17. Introduction to Biotechnology

Animal tissues: Animal tissues are classified into four types based on the functions they perform: Epithelial, Connective, Muscular and Nervous tissue.

- **Epithelial tissues** –Tightly packed cells with almost no intercellular spaces. It forms the covering of the external surfaces, internal cavities, and organs of the animal body
- Various types of epithelial tissues:
- **Squamous epithelium - S**ingle layer of extremely thin and flat cells are called simple squamous epithelium while multi layered cells forms stratified squamous epithelium in order to prevent wear and tear
- **Location in the human body**:
    - Simple squamous epithelium - Lining of the mouth, oesophagus, lung alveoli, etc.
    - Stratified squamous epithelium – Skin
- **Cuboidal epithelium -** Consists of cube-like cells that provide mechanical support
    - **Location in the human body**:Lining of kidney tubules and ducts of the salivary glands
- **Columnar epithelium -** Consists of elongated or column-like cells to facilitate movement across the epithelial barriers.
    - **Location in the human body:** Inner lining of the intestine and gut

- **Glandular epithelium -** Consists of multicellular glands

Connective tissues -Specialised to connect various body organs. Various types of connective tissues are:

Loose connective tissue- It includes areolar and adipose connective tissues

- **Areolar tissue -** It provides supports to internal organs and helps in repair of tissues
    - Found in the skin and muscles, around the blood vessels, nerves, etc.

- **Adipose tissue -** Acts as the storage site of fats; found between the internal organs and below the skin; acts as an insulator for the body

Dense regular connective tissue- Main components are tendons and ligaments.

- Ligaments – Connective tissues that connect a bone to a bone. It is very elastic
- Tendons – Connective tissue that connect a bone to a muscle. It has limited flexibility

Specialized connective tissue -It includes skeletal tissues i.e cartilage and bone.

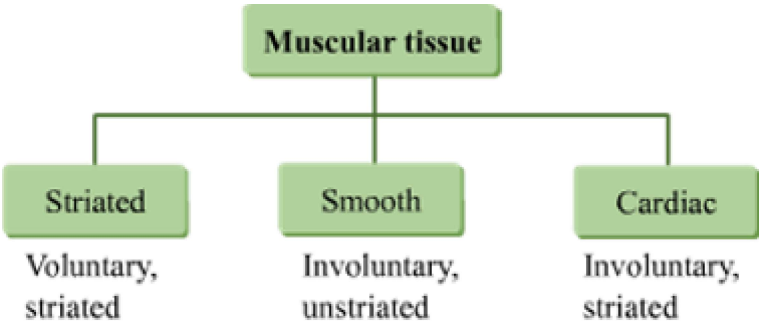
Fluid connective tissue - Blood is the special connective tissue present in animals that helps in the transport of various substances. It is composed of plasma, Red blood cells (RBC), White blood cell (WBC) and platelets.

Lymph- It is a transparent, light yellowish fluid located in the intercellular spaces of our body. It is part of the defensive mechanism of the body and also helps in transporting nutrients to tissues and cells. It also helps in carrying digested fats from the intestine.

Muscular Tissues

Muscles, made up of muscular tissues, make it possible for the different body parts to move.

Muscular tissues can be classified into three categories, as is shown in the figure.



Striated Muscles

- Striated muscles show alternate light and dark bands or striations when stained appropriately.
- They are also called **skeletal muscles** because they are found attached to the bones which form the skeleton.
- They are voluntary muscles.
- The cells of striated muscular tissues are long, cylindrical, unbranched and multinucleate (i.e., having many nuclei).
- They are located in the body wall, tongue, limbs and pharynx.

Smooth Muscles

- Unstriated or smooth muscles do not show any alternate light and dark bands.
- They are involuntary muscles as they are involved in involuntary actions of the body.
- The cells of smooth muscular tissues are long with pointed ends (or spindle-shaped) and uninucleate**.**
- Smooth muscles are located in the alimentary canal, urinary bladder, blood vessels and ducts of glands.

Cardiac Muscles

- Cardiac muscles are the muscles of the heart.
- They are striated, but involuntary in action.
- They show rhythmic contraction and relaxation throughout life.
- The cells of cardiac muscular tissues are cylindrical, branched and uninucleate.
- Cardiac muscles are exclusively present in the heart. They control the rhythmic beating of the heart.

- Nervous tissues –Highly specialised tissues present in the brain, spinal cord, and nerves.
  - Neuron – It is the functional unit of nervous tissue
  - A neuron consists of a cell body, an axon, and a dendrite.

- Cells of the nervous tissues are highly specialized for becoming stimulated and then transmitting the stimulus very rapidly from one place to another within the body.
- Neurons are responsible for both collecting and delivering messages in our body.

Neurons

The fundamental unit of the nervous system is the nerve cell.
Parts of neurons:

- **Dendrite**: It receives information from the axon of an adjacent neuron and conducts it toward the cell body.
- **Axon**: It conducts messages away from the cell body.
- **Cell body**: It contains a nucleus, mitochondria and other organelles. It is concerned with the maintenance and growth of the cell.

Fat containing Shwann cells help in insulating the neurons makimng them capable of transmitting signals very fast.
The myelin sheath is not continuous over the axon and has some gaps exposing the axon. A gap between two adjacent myelin sheaths is called node of Ranvier.

Transfer of a Nerve Impulse from one to another nerve cell

The axon endings of one nerve cell are loosely placed on the cell body or cyton of another nerve cell, thereby forming a loose connection called synapse. Electric signals are transmitted from one neuron to the next across such synapses through the release of chemicals called neurotransmitters.

A released neurotransmitter crosses a synapse and starts a similar electrical impulse in the dendrite of the adjacent neuron. In this way, impulses are transmitted from one neuron to another and, ultimately, to the brain.

Glial Cells- nervous tissue also contains supportive cells of various kinds which do not help in conduction. These cells are called glial or neuroglial cells

Nerves:
They are formed of a bundle of axons that are enclosed in a sheath.
They are of three types: sensory, motor and mixed.

Tissues

- Group of cells that work together to perform a particular function is called tissue
- **Plant tissues**: On the basis of the dividing capacity, plant tissues are of two types: Meristematic and Permanent tissues
- **Meristematic tissues –** It consists of actively-dividing cells.

Properties of Meristematic Tissues-

- Made up of immature cells or undifferentiated cells.
- Cell wall is thinner with a prominent nucleus.
- Their cells are metabolically highly active with a dense cytoplasm.

Meristematic tissues are of three types:

Meristematic Tissue	Location	Function
Apical meristem	Present at the growing tips of stems and roots	To increase the length of stems and roots
Intercalary meristem	Present at the base of leaves or internodes	For the longitudinal growth of plants

Lateral meristem	Present on the lateral sides of the stems and roots	To increase the thickness of stems and roots

Permanent tissues – It is formed from meristematic tissues. The cell loses the ability to divide. Permanent tissues are divided into two categories:

- **Simple permanent -** Consist of only one type of cells performing same functions.
- **Types of simple permanent tissues**:- **Parenchyma , Collenchyma and Sclerenchyma**
- **Parenchyma -** Composed of unspecialised loosely packed living cells with relatively thin cell walls and large intercellular spaces.
    i. **Chlorenchyma:** Parenchyma that contains chloroplast and performs photosynthesis is called chlorenchyma.
    ii. **Aerenchyma:** Parenchyma that contains large air cavities is called aerenchyma. These large air cavities provide buoyancy to aquatic plants
- **Collenchyma -** Composed of living and elongated cells with cell walls irregularly thickened at the corners ; have very little intercellular spaces; provide flexibility and mechanical support to the various parts of the cells. The are present in leaf stalks just below the epidermis.
- **Sclerenchyma -** Composed of long, narrow, and lignin deposited thick-walled cells. This tissue is made up of dead cells and there are no intercellular spaces. For example, husk of coconut.

- For obtaining silk, silkworms are reared on a large scale. A female silk moth gives hundreds of eggs on the mulberry leaf. The eggs are then hatched by keeping them under the right temperature and humidity conditions. Then, the silk caterpillars are fed on mulberry leaves. After 20-25 days, caterpillars stop eating and start spinning cocoons around them. Further development of the moth continues inside the cocoon. The moth leaves the cocoon after its development is complete.
- Once the moth has left the cocoon, it is collected to obtain silk. The cocoons are kept under the sun or boiled or exposed to steam to separate the silk fibres. This process is known as **reeling** the silk. Silk fibres obtained after reeling are spun into silk threads.

Biotechnology is the field of molecular biology dealing with the techniques of using live microorganisms to produce products that are useful to humankind.

Genetic engineering

- It is a technique used by scientists for manipulating genetic material of living organisms.
- It involves artificial synthesis, isolation, modification and transfer of genetic material into a host organism to alter its phenotype.
- DNA cloning/Gene cloning: It is the method of making multiple identical copies of a single gene.
- Plasmid: It is a small, circular, extra-chromosomal genetic material that is capable of self replication.
- Characteristics of plasmid –
    - Has an origin of replication
    - Has a selectable marker
    - One or few cloning sites

Recombinant DNA technology

- It is a set of techniques for altering DNA. It includes the recognition and cloning of genes, the study of the expression of cloned genes and the production of a large number of gene products.

Construction of a Recombinant DNA

- Plasmid (autonomously replicating, circular, extra-chromosomal DNA) is isolated.
- Plasmid DNA is cut with a specific restriction enzyme at specific locations.
- The DNA of interest (to be inserted) is also cut with the same restriction enzyme.
- The DNA of interest is hybridised with the plasmid with the help of DNA ligase to form a **Recombinant DNA**.
- Recombinant DNA is then transferred into host for cloning.

- Biotechnology is the field of applied biology that involves the use of biological processes and living organisms in engineering, technology, medicines and other fields requiring bioproducts.
- **Seven techniques are applied for the improvement of plants:**

Selection: choosing varieties of crops that have healthier and desirable characteristics from among all the crops grown.
Hybridisation: crossing two plants of different breeds but of the same species and producing an offspring that has new, desirable characteristics.
Polyploid breeding: breeding of a plant containing more than two haploid sets of chromosomes.
Mutation breeding: Inducing the desired change in the DNA sequence of the crop and then cultivating it to increase its yield.
Protoplast fusion: Fusing two plant cells without cell walls such that their DNA combines and give rise to a new plant having the characteristics of both the parents.
Tissue culture: artificial method of reproduction by which a small cutting of a plant, such as a root or a stem, is grown in a Petri plate or a test tube in laboratory conditions, by providing it with suitable nutrients in a medium.

Biotechnology is used in the food processing industry for following reasons.

- To increase the shelf life of food items
- To improve the quality of food items
- To increase the production of food items
- To improve food-processing aids and additives

Genetic engineering: introducing foreign DNA carrying the desired gene of interest into the host organism, and thus changing the phenotype of the host organism.

Benefits of genetic engineering

- Improves the yield of the crop
- Improves the shelf life and flavour of the produce
- Enhances the nutritional value of the produce
- Protects crops from insects and other pests

Agritourism

It is also known as farm tourism in which agricultural activities are carried out to attract tourists. On private agricultural lands, plantlets of flowering, medicinal, vegetable plants and fruit trees are produced.

- **Complex permanent -** Made up of more than one type of cell. These tissues constitute vascular bundles. Types of complex permanent tissues are
  - **Xylem**
    - Conducts water and minerals from the roots to the different parts of the plant
    - Composed of four different types of cells – Tracheids, vessels, xylem parenchyma and xylem fibres. Except xylem parenchyma all other xylem elements are non- living.
  - **Phloem**
    - Conducts food material from the leaves to the different parts of the plant
    - Composed of four different types of cells – Sieve tubes, companion cells, phloem parenchyma, and phloem fibres. Except for phloem fibres, all other phloem cells are living.

Animal Husbandry - It deals with the scientific management of livestock. These include cattle farming, poultry farming, fish culture, and bee culture.

- **Cattle farming-** It is done to obtain milk and draught labour cattle's for agricultural purposes. This can be achieved by producing hybrid breeds and by providing proper shelter and cleaning facilities to animals. Hybrid cattle breeds are produced by crossing the two superior breeds, in which both the characteristics (milk pro
- **Poultry farming-** It is undertaken to obtain egg production and meat. objectives of poultry farming is to improve following traits- Number and quality of chicks,tolerance to high temperatures,dwarf broiler parent for commercial chick production
- duction and diseases resistance) are available.
- **Fish Farming-**Fish is a cheap source of animal protein for our food. Therefore, fish culture is an important part of animal husbandry. The two ways of obtaining fish are - Capture fishing and Culture fishery. Farming can be done in both fresh water (such as rivers, ponds etc.) and marine ecosystems.
- **Apiculture-** It is the practice of bee keeping. Bee farms are also known as apiaries.The quality of honey produced does not depend upon the variety of bees used. The quality of honey is greatly affected by both the quantity and quality of the available flowers, from which bees collect nectar and pollen.
  - Local varieties of bees used commonly for honey production are Apis cerana, Apis dorsata, A. florae.
  - An Italian bee variety A. mellifera is used for commercial production of honey.

Animals and their Products

- Milk and Flesh Yielding Animals - cattle goat, poultry, pig, sheep, etc.
- Draught Animals – horse, donkey, mule, etc.
- Fibre, Hide and Skin Yielding Animals - sheep, goat, cattle, camel, etc.

Some important animals

- Cattle – we obtain milk, cow dung (for gobar gas and manure) from them. Also used to plough fields.
- Sheep and goat – provide meat, wool and hide
- Pig – provides pork and hide

- Poultry – provide meat and eggs
- Fishes – act as nutritious food.
    - Freshwater fishes – Catla, Rohu
    - Marine fishes – Hilsa, salmon
- Honeybees – Reared to obtain honey and beeswax. Queen bee lays eggs which are fertilized by drones. The worker bee looks after larvae and collects nectar from the flowers to produce honey. Rearing honeybees on commercial scale is called apiculture.
- Silk moth – provides silk. Larvae develop into cocoon whose body is covered with silk threads. The commercial rearing of silk moths is called sericulture.
- Food from animals
- Milk obtained from cow, buffalo, goat, and camel
- Meat obtained from chicken, goat, and sheep
- Eggs obtained from chicken and ducks

Some common diseases of useful animals

- Cattle
    - Diarrhoea
    - smallpox
    - Necrosis
    - anthrax
    - haemorrhagic septicaemia
    - pinkeye
    - Mad cow disease
- Poultry
    - fowl pox
    - cholera
    - tuberculosis
    - diarrhoea