cells (Figure 3.5).

Adipose tissue is similar to areolar tissue in structure and function and located beneath the skin. Adipocytes commonly called **adipose** or **fat cells** predominate and account for 90% of this tissue mass. The cells of this tissue store fats and the excess nutrients which are not utilised immediately are converted to fats and are stored in tissues. Adipose tissue is richly vascularised indicating its high metabolic activity. While fasting, these cells maintain life by producing and supplying energy as fuel. Adipose tissues are also found in subcutaneous tissue, surrounding the kidneys, eyeball, heart, etc. Adipose tissue is called '**white fat**' or **white adipose tissue.** The adipose tissue which contains abundant mitochondria is called '**Brown fat**' or **Brown adipose tissue.** White fat stores nutrients whereas brown fat is used to heat the blood stream to warm the body. Brown fat produces heat by **non-shivering thermogenesis** in neonates.

Reticular connective tissue resembles areolar connective tissue, but, the matrix is filled with fibroblasts called reticular cells. It forms an internal framework (**stroma**) that supports the blood cells (largely lymphocytes) in the lymph nodes, spleen and bone marrow.

Dense connective tissues (connective tissue proper)

Fibres and fibroblasts are compactly packed in the dense connective tissues. Orientation of fibres show a regular or irregular pattern and is called dense regular

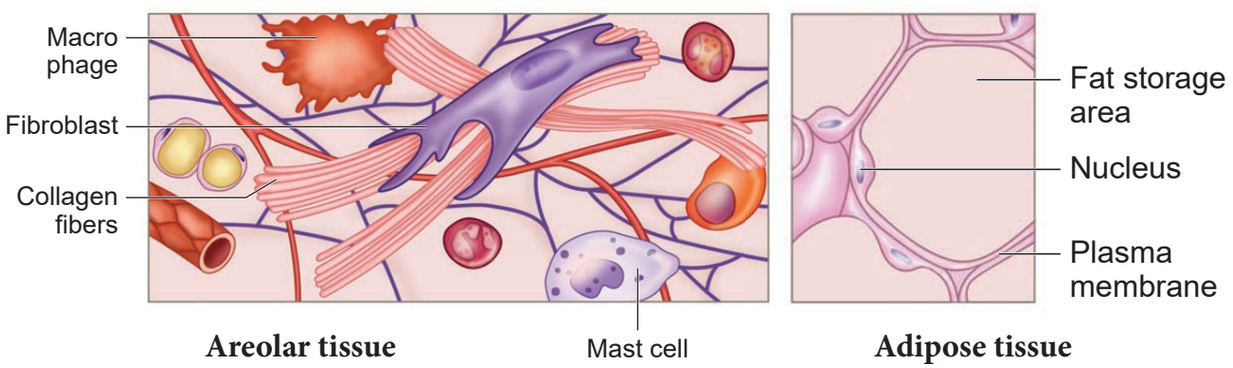


Figure 3.5 Loose connective tissues

and dense irregular tissues. **Dense regular connective tissues** primarily contain collagen fibres in rows between many parallel bundles of tissues and a few elastic fibres. The major cell type is **fibroblast.** It attaches muscles and bones and withstands great tensile stress when pulling force is applied in one direction. This connective tissue is present in **tendons,** that attach skeletal muscles to bones and ligaments attach one bone to another. **Dense irregular connective tissues** have bundles of thick collagen fibres and fibroblasts which are arranged irregularly. The major cell type is the **fibroblast**. It is able to withstand tension exerted in many directions and provides structural strength. Some elastic fibres are also present. It is found in the skin as the leathery dermis and forms fibrous capsules of organs such as kidneys, bones, cartilages, muscles, nerves and joints.

Elastic connective tissue contains high proportion of elastic fibres. It allows recoil of tissues following stretching. It maintains the pulsatile flow of blood through the arteries and the passive recoil of lungs following inspiration. It is found in the walls of large arteries; ligaments associated with **vertebral column** and within the walls of the **bronchial tubes.**

Specialised connective tissues are classified as cartilage, bones and blood. The intercellular material of **cartilage** is solid and pliable and resists compression. Cells of this tissue (chondrocytes) are enclosed in small cavities within the matrix secreted by them (Figure 3.6). Most of the cartilages in vertebrate embryos are replaced by bones in adults. Cartilage is present in the tip of nose, outer ear joints, ear pinna, between adjacent bones of the vertebral column, limbs and hands in adults.

Bones have a hard and non-pliable ground substance rich in calcium salts and collagen fibres which gives strength to the bones. It is the main tissue that provides structural frame to the body. Bones support and protect softer tissues and organs. The bone cells (osteocytes) are present in the spaces called **lacunae**. Limb bones, such as the long bones of the legs, serve weight-bearing functions. They also interact with skeletal muscles attached to them to bring about movements. The bone marrow in some bones is the site of production of blood cells.

Blood is the fluid connective tissue containing plasma, red blood cells (RBC), white blood cells (WBC) and platelets. It functions as the transport medium for the cardiovascular system, carrying nutrients, wastes, respiratory gases throughout the body. You will learn more about blood in Chapter 7.

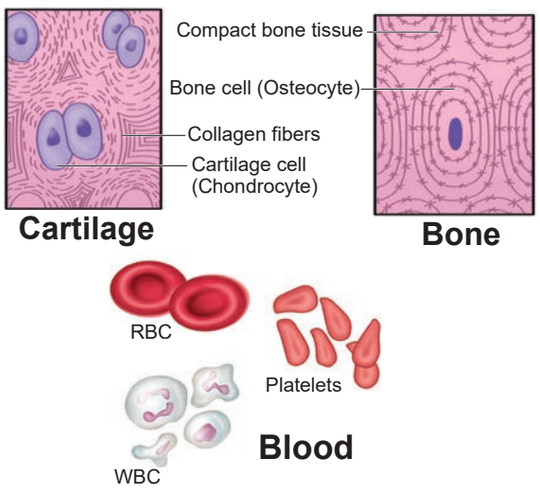


Figure 3.6 Specialized connective tissues

You are looking at a slide of a tissue through the compound microscope and you see striped branching cells that connect with one another. What type of muscle are you viewing?

Important connective tissue disorders: (Heritable types)

1. **Ehler's -Danlos syndrome –** Defect in the synthesis of collagen in the joints, heart valves, organ walls and arterial walls.
2. **Stickler syndrome –** Affects collagen and results in facial abnormalities.
3. **Rhabdomyosarcoma** – Life threatening soft tissue tumour of head, neck and urinogenital tract.

Autoimmune connective tissue disorders

1. **Rheumatoid arthritis:** The immune cells attack and inflame the membranes around the joints. It can also affect heart, lungs and eyes.
2. **Sjogren's syndrome:** Progressive inability to secrete saliva and tears.

3.4 Muscle Tissue

Each muscle is made of many long, cylindrical fibres arranged in parallel arrays. These fibres are composed of numerous fine fibrils, called **myofibrils**. Muscle fibres contract (shorten) in response to stimulation, then relax (lengthen) and return to their uncontracted state in a coordinated fashion. In general muscles play an active role in all the movements of the body.

Muscles are of three types, skeletal, smooth and cardiac. **Skeletal muscle tissue** is closely attached to skeletal bones. In a typical muscle such as the biceps, the striated (striped) skeletal muscle fibres are bundled together in a parallel fashion. A sheath of tough connective tissue encloses several bundles of muscle fibres (You will learn more about this in Chapter 9).

The **smooth muscle** fibres taper at both ends (fusiform) and do not show striations (Figure 3.7). Cell junctions hold them together and they are bundled together in a connective tissue sheath. The walls of internal organs such as the blood vessels, stomach and intestine contain this type of muscle tissue. Smooth muscles are 'involuntary' as their functions cannot be directly controlled. Unlike the smooth muscles, skeletal muscles can be controlled by merely thinking.

Cardiac muscle tissue is a contractile tissue present only in the heart. Cell junctions fuse the plasma membranes of cardiac muscle cells and make them stick together. Communication junctions (intercalated discs) at some fusion points allow the cells to contract as a unit, i.e., when one cell receives a signal to contract, its neighbours are also stimulated to contract.

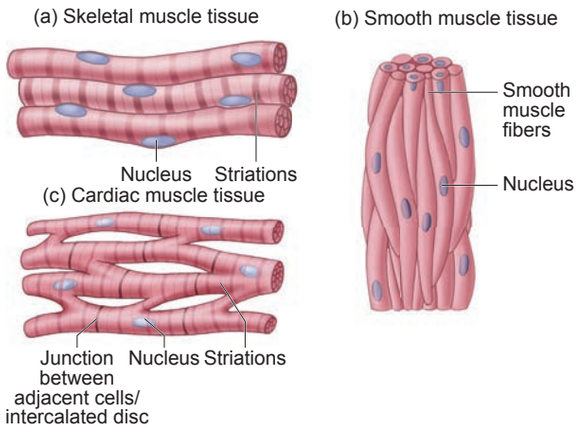


Figure 3.7 Muscle tissues

Palmaris muscle:

This long narrow muscle runs from the elbow to the wrist and is important for hanging and climbing in primates, is missing in 11% of humans today.

3.5 Neural Tissue

Nervous tissue exerts the greatest control over the body's responsiveness to changing

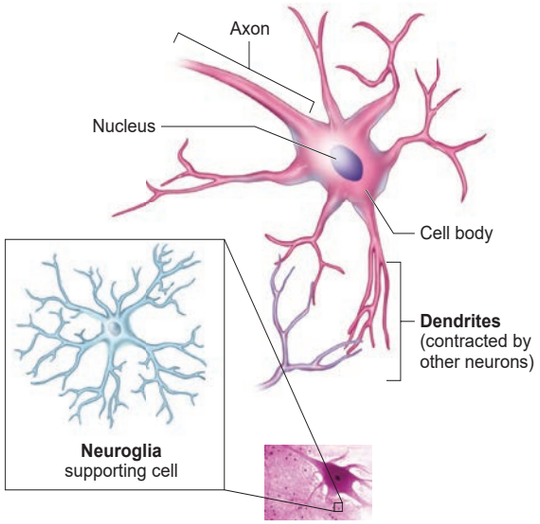


Figure 3.8 Nervous tissues with neuroglia

conditions. Neurons, the unit of neural system are excitable cells (Figure 3.8). The neuroglial cells which constitute the rest of the neural system protect and support the neurons. **Neuroglia** makes up more than one-half of the volume of neural tissue in our body.

When a neuron is suitably stimulated, an electrical disturbance is generated which swiftly travels along its plasma membrane. Arrival of the disturbance at the neuron's endings, or output zone, triggers events that may cause stimulation or inhibition of adjacent neurons and other cells (You will study in detail in Chapter 10)

Diseases of Nervous System:

1. **Parkinson's disease:** A degenerative disorder of the nervous system that affects movement, often including tremors.
2. **Alzheimer's disease:** It is a chronic neurodegenerative disease which includes the symptoms of difficulty in remembering recent events, problems with language, disorientation and mood swings.

Biopsy is an examination of tissue or liquid removed from a living body to discover the presence, cause or extent of a disease.

Autopsy is a post-mortem (dissection of a dead body) examination to discover the cause of death or the extent of disease.

The field of **Forensic science** effectively uses the histological techniques to trace out crimes.

Summary

The body cells combine to form four different types of tissues; epithelial, connective, muscle and nervous tissues. Though the cells of these tissues share certain features in common, by no means they are identical. They belong together because they have basic fundamental resemblances. The important concept to carry away with you is that tissues, despite their unique abilities, cooperate to keep the body safe, healthy, viable and whole.

Activity

1.Students are asked to identify the unlabelled slides of tissues and to classify them. Similar exercise can also be accomplished by projecting unlabelled histological images on a screen. They can identify the slides of different tissues through microscope

2.The preparation of smear of stratified squamous epithelia from the inner lining of cheek allows the students to make their own slides using biological stain. They will have the experience of examining their cheek cells.

Evaluation

1. The main function of the cuboidal epithelium is
   a. Protection
   b. Secretion
   c. Absorption
   d. Both (b) and (c)
2. The ciliated epithelium lines the
   a. Skin b. Digestive tract
   c. Gall bladder d. Trachea
3. What type of fibres are found in connective tissue matrix?
   a. Collagen b. Areolar
   c. Cartilage d. Tubular
4. Prevention of substances from leaking across the tissue is provided by
   a. Tight junction
   b. Adhering junction
   c. Gap junction
   d. Elastic junction
5. Non-shivering thermogenesis in neonates produces heat through
   a. White fat b. Brown fat
   c. Yellow fat d. Colourless fat
6. Some epithelia are pseudostratified. What does this mean?
7. Differentiate white adipose tissue from brown adipose tissue.
8. Why blood is considered as a typical connective tissue?
9. Differentiate between elastic fibres and elastic connective tissue.
10. Name any four important functions of epithelial tissue and provide at least one example of a tissue that exemplifies each function.
11. Write the classification of connective tissue and their functions
12. What is an epithelium? Enumerate the characteristic features of different epithelia.

ICT Corner

The Online Epithelium

Let's explore the anatomy and functions of **Epithelium Tissues**.

Step – 1 Use the URL to open 'The Online Epithelium' page. Click any of the organ given in the list to view the interactive epithelial tissues present in that organ.

Step – 2 Click the play icon to load the 3D interactive. The loaded 3DTissue can be viewed 360 degree by click and drag of the mouse.

Step – 3 Roll the mouse over the interactive diagram and click the number on the diagram. A brief description of the parts will appear, description can be viewed by selecting the parts given at the bottom of the activity window.

Step – 4 Additional information regarding the particular epithelial tissue can be learned from the descriptions given below the 3D interactive diagram.

The Online Epithelium'sURL:

http://www.epithelium3d.com/index.html

* Pictures are indicative only