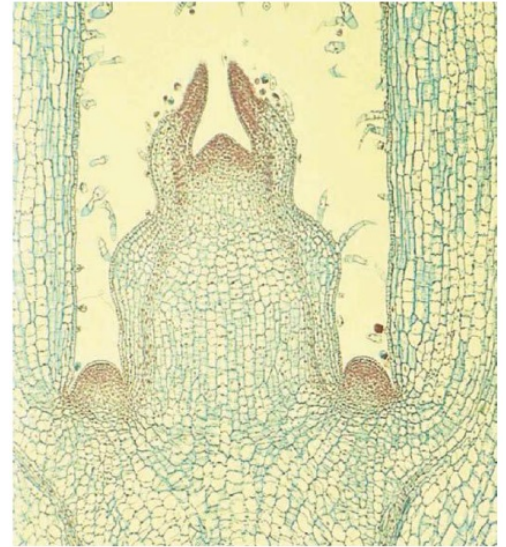


Organization of the Organism

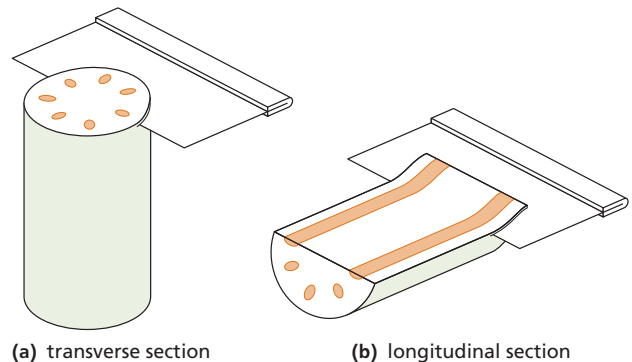
Cell Structure and Organization:

Cell Structure:

If a very thin slice of a plant stem is cut and studied under a microscope, it can be seen that the stem consists of thousands of tiny, box-like structures. These structures are called **cells**. The figure below is a thin slice taken from the tip of a plant shoot and photographed through a microscope. Photographs like this are called **photomicrographs**. The one in the figure is 60 times larger than life, so a cell which appears to be 2 mm long in the picture is only 0.03 mm long in life.

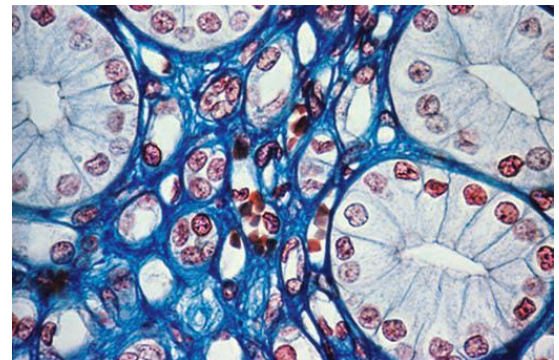


Thin slices of this kind are called **sections**. If you cut *along the length* of the structure, you are taking a **longitudinal section**. The figure above shows a longitudinal section, which passes through two small developing leaves near the tip of the shoot, and two larger leaves below them. The leaves, buds and stem are all made up of cells. If you cut *across* the structure, you make a **transverse section**.



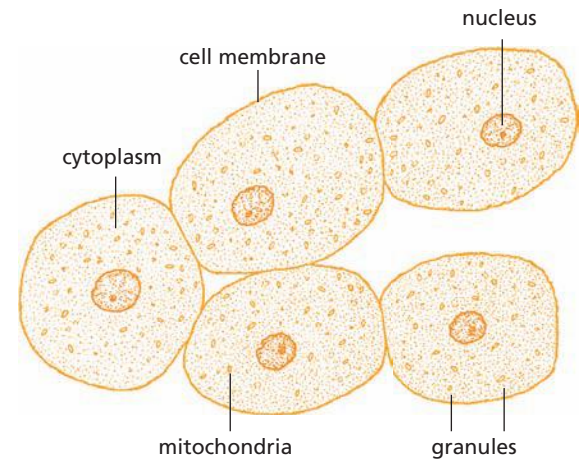
It is fairly easy to cut sections through plant structures just by using a razor blade. To cut sections of animal structures is more difficult because they are mostly soft and flexible. Pieces of skin, muscle or liver, for example, first have to be soaked in melted wax. When the wax goes solid it is then possible to cut thin sections. The wax is dissolved away after making the section.

When sections of animal structures are examined under the microscope, they, too, are seen to be made up of cells but they are much smaller than plant cells and need to be magnified more. The photomicrograph of kidney tissue in the figure has been magnified 700 times to show the cells clearly. The sections are often treated with dyes, called **stains**, in order to make the structures inside the cells show up more clearly.



Making sections is not the only way to study cells. Thin strips of plant tissue, only one cell thick, can be pulled off stems or leaves. Plant or animal tissue can be squashed or smeared on a microscope slide or treated with chemicals to separate the cells before studying them.

There is no such thing as a typical plant or animal cell because cells vary a great deal in their size and shape depending on their function. Nevertheless, it is possible to make a drawing like the figure to show features which are present in most cells. *All cells* have a **cell membrane**, which is a thin boundary enclosing the **cytoplasm**. Most cells have a **nucleus**.



Cytoplasm:

Under the ordinary microscope (light microscope), cytoplasm looks like a thick liquid with particles in it. In plant cells it may be seen to be flowing about. The particles may be food reserves such as oil droplets or granules of starch. Other particles are structures known as **organelles**, which have particular functions in the cytoplasm. In the cytoplasm, a great many chemical reactions are taking place which keep the cell alive by providing energy and making substances that the cell needs.

The liquid part of cytoplasm is about 90% water with molecules of salts and sugars dissolved in it. Suspended in this solution there are larger molecules of fats (lipids) and proteins. Lipids and proteins may be used to build up the cell structures, such as the membranes. Some of the proteins are **enzymes**. Enzymes control the rate and type of chemical reactions which take place in the cells. Some enzymes are attached to the membrane systems of the cell, whereas others float freely in the liquid part of the cytoplasm.

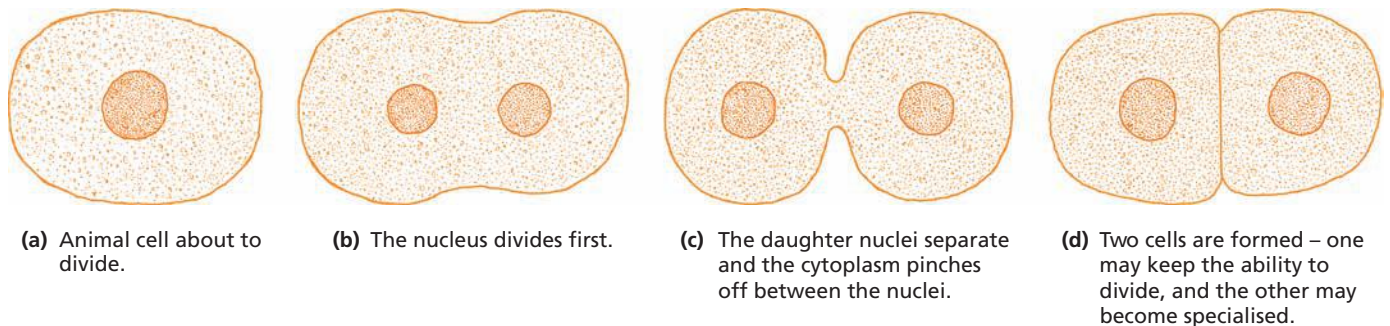
Cell Membrane:

This is a thin layer of cytoplasm around the outside of the cell. It stops the cell contents from escaping and also controls the substances which are allowed to enter and leave the cell. In general, oxygen, food and water are allowed to enter; waste products are allowed to leave and harmful substances are kept out. In this way the cell membrane maintains the structure and chemical reactions of the cytoplasm.

Nucleus (plural: nuclei):

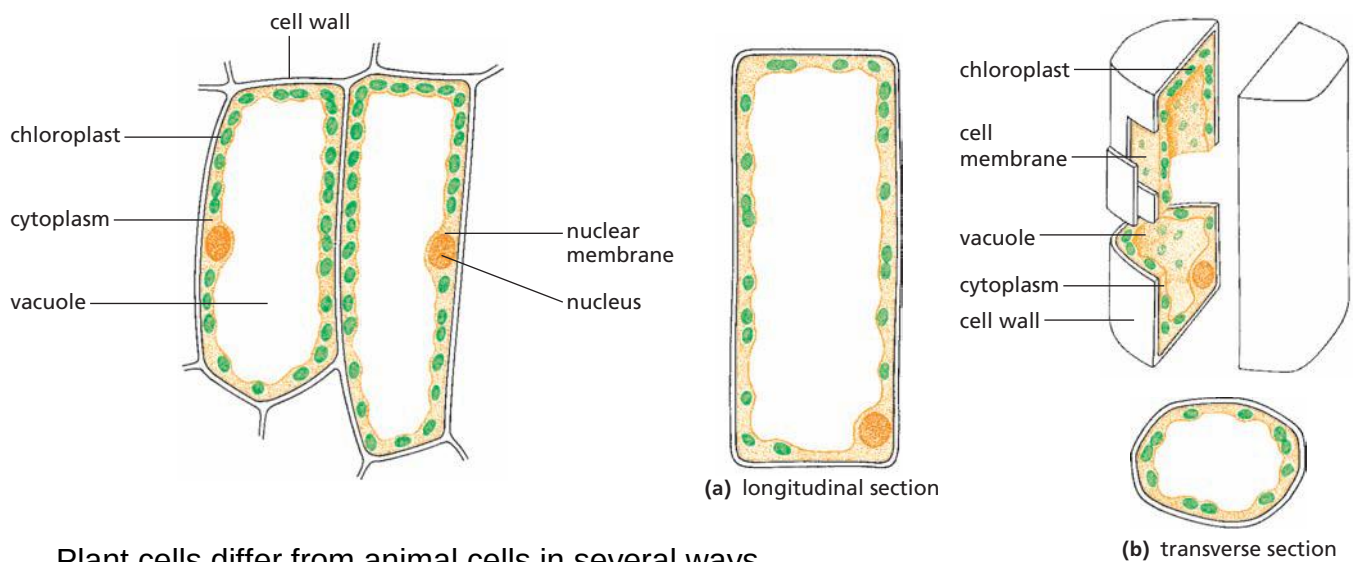
Most cells contain one nucleus, which is usually seen as a rounded structure enclosed in a membrane and embedded in the cytoplasm. In drawings of cells, the nucleus may be shown darker than the cytoplasm because, in prepared sections, it takes up certain stains more strongly than the cytoplasm. The function of the nucleus is to control the type and quantity of enzymes produced by the cytoplasm. In this way it regulates the chemical changes which take place in the cell. As a result, the nucleus determines what the cell will be, for example, a blood cell, a liver cell, a muscle cell or a nerve cell.

The nucleus also controls cell division, as shown in the figure below. A cell without a nucleus cannot reproduce. Inside the nucleus are thread-like structures called **chromosomes**, which can be seen most easily at the time when the cell is dividing.



Plant Cells:

A few generalized animal cells are represented by the figure above, while the figure below is a drawing of two palisade cells from a plant leaf.



Plant cells differ from animal cells in several ways.

1. Outside the cell membrane they all have a **cell wall** which contains cellulose and other compounds. It is non-living and allows water and dissolved substances to pass through. The cell wall is not selective like the cell membrane. (Note that plant cells *do* have a cell membrane but it is not easy to see or draw because it is pressed against the inside of the cell wall).

Under the microscope, plant cells are quite distinct and easy to see because of their cell walls. In the first figure it is only the cell walls (and in some cases the nuclei) which can be seen. Each plant cell has its own cell wall but the boundary between two cells side by side does not usually show up clearly. Cells next to each other therefore appear to be sharing the same cell wall.

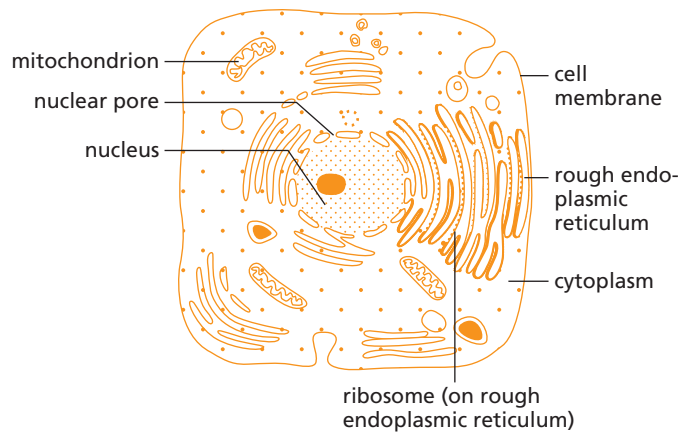
- Most mature plant cells have a large, fluid-filled space called a **vacuole**. The vacuole contains **cell sap**, a watery solution of sugars, salts and sometimes pigments. This large, central vacuole pushes the cytoplasm aside so that it forms just a thin lining inside the cell wall. It is the outward pressure of the vacuole on the cytoplasm and cell wall which makes plant cells and their tissues firm. Animal cells may sometimes have small vacuoles in their cytoplasm but they are usually produced to do a particular job and are not permanent.
- In the cytoplasm of plant cells are many organelles called **plastids**. These are not present in animal cells. If they contain the green substance **chlorophyll**, the organelles are called **chloroplasts**. Colorless plastids usually contain starch, which is used as a food store.

Summary of The Parts of a Cell:

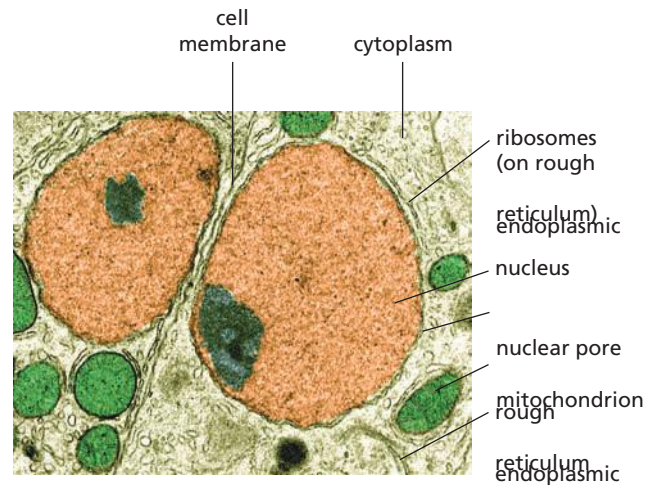
	Name of part	Description	Where found	Function
Animal and plant cells	cytoplasm	jelly-like, with particles and organelles in	enclosed by the cell membrane	contains the cell organelles, e.g. mitochondria, nucleus site of chemical reactions
	cell membrane	a partially permeable layer that forms a boundary around the cytoplasm	around the cytoplasm	prevents cell contents from escaping controls what substances enter and leave the cell
	nucleus	a circular or oval structure containing DNA in the form of chromosomes	inside the cytoplasm	controls cell division controls cell development controls cell activities
Plant cells only	cell wall	a tough, non-living layer made of cellulose surrounding the cell membrane	around the outside of plant cells	prevents plant cells from bursting allows water and salts to pass through (freely permeable)
	vacuole	a fluid-filled space surrounded by a membrane	inside the cytoplasm of plant cells	contains salts and sugars helps to keep plant cells firm
	chloroplast	an organelle containing chlorophyll	inside the cytoplasm of some plant cells	traps light energy for photosynthesis

When studied at much higher magnifications with the **electron microscope**, the cytoplasm of animal and plant cells no longer looks like a structureless jelly but appears to be organized into a complex system of membranes and vacuoles. Organelles present include the **rough endoplasmic reticulum**, a network of flattened cavities surrounded by a membrane, which links with the nuclear membrane. The membrane holds **ribosomes**, giving its surface a rough appearance. Rough endoplasmic reticulum has the function of producing, transporting and storing proteins. Ribosomes can also be found free in the cytoplasm. They build up the cell's proteins.

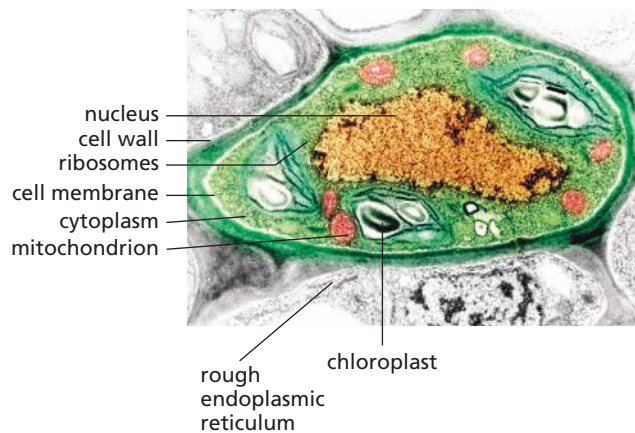
Mitochondria are tiny organelles, which may appear slipper-shaped, circular or oval when viewed in section. In three dimensions, they may be spherical, rod-like or elongated. They have an outer membrane and an inner membrane with many inward-pointing folds. Mitochondria are most numerous in regions of rapid chemical activity and are responsible for producing energy from food substances through the process of aerobic respiration.



(a) diagram of a liver cell ($\times 10\,000$)



(b) electron micrograph of two liver cells ($\times 10\,000$)



(c) electron micrograph of a plant cell ($\times 6\,000$)

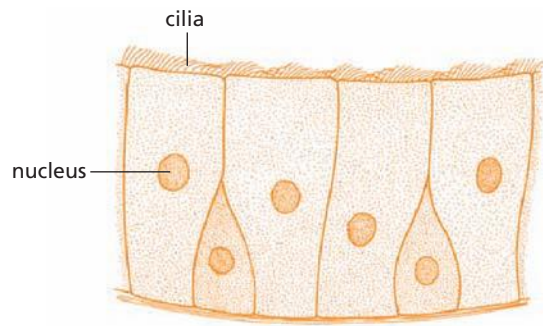
Levels of Organization:

Specialization of cells Most cells, when they have finished dividing and growing, become specialized. When cells are specialized:

- They do one particular job.
- They develop a distinct shape.
- Special kinds of chemical change take place in their cytoplasm.

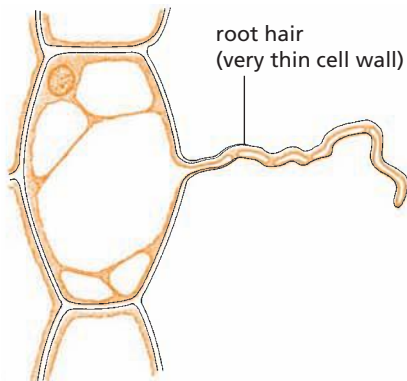
The changes in shape and the chemical reactions enable the cell to carry out its special function. Red blood cells and root hair cells are just two examples of specialized cells. The figure below shows a variety of specialized cells.

The specialization of cells to carry out particular functions in an organism is sometimes referred to as **division of labor** within the organism. Similarly, the special functions of mitochondria, ribosomes and other cell organelles may be termed division of labor within the cell.



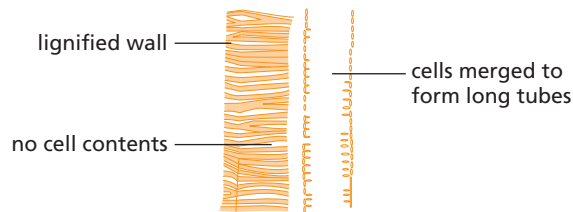
(a) ciliated cells

These cells form the lining of the nose and windpipe, and the tiny cytoplasmic 'hairs', called cilia, are in a continual flicking movement which creates a stream of fluid (mucus) that carries dust and bacteria through the bronchi and trachea, away from the lungs.



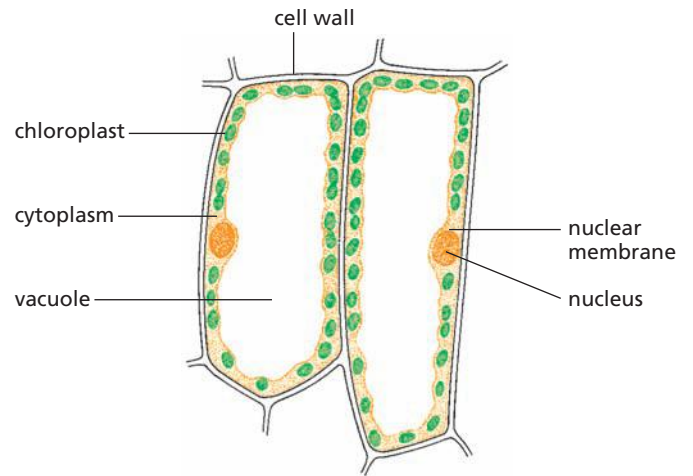
(b) root hair cell

These cells absorb water and mineral salts from the soil. The hair-like projection on each cell penetrates between the soil particles and offers a large absorbing surface. The cell membrane is able to control which dissolved substances enter the cell.



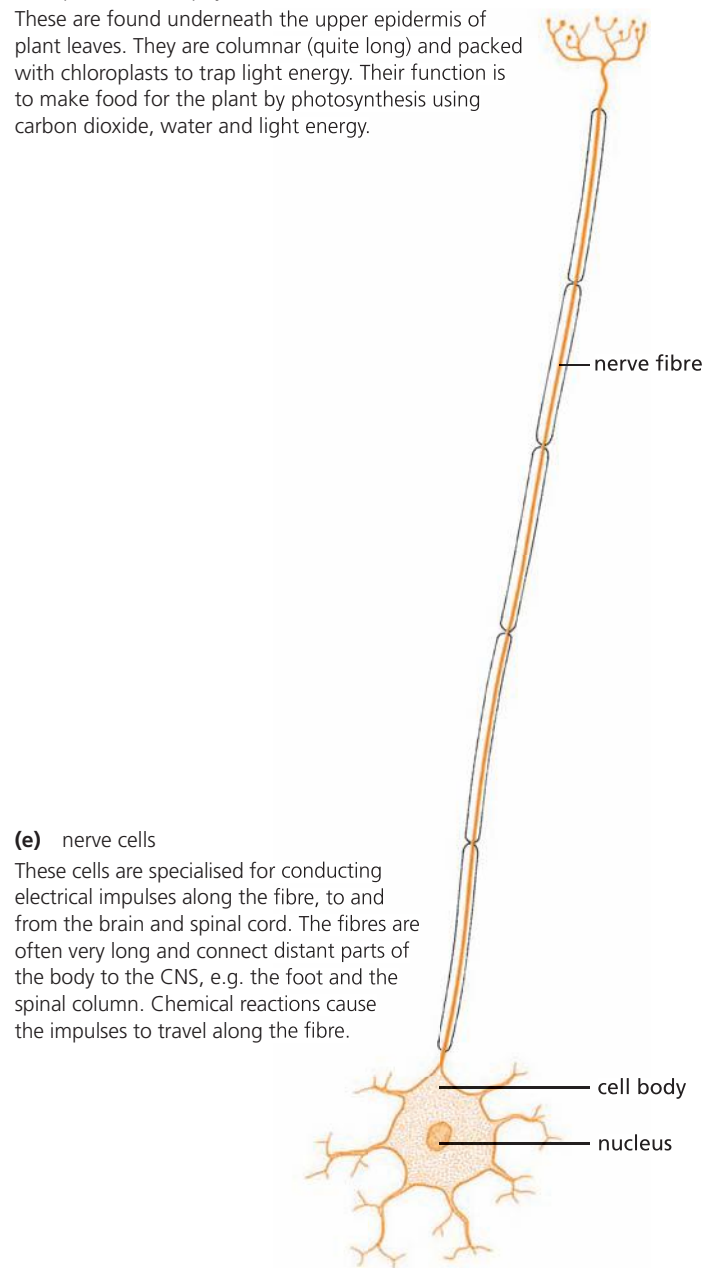
(c) xylem vessels

These cells transport mineral ions from the roots to the leaves. A substance called lignin impregnates and thickens the cell walls making the cells very strong and impermeable. This gives the stem strength. The lignin forms distinctive patterns in the vessels – spirals, ladder shapes, reticulate (net-like) and pitted. Xylem vessels are made up of a series of long xylem cells joined end-to-end. Once a region of the plant has stopped growing, the end walls of the cells are digested away to form a continuous, fine tube. The lignin thickening prevents the free passage of water and nutrients, so the cytoplasm in the cells dies. Effectively, the cells form long, thin, strong straws.



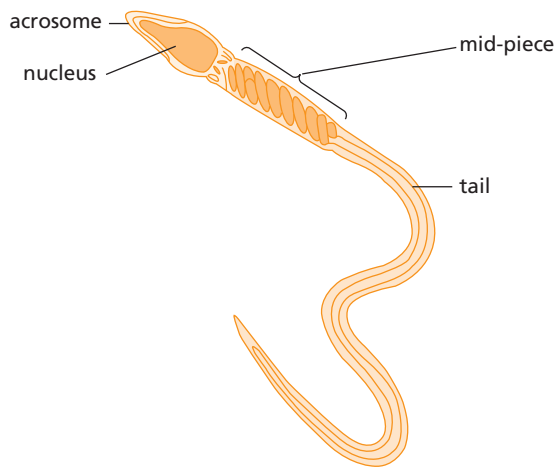
(d) palisade mesophyll cells

These are found underneath the upper epidermis of plant leaves. They are columnar (quite long) and packed with chloroplasts to trap light energy. Their function is to make food for the plant by photosynthesis using carbon dioxide, water and light energy.



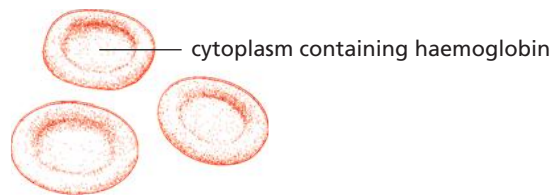
(e) nerve cells

These cells are specialised for conducting electrical impulses along the fibre, to and from the brain and spinal cord. The fibres are often very long and connect distant parts of the body to the CNS, e.g. the foot and the spinal column. Chemical reactions cause the impulses to travel along the fibre.



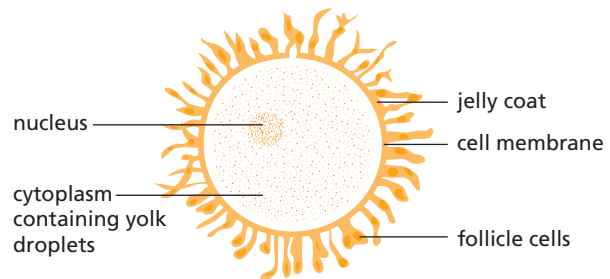
(g) sperm cell

Sperm cells are male sex cells. The front of the cell is oval shaped and contains a nucleus which carries genetic information. There is a tip, called an acrosome, which secretes enzymes to digest the cells around an egg and the egg membrane. Behind this is a mid-piece which is packed with mitochondria to provide energy for movement. The tail moves with a whip-like action enabling the sperm to swim. Their function is reproduction, achieved by fertilising an egg cell.



(f) red blood cells

These cells are distinctive because they have no nucleus when mature. They are tiny disc-like cells which contain a red pigment called haemoglobin. This readily combines with oxygen and their function is the transport of oxygen around the body.



(h) egg cell

Egg cells (ova, singular: ovum) are larger than sperm cells and are spherical. They have a large amount of cytoplasm, containing yolk droplets made up of protein and fat. The nucleus carries genetic information. The function of the egg cell is reproduction.

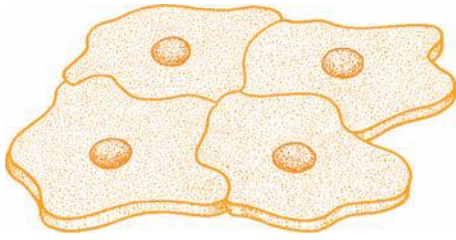
Tissues and Organs:

There are some microscopic organisms that consist of one cell only. These can carry out all the processes necessary for their survival. The cells of the larger plants and animals cannot survive on their own. A muscle cell could not obtain its own food and oxygen. Other specialized cells have to provide the food and oxygen needed for the muscle cell to live. Unless these cells are grouped together in large numbers and made to work together, they cannot exist for long.

Tissues:

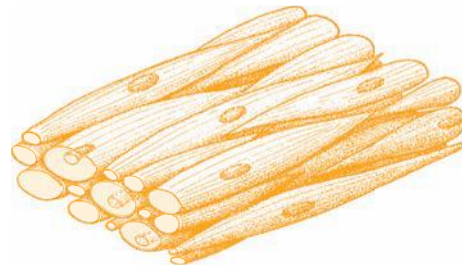
Tissue: a group of cells with similar structures, working together to perform a shared function.

A **tissue**, such as bone, nerve or muscle in animals, and epidermis, xylem or pith in plants, is made up of many hundreds of cells often of a single type. The cells of each type have a similar structure and function so that the tissue itself can be said to have a particular function; for example, muscles contract to cause movement, xylem carries water in plants.



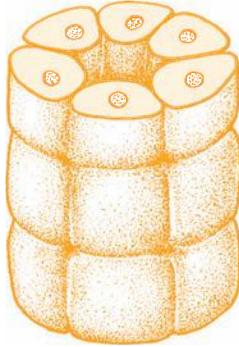
(a) cells forming an epithelium

A thin layer of tissue, e.g. the lining of the mouth cavity. Different types of epithelium form the internal lining of the windpipe, air passages food canal, etc., and protect these organs from physical or chemical damage.



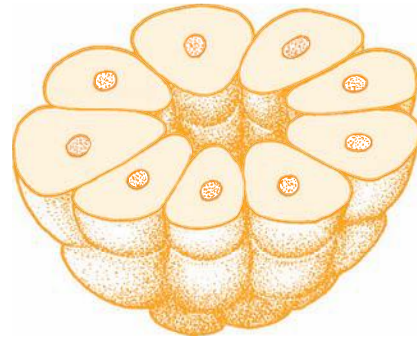
(c) one kind of muscle cell

Forms a sheet of muscle tissue. Blood vessels, nerve fibres and connective tissues will also be present. Contractions of this kind of muscle help to move food along the food canal or close down small blood vessels.



(b) cells forming a small tube

Tubules such as this carry liquids from one part of an organ to another.



(d) cells forming part of a gland

The cells make chemicals which are released into the central space and carried away by a tubule such as shown in **(b)**. Hundreds of cell groups like this would form a gland like the salivary gland.

Organs:

Organ: a structure made up of a group of tissues, working together to perform a specific function.

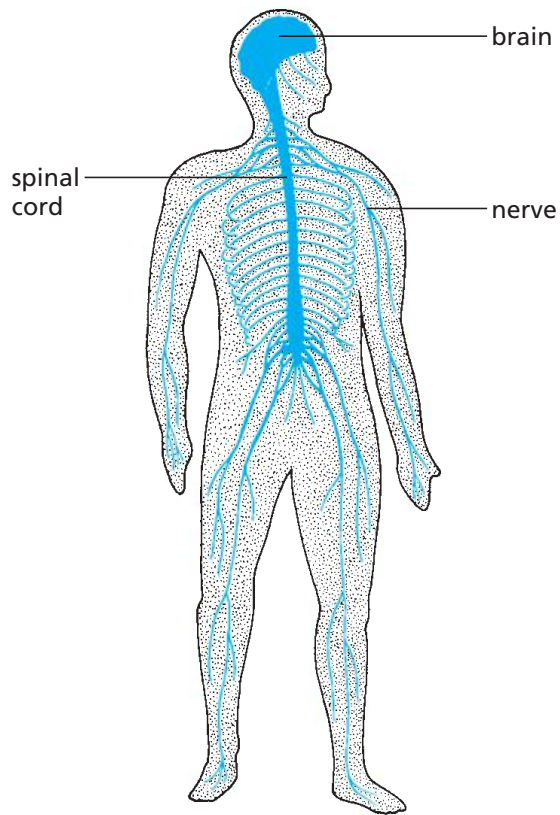
Organs consist of several tissues grouped together to make a structure with a special function. For example, the stomach is an organ which contains tissues made from epithelial cells, gland cells and muscle cells.

These cells are supplied with food and oxygen brought by blood vessels. The stomach also has a nerve supply. The heart, lungs, intestines, brain and eyes are further examples of organs in animals. In flowering plants, the root, stem and leaves are the organs. The tissues of the leaf include epidermis, palisade tissue, spongy tissue, xylem and phloem.

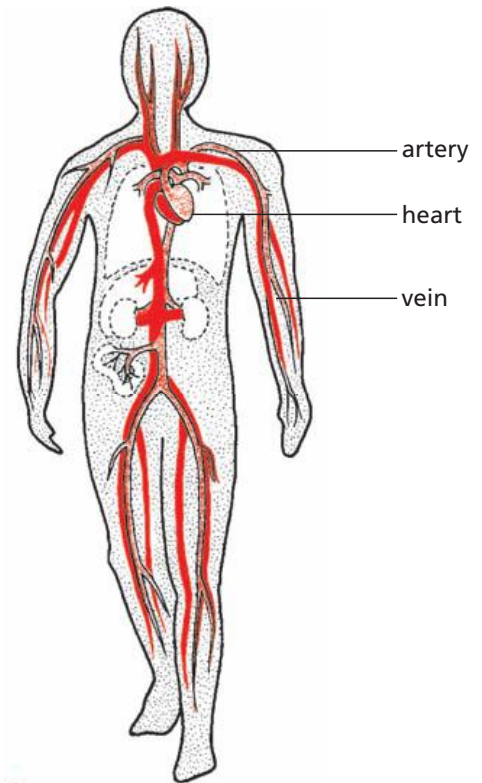
Organ Systems:

System: a group of organs with related functions, working together to perform a body function.

An **organ system** usually refers to a group of organs whose functions are closely related. For example, the heart and blood vessels make up the **circulatory system**; the brain, spinal cord and nerves make up the **nervous system**. In a flowering plant, the stem, leaves and buds make up a system called the **shoot**.



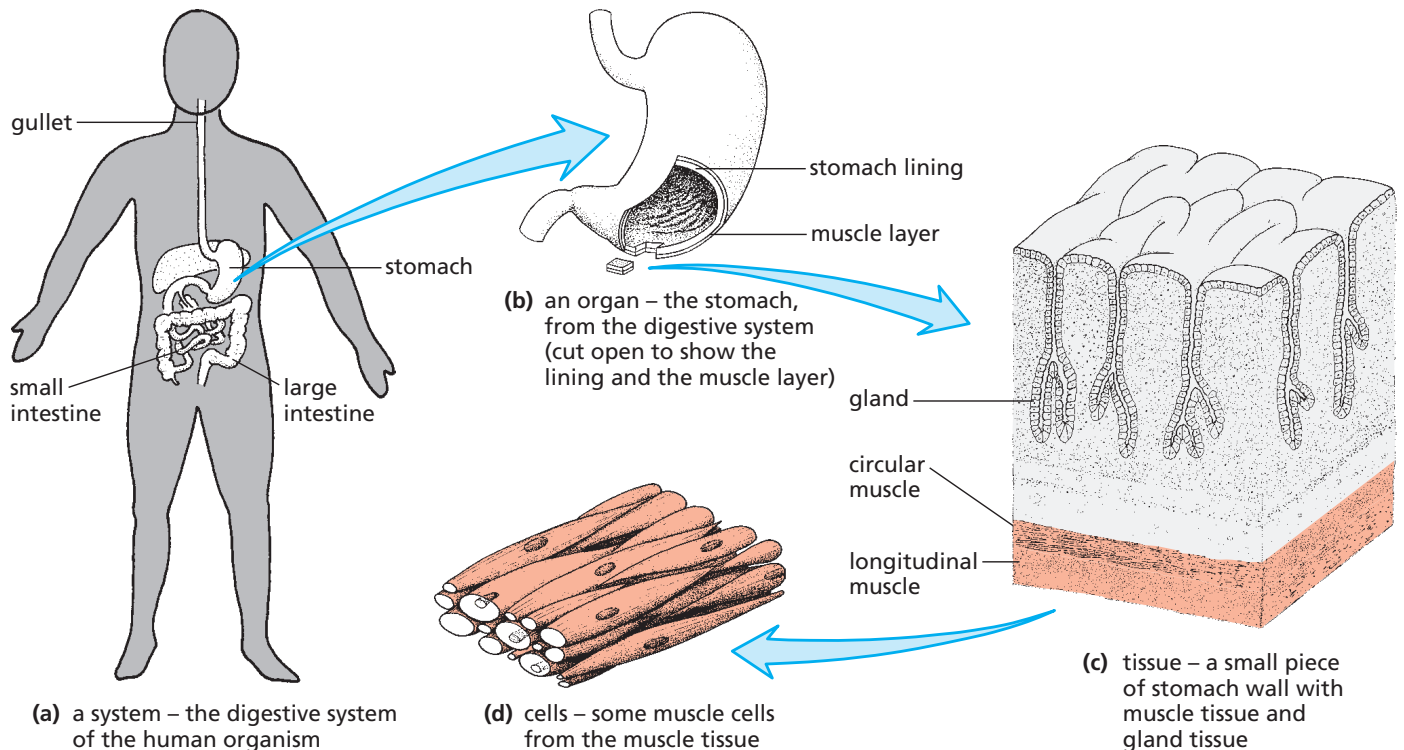
(a) nervous system



(b) circulatory system

Organisms:

An **organism** is formed by the organs and systems working together to produce an independent plant or animal.



Size of Specimens:

Law of Magnification:

$$\frac{\text{Actual Length of Drawing}}{\text{Length of Drawing on Microscope}}$$

1 Centimeter (cm): 10 Millimeter (mm): 1000 Micrometer (μm)