Biology

ANIMAL TISSUES

Chapter

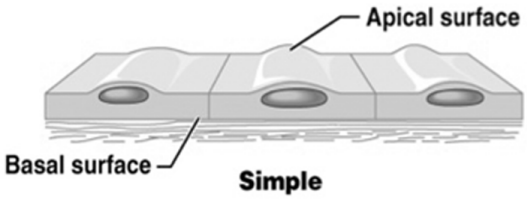
A **tissue** may be defined as a group of similar cells performing a common activity. **Histology** is the study of tissues. An **organ** may be defined as a group of tissues collectively performing a specific function. Finally, an **organ system** may be defined as a group of organs performing a major body function. The multi-cellularity of an organism generally results from mitosis (cell division) of a single cell, followed by differentiation and specialization of the cells. The basic organization of plants and animals is different since plants display indeterminate growth (i.e. they continue to grow bigger and taller throughout their lives) while many animals display determinate growth (i.e. they achieve a mature size and stop growing). In animals, some cells in the various tissues undergo cell division but only to replace dead or damaged cells. Some mature cells (nerve tissue) are incapable of cell division.

ANIMAL TISSUES

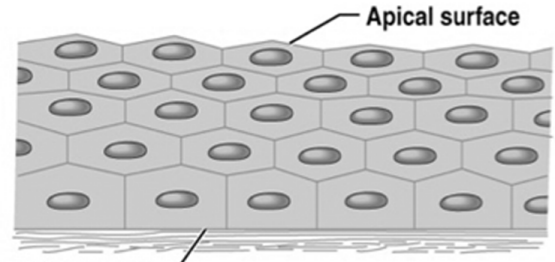
There are four types of tissues found in animals:

I. Epithelial Tissue

Epithelial tissues line body surfaces and cavities, as well as form glands. The cells of the tissue are closely connected to each other via cellular junctions and because epithelium is found on the edges of organs, it has two distinct surfaces. The **apical surface** is exposed to the body cavity or exterior, while the **basal surface** is adjacent to the under lying tissue. Epithelia contains no blood vessels (they are non vascular) and are dependent upon the underlying connective tissue for nutrients. As a group, epithelial tissues



Simple



Stratified

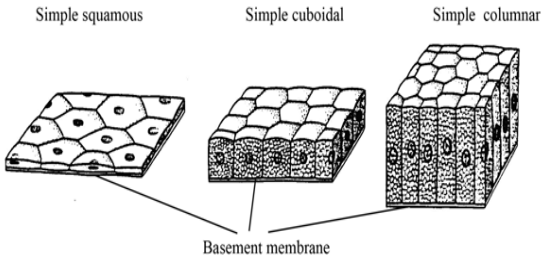
perform a variety of functions, including **protection, absorption, excretion, secretion** and **lubrication**. Epithelial cells can be one of three shapes:

(i) **Squamous** — flat, scale-like cells ("fried-egg" appearance).

(ii) **Cuboidal** — cells appear square in side view with nucleus in a central position.

(iii) **Columnar** — cells appear rectangular in side view with the nucleus displaced toward the base of the cell.

If the epithelium consists of one cell layer it is called **simple epithelium**. **Stratified epithelium** has more than one layer. The combination of cell shape and the number of cell layers is used to classify epihelial tissue (i.e. simple columnar epithelium would consist of a single layer of column shaped cells). Cell shape in stratified epithelium can vary, but the shape of the cells at the apical surface determines the name. The function of epthelial tissue varies depending on its location.



Some types of simple epithelial tissue

II. Connective Tissue

They vary widely in their form and function, but they are all characterized by the presence of **extracellular matrix**. The extracellular matrix is non living material composed of **protein fibres** and **ground substance**. The protein fibers are composed of **collagen** (which gives strength) or **elastin** (which gives flexibility). The number and type of fibers differs between the various types of connective tissue. The ground substance fills the spaces between the cells and the fibers. It contains interstitial fluid (tissue fluid) and large polysaccharide molecules. The consistency of the ground substance can vary from liquid to gel— like to a solid. Nuclei of the connective tissue cells are scattered throughout the collagen fibers. This is the most widespread and abundant type of tissue in the human body. Its function primarily is to **support**, **anchor** and **connect** various parts of the body. Although connective tissue exists in a number of forms, all types have three basic structural elements — cells, fibres and intercellular substance (ground substance). The most common cell types are fibroblasts, which produce fibres and other intercellular materials. The two most common types of fibres are: collagen (collagenous) and elastic. Collagen fibres are for strength while the elastic ones are for elasticity of the tissue. Both the ells and the fibres are embedded in the intercellular substance. The consistency of this substance is highly variable from gelatin-like to a much more rigid material. The proportions of the cells, fibres, and intercellular substance vary, depending on a particular nature and function of the connective tissue. For example, a strong connective tissue needs a greater proportion of the collagen fibres and fewer cells. An example would be a dense regular connective tissue, which is found in tendons and ligaments. On the other hand, a connective tissue composed of mostly cells could not be very strong. An example would be an adipose (fat) connective tissue.

Adipose tissue

Adipose tissue consists of adipocytes, or fat storage cells. It functions in energy storage, insulation, and cushioning. Small pockets of adipose tissue can be found all over the body, but accumulates under the skin (subcutaneous fat) and around certain organs, such as the kidneys. Unlike other connective tissues, it has very little matrix and the cells are closely packed together. Each cell contains a large fat droplet, which pushes the nucleus to the side. Hyaline cartilage is the most abundant type of cartilage in the body and is found in the rib cage, the nose, the trachea, and the ends of long bones. It provides structural support (but is more flexible than bone) and has cushioning properties. Hyaline cartilage has a firm matrix with abundant collagen fibres, but the individual fibers cannot be seen under the microscope. When viewed under the microscope the matrix an amorphous quality (no discernable structures). The cells, which are known as **chondrocytes**, reside in small cavities within the matrix called **lacunae**.

Bone tissue

Bone tissue forms the skeletal system. It functions in structural support, protection, and mineral (calcium) storage. The extracellular matrix of bone tissue contains abundant collagen fibers as well as a hard, calcified ground substance. Mature bone cells, called

osteocytes, reside in cavities within the matrix called lacunae. As bone tissue is formed, channels remain in the hardened matrix that provide passageways for blood vessels and nerves. The larger channels are called central canals (Haversian canals). Bone tissue forms in rings (lamellae) around these canals, creating a structure called an **osteon**. Examine the bone tissue slide, noting the osteons with their lamellae and bulls— eye like central canals. The lacunae, which contain the bone ells, are visible as small dark patches in the lamellae.

Blood

Blood is a typical connective tissue because of the absence of fibers. It is a constantly circulating fluid providing the body with nutrition, oxygen, and waste removal. It is a complex fluid with numerous cells and proteins suspended in it, making blood "thicker" than pure water. The average person has about 5 liters of blood. Normally, 7-8% of human body weight is from blood. It is a combination of plasma (watery liquid) and cells that float in it. It is a specialized bodily fluid that supplies essential substances and nutrients, such as sugar, oxygen, and hormones to our cells, and carries waste away from those cells, this waste is eventually flushed out of the body in urine, faeces, sweat, and lungs (carbon dioxide). Blood also contains clotting agents. It plays a vital role in our immune system and in maintaining a relatively constant body temperature. Blood pH is regulated to stay within the narrow range of 7.35 to 7.45, making it slightly basic. The coloring matter of blood (haemochrome) is largely due to the protein (Haemoglobin) in the blood responsible for oxygen transport.

Formation

Red blood cells, most white blood cells, and platelets are produced in the bone marrow, the soft fatty tissue inside bone cavities. Two types of white blood cells, T and B cells (lymphocytes), are also produced in the lymph nodes and spleen, and T cells are produced and mature in the thymus gland. Within the bone marrow, all blood cells originate from a single type of unspecialized cell called a stem cell. When a stem cell divides, it first becomes an immature red blood cell, white blood cell, or platelet-producing cell. The immature cell then divides, matures further, and ultimately becomes a mature red blood cell, white blood cell, or platelet. The rate of blood cell production is controlled by the body's needs. Normal blood cells last for a limited time (ranging from a few hours to a few days for white blood cells, to about 10 days for platelets, to about 120 days for red blood cells) and must be replaced constantly. Certain conditions may trigger additional production of blood cells. When the oxygen content of body tissues is low or the number of red blood cells decreases, the kidneys produce and release erythropoietin, a hormone that stimulates the bone marrow to produce more red blood cells. The bone marrow produces and releases more white blood cells in response to infections. It produces and releases more platelets in response to bleeding.

Components

Blood is a highly specialized tissue composed of more than 4,000 different kinds of components. Four of the most important ones are red cells, white cells, platelets, and plasma.The fluid portion of the blood carries nutrients needed to fuel each cell in the body. It also shuttles wastes that need to be transported to the excretory system to be passed out of the body and carbon dioxide that needs to be transported to the lungs to be exhaled.

❐ Red blood cells

The red blood cells, which are also called erythrocytes (erythro means red, cytes means cells), have the important responsibility of carrying the oxygen throughout the body. Hemoglobin exists in the red blood cells. Haemoglobin not only binds oxygen and transports it to the capillaries, but it also helps to transport carbon dioxide from the capillaries back to the lungs to be exhaled. Red blood cells make up about 40% of the blood's volume. They are relatively large microscopic cells without nuclei. In this latter trait, they are similar to the primitive prokaryotic cells of bacteria.

❐ White blood cells

White blood cells (also called leukocytes (leuko = white) are fewer in number than red blood cells, with a ratio of about 1 white blood cell to every 600 to 700 red blood cells. White blood cells are responsible primarily for defending the body against infection. The immune system is responsible for fighting infections. If a person has a low white blood cell count, it means that the immune system is not functioning properly. If a white blood cell count is too high, it indicates that the person has some type of infection.

There are two major classes of white blood cells:

Granular Leukocytes

The three types of granular leukocytes are neutrophils, eosinophils, and basophils. Each type of granular leukocyte is classified by the presence of chemical-filled vesicles in their cytoplasm that give them their function. Neutrophils contain digestive enzymes that neutralize bacteria that invade the body. Eosinophils contain digestive enzymes specialized for digesting viruses that have been bound to by antibodies in the blood. Basophils release histamine to intensify allergic reactions and help protect the body from parasites.

Agranular Leukocytes

The two major classes of agranular leukocytes are lymphocytes and monocytes. Lymphocytes include T cells and natural killer cells that fight off viral infections and B cells that produce antibodies against infections by pathogens. Monocytes develop into cells called macrophages that engulf and ingest pathogens and the dead cells from wounds or infections

Some white blood cells flow smoothly through the bloodstream, but many adhere to blood vessel walls or even penetrate the vessel walls to enter other tissues. When white blood cells reach the site of an infection or other problem, they release substances that attract more white blood cells.

❐ Platelets

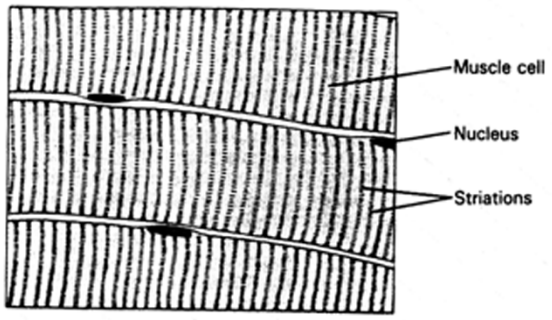
Platelets or thrombocytes are cell fragments without nuclei that work with blood clotting chemicals at the site of wounds. They are smaller than red or white blood cells. Platelets are fewer in number than red blood cells, with a ratio of about 1 platelet to every 20 red blood cells. Platelets help in the clotting process by gathering at a bleeding site and clumping together to form a plug that helps seal the blood vessel. At the same time, they release substances that help promote further clotting. When the number of platelets is too low (thrombocytopenia), bruising and abnormal bleeding become more likely. They also can release coagulating chemicals which cause clots to form in the blood that can plug up narrowed blood vessels. Individual platelets are about 1/3 the size of red cells. They have a lifespan of 9-10 days. They are produced in bone marrow from stem cells.

❐ Plasma

Plasma is a straw coloured, viscous fluid constituting nearly 55 percent of the blood. 90-92 per cent of plasma is water and proteins contributes 6-8 Percent of it. Fibrinogen, globulins and albumins are the major proteins. It is the liquid component of blood, in which the red blood cells, white blood cells, and platelets are suspended. The major protein in plasma is albumin. Albumin helps keep fluid from leaking out of blood vessels and into tissues, and albumin binds to and carries substances such as hormones and certain drugs. Other proteins in plasma include antibodies. Plasma has other functions. It acts as a reservoir that can either replenish insufficient water or absorb excess water from tissues. When body tissues need additional liquid, water from plasma is the first resource to meet that need. Plasma also prevents blood vessels from collapsing and clogging and helps maintain blood pressure and circulation throughout the body simply by filling blood vessels and flowing through them continuously. Plasma without the clotting factors is called serum.

III. Muscle Tissue

Muscle cells are highly specialized for contractions. Such contractions may result in the movement of the whole body or a portion of it, if the muscles are attached to a movable part of the skeleton. If the muscle is located in the wall of a hollow organ, its contractions may cause the contents of the organ to move, e.g. peristaltic movement of material through the digestive tract. Several specific terms are used exclusively for muscle tissue. For example, muscle cells are called fibres, their cytoplasm is termed sarcoplasm; and their cell membrane is referred to as sarcolemma. Three types of muscle tissue are distinguished on he basis of structural, functional and locational differences:



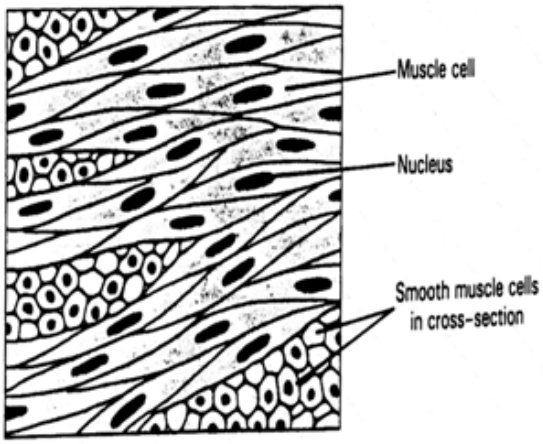
(a) Skeletal (Striated) Muscle

Skeletal muscles form the "flesh"; sometimes referred to as the red meat" of an animal's body. They are attached to, and result in, the movement of the bones of the skeleton. For example, the biceps brachii and pectoralis are skeletal muscles. As the contraction of the skeletal muscles is under conscious control, they are also called voluntary muscles. A typical skeletal muscle cell is a highly modified, giant, multi-nucleate cell (fibre). Each fibre is cylindrical in shape with blunt, rounded ends. The flattened nuclei are located mainly at the periphery of the cell, just inside the sarcolemma. The "cross-striped" (or striated) appearance of light and dark banding results from the arrangement of myofibrils, small protein contractile units embedded in the sarcoplasm .

(b) Smooth Muscle

Smooth muscles are abundant throughout the internal organs of the body especially in regions such as the digestive tract. As its contraction is not under conscious nervous control, it is referred to as involuntary muscle. Smooth muscle fibres are spindle-shaped structures with a prominent centrally located nucleus. they have a single nucleus, and have tapered ends. In comparison with skeletal muscle fibres, they are much shorter in length and they do not exhibit striations. The cells occur as individual fibres within organs or as groups of fibres closely interlaced in sheets

or bands. In blood vessels there is a layer of smooth muscle deep to the epithelial layer

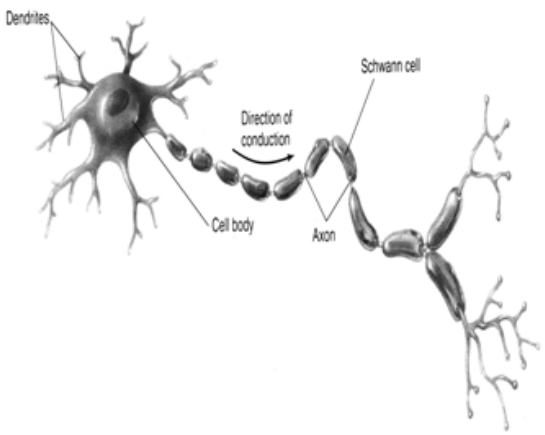


(c) Cardiac Muscle

Cardiac muscle is a highly specialized tissue restricted to the wall of the heart. It is also an involuntary type of muscle, as its contraction is not consciously controlled. Cardiac muscle is present in the heart. Cells are striated, but the striations are much less obvious than in skeletal muscle tissue. The cells are shorter than skeletal muscle fibers, have a single nucleus and are often branched. Individual cells are connected via gap junctions. These cellular connections are visible under the microscope as dark bands called **intercalated disks**. These cellular communication junctions are necessary for the coordinated beating of the heart.

IV. Nervous Tissue

Nervous tissue is specialized for communication and comprises the brain, spinal cord, and peripheral nerves. The tissue consists of two major cell types: **neurons** and **glial cells**. Neuron communicate with each other via electrical and chemical signals. They have



nucleated cell bodies and two types of elongate cellular processes: dendrites–which receive signals, and axons–which send signals. Glial cells are the support cells of nervous tissue. There are several different types with various functions, including maintaining proper ion concentrations in the fluid surrounding neurons, generating myelin (an insulating material that surrounds some axons), and cleaning up debris. Note the large neurons with their elongated cellular processes and the smaller, more numerous glial cells. The components of nervous tissue are specialized for the conduction of electrical impulses, which allow communication among other tissue types. The major structural and functional "unit" of nervous tissue is the nerve cell called neuron. Each neuron is composed of a cell body containing a nucleus and one or more long cytoplasmic extensions known as fibres. Highly branched fibres, called dendrites, bring impulses toward the cell body, while a single, unbranched fibre, the axon, carries information away from the cell body. The overall length of a neuron, including dendrites, cell body and axon, may vary from less than two centimeters to a meter or more.

■■■