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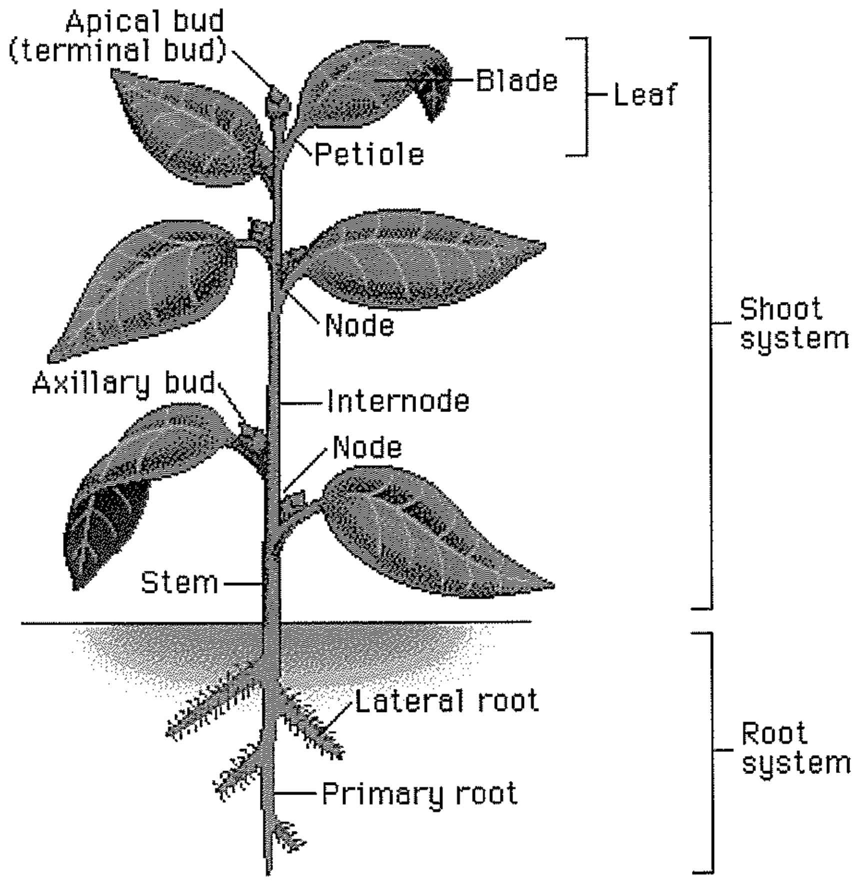
Unit Standard 22177

Demonstrate knowledge of the structure and function of plants

Version 1 Level 2 Credit 5



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Contents

Plant parts

When studying agricultural and horticultural plants, it is important not only to recognise the different types of agricultural and horticultural plants, but also to appreciate plant forms, and to recognise leaves, stems and roots. In many plants this is easy, but in some plants their structure has been modified making recognition difficult.

Plants have existed long before people began to manipulate them for food and shelter. The ability of plants to absorb carbon dioxide and give off oxygen has made them an essential part of life on earth. Plant roots anchor valuable topsoil, preventing erosion from occurring. Plant leaves decay which forms humus, so improving soil structure.

When you have finished this module you should be able to:

- Describe the external parts of a plant
- Explain the function of the external parts of plants
- Describe the internal parts of plants
- Explain the function of the internal parts of plants.

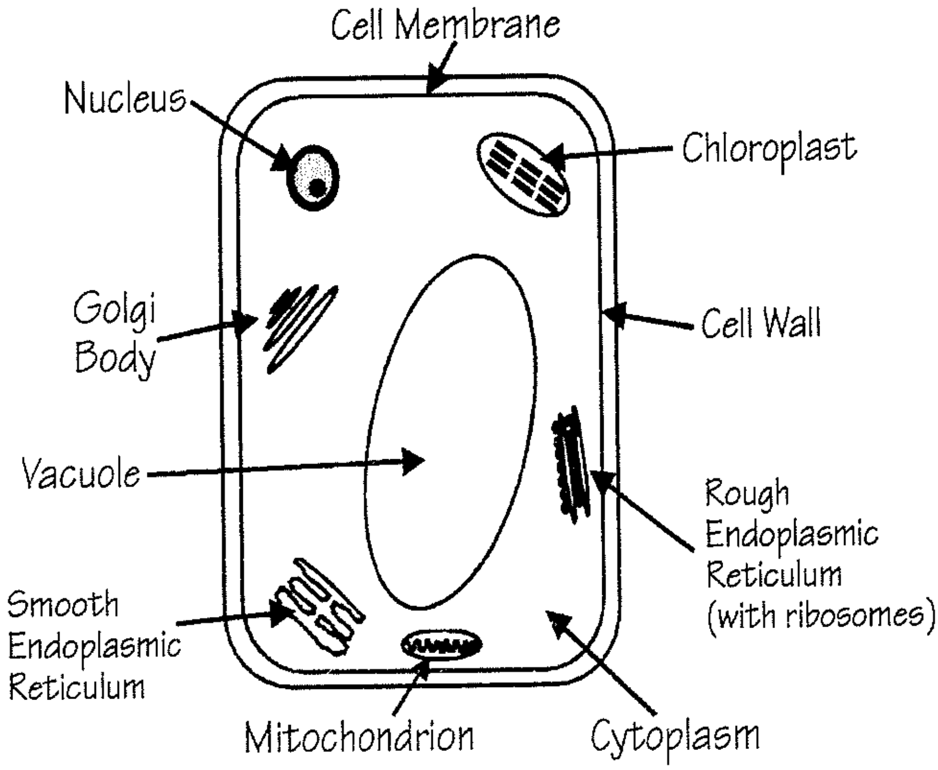
Plant cells

The cell is the basic ***component*** (*building block*) of all living organisms. All metabolic processes occur within the cell. The cells of plants are surrounded by a very rigid cell wall, while the cells of animals are surrounded by a very thin cell membrane.

A plant cell has a prominent ***nucleus***, which is the control centre for the cell. Within the nucleus are the ***nucleolus*** and the ***chromatin***. It is from the chromatin that ***chromosomes*** develop. The chromosomes contain ***genes***, which are the ***units of inheritance***, and is how ***traits*** from parents are passed onto their offspring. Chromosomes are made of a chemical substance called ***deoxyribonucleic acid***, or ***DNA***.

TYPICAL PLANT CELL

The *cell* **wall**



surrounds the plant cell and allows dissolved certain substances (solvents and solutes) to move through it. It is relatively rigid, which means it gives support and protection to the plant. Cell walls are produced by the cytoplasm of the cell.

Cells of soft, green plant material have only a ***primary cell wall***, made of protein, cellulose and hemicellulose. ***Cells of woody plant material*** have a ***secondary cell wall*** inside the primary cell wall. The secondary cell wall is made of cellulose, hemicellulose and lignin. When a cell develops a secondary cell wall, the primary cell wall will also contain lignin. Lignin increases the strength and rigidity of plant cell walls that contain it. This is the reason for the strength of wood.

The ***cell membrane*** is found inside the cell wall and encloses and limits the contents of the cell. Water can pass freely through the cell membrane, but other substances and molecules can be prevented from moving through the cell membrane.

The ***cytoplasm*** is 75 - 90% water, and contains proteins, lipids (fatty material) and carbohydrates. The cytoplasm contains the various cell structures.

The ***endoplasmic reticulum*** is a network of membrane channels through the cell. There are two types of endoplasmic reticulum, rough and smooth. Attached to the rough endoplasmic reticulum are round spheres called ***ribosomes***. Ribosomes and the endoplasmic reticulum are involved in the formation and production of proteins within the cell.

Golgi bodies are another network of membrane channels. They are involved in the development of cell walls and the transporting of material between cells.

The ***nucleus*** is an oval-shaped structure surrounded by a nuclear membrane. The nucleus contains the chromosomes which are made up of deoxyribonucleic acid (DNA). This is the genetic information of the cell.

The most important structures in the plant cell are the ***chloroplasts***. Chloroplasts contain chlorophyll (which gives plants their green colour) and are responsible for the production of food and energy during the photosynthesis process.

Mitochondria are the cells centre for energy production. Mitochondria contain lipids and are surrounded by an outer membrane. Another membrane is folded inwards into the mitochondria.

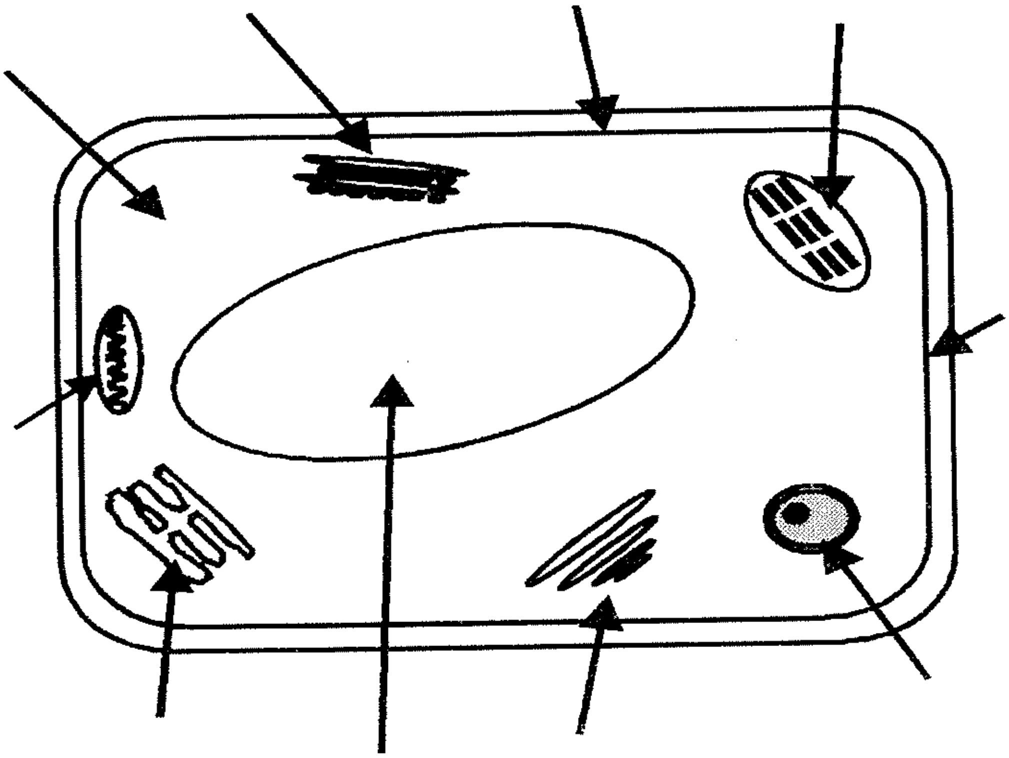
The ***vacuole*** is membrane-bound sac that acts as a storage structure for the plant cell.
It contains mineral nutrients and water.

Test Yourself #1

1. Complete this table.

CELL STRUCTURE	FUNCTION
Cytoplasm	
Endoplasmic Reticulum	
Cell Wall	
Ribosomes	
Chloroplasts	
Cell Membrane	
Nucleus	
Golgi Body	
Vacuole	
Mitochondrion	

2. Label this diagram.



Plant parts

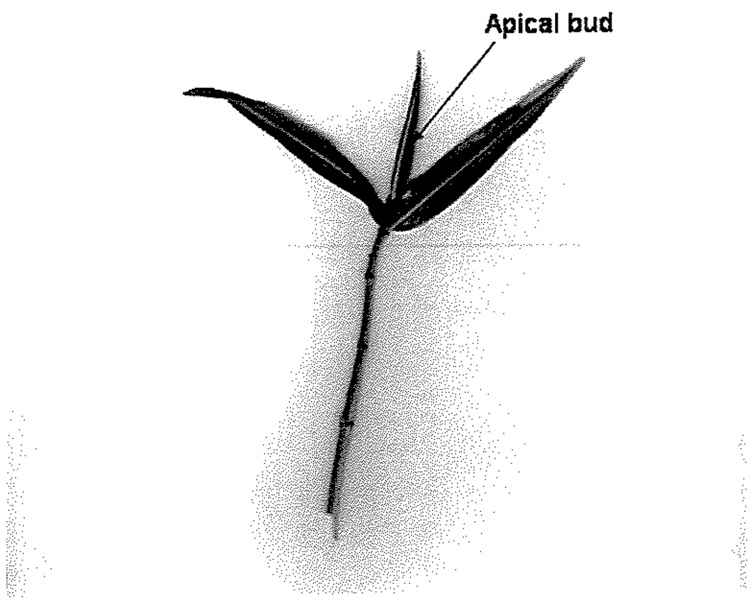
Although plants have a wide range of forms, they all have a basic structure which is divided into:

- parts concerned with growth
- parts concerned with reproduction

The basic building block of plants is the ***cell***. A collection of groups of identical cells is called a ***tissue***. A plant is made up of different types of tissues, each one performing a special function. The main tissue types that make up a plant are:

Meristem

Meristem tissue is located in actively growing regions of the plant, for example in the shoot and root apices. Meristematic cells are small, with a large nucleus and small vacuole. These cells are many-sided, like a soccer ball. Meristematic cells are capable of dividing by the process known as mitosis. This is where one cell divides into two identical cells. As the stem or root grows, the meristematic cells differentiate, that is, change, into specialized cells such as cortex or epidermis. A mature cell no longer has the ability to divide.



Hebe shoot showing the location of the apical or terminal bud

Epidermis

This tissue is only one cell thick, and covers the outer surface of roots, stems and leaves. Epidermis cells contain no chloroplasts. The epidermis on stems and leaves has an outer layer of wax and lipids called a ***cuticle***. This prevents the loss of water from the epidermis cells.

Cortex

The cortex tissue provides support for the plant, and may also act as a food storage tissue.

Vascular

The vascular tissues are arranged in a circle of bundles around the stem. Vascular tissue is made up of:

- phloem cells
- xylem cells
- cambium cells

Phloem cells transport sugars, proteins and hormones from where they are made to the rest of the plant.

Xylem cells transport water and minerals from the roots up the stem to the rest of the plant.

Cambium cells are a thin layer of cells that are responsible for the increase in the size of stems and roots (they are also called ***meristematic cells***).

Rays

These are thin strips of cells between the vascular bundles. They transport water and nutrients across the stem to the cortex and pith.

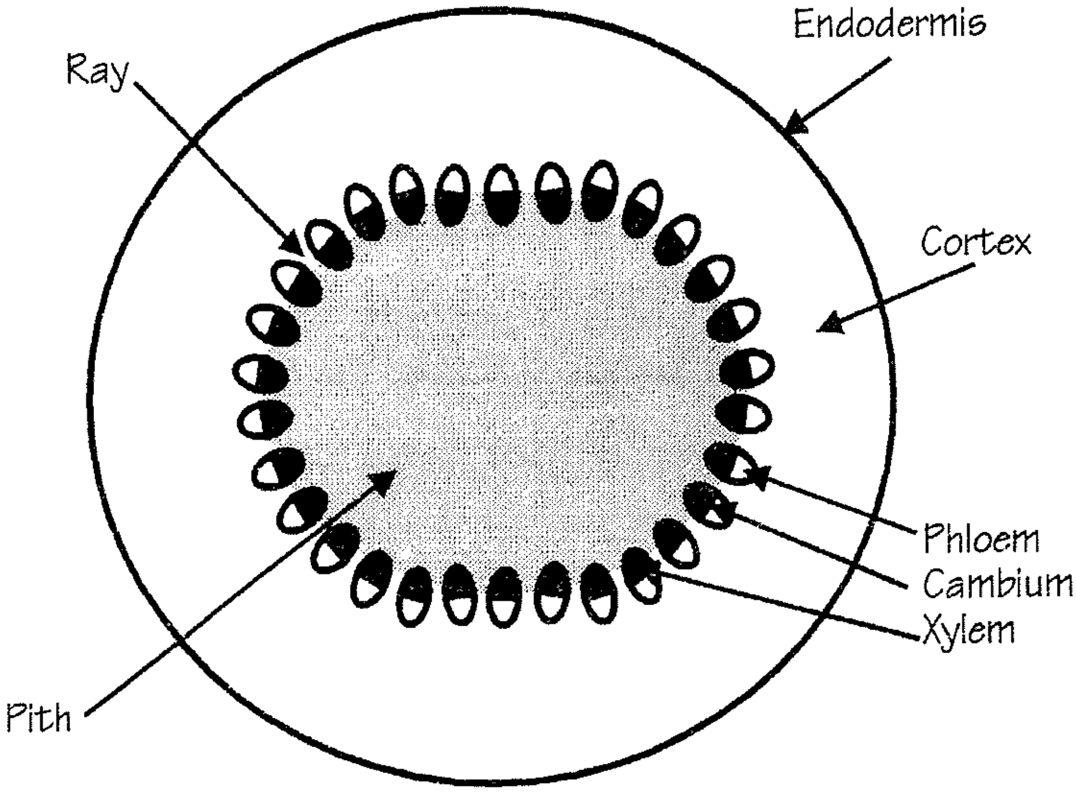
Pith

Pith (also called ***medulla***) tissue lies in the centre of the vascular bundles and is a food storage tissue.

Endodermis

The endodermis is a specialised form of cortex tissue. It forms a protective layer around the vascular bundles and is found only in roots.

Parts Of A Plant Stem (Dicotyledon)



The root

The roots of a plant form a branched system that extends through the soil. From the ***main root*** (often called the ***primary root***), ***side roots*** are produced.

Plant roots have three main functions:

1. To anchor the plant.
2. To absorb water and nutrients into the plant.
3. To transport water and nutrients to the rest of the plant.

In some plants, (most dicotyledons and gymnosperms), the main root can keep growing downwards and will develop lateral roots which branch off from it. The main root is then called the ***tap root***, and the whole system is called the ***tap root system***.

Tap root systems are adapted to grow in deep soils. They are thick and woody and provide a strong anchor.

In some other plants, the lateral roots grow as large as the main root, until a large, branched system is built up. Such a system is called a ***fibrous root system***.

Fibrous root systems do not provide enough support and anchorage for large plants, so they are only found in monocotyledon plants.

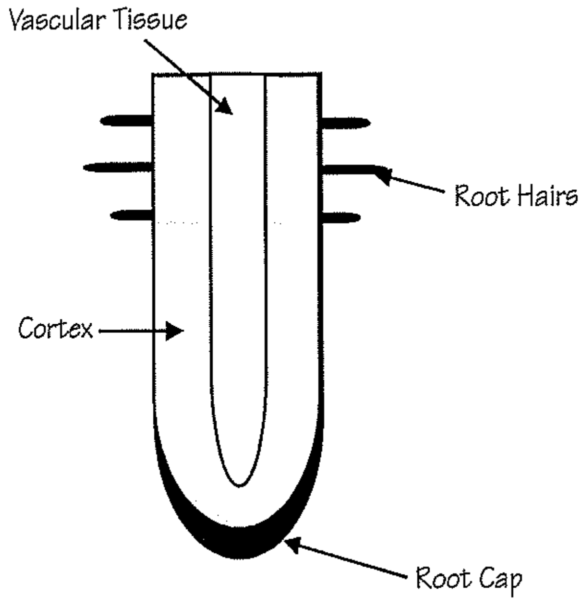
As well as differing in size and shape, tap roots and fibrous roots also differ internally:

- fibrous roots have pith tissue in the centre of the root, which is surrounded by a ring of xylem and phloem; tap roots have xylem in the centre, shaped like a 'star', with phloem between the points
- tap roots have cambium tissue, while fibrous roots have no cambium tissue

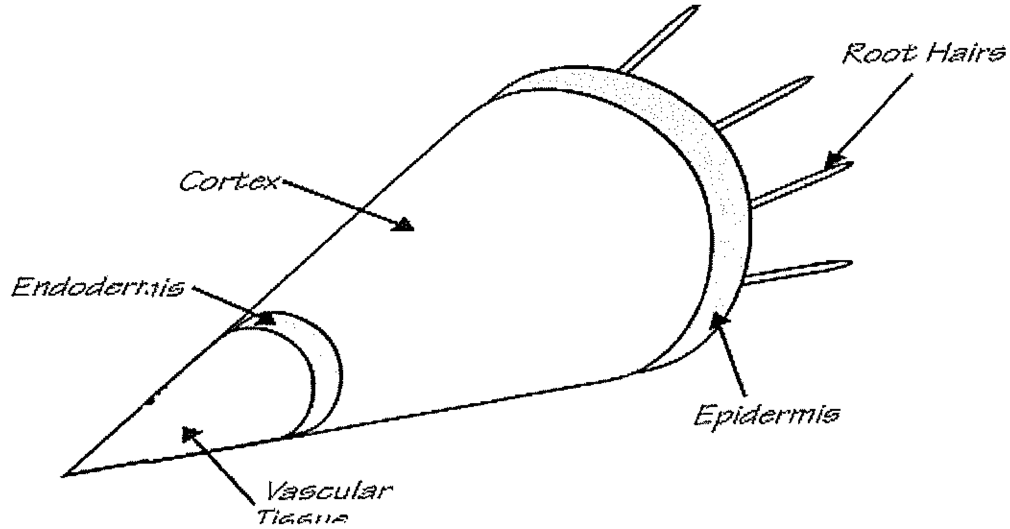
The structure of the dicotyledon root is similar to that of the stem. However, there are three main differences:

- The surface layer of the root has some of its cells lengthened into root hairs.
- The transporting tissue is made up of alternating strands of phloem and xylem.
- Between the cortex and vascular tissue is a complex ring of special cells called the endodermis.

Longitudinal Section Through A Plant Root



Cross Section Through A Plant Root



The root system of plants is much larger than is usually realised, and it may equal or exceed the above-ground parts of the plant. The size of the root system depends on:

- ***The texture and structure of the soil the plant is growing in***
  In soils with very poor texture and structure, the root system of a plant will be limited in size, because it is unable to penetrate through the soil.
- ***The amount of water in the soil***
  Soils with little or no water will have plants with large root systems, because the roots will be 'searching' for water, whereas soils which have a very high water content will generally have plants with a small root system because of the lack of air in the soil. This high concentration of water can cause the roots and ultimately the plant to die through lack of respiration.
- ***The number of plants growing in any one area***
  An area with a large plant population will mean that each plant is 'crowded' by its neighbour, and will have a small root system.

Tap roots grow in both length and width, while fibrous roots only grow in length (because they contain no cambium tissue). Growth in ***length*** is called ***primary growth***. Growth in ***width*** is called ***secondary growth***.

This secondary growth of roots occurs in a similar way as in the stem. The main difference is that when the cambium ring develops, it is an irregular ring passing through the outside of the xylem and inside the phloem. Older roots will also have corky bark like that of older stems.

After secondary growth has begun, there is very little difference in structure between roots and stems.

Monocotyledons have roots that are similar to dicotyledonous plants. However, the roots of monocotyledon plants have no cambium and no secondary growth. This is why monocotyledon roots are thin and fibrous.

Test Yourself #2

ANSWER THESE QUESTIONS BY SELECTING THE CORRECT STATEMENT (A, B or C)

1. The basic building block of all plants is the
   a) tissue
   b) cell
   c) bundle

2. Cortex tissue provides
   a) food transport within the plant
   b) support for the plant
   c) growth for the plant

3. Phloem cells
   a) transport sugars, proteins and hormones
   b) transport water and minerals
   c) provide support for the plant

4. Xylem cells
   a) transport sugars, proteins and hormones
   b) transport water and minerals
   c) provide support for the plant

5. Pith tissue is found
   a) only in plant roots
   b) between the cortex and epidermis
   c) in the centre of vascular bundles

6. The endodermis
   a) is only found in stems
   b) is a type of cortex tissue
   c) helps to transport water

7. The root system is
   a) smaller than the above-ground plant
   b) larger than the above-ground plant
   c) the same size as than the above-ground plant

8. In gymnosperms, the main root is called
   a) the fibrous root
   b) the tap root
   c) the root hair

9. When lateral roots grow as large as the tap root, the system is called
   a) a tap root system
   b) a primary root system
   c) a fibrous root system

10. Fibrous root systems are only found in
   a) gymnosperms
   b) dicotyledons
   c) monocotyledons

11. The main internal difference between tap and fibrous roots is
   a) the presence of pith tissue in fibrous roots
   b) the presence of endodermis tissue in tap roots
   c) the presence of cortex tissue in fibrous roots

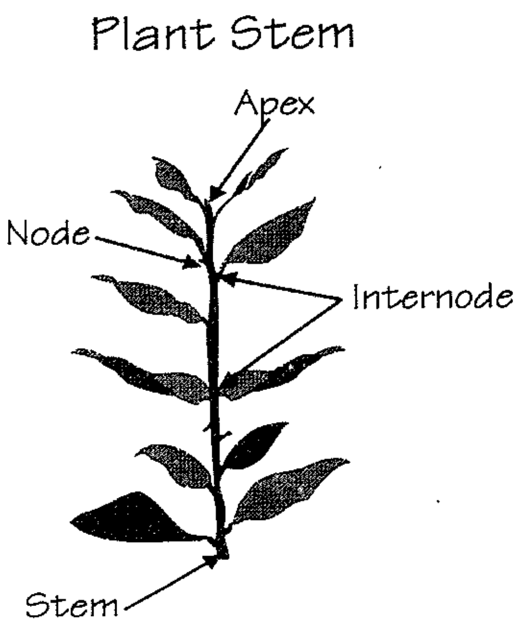
12. Dicotyledon roots grow in
   a) both length and width
   b) length only
   c) width only

The stem

The stem of a plant usually grows above the ground and supports the leaves and flowers. Some plants do have underground stems. Stems vary in their form, but in spite of these differences, they have a number of common features:

- The top of the stem (***the apex***) is the ***growing point*** where new cells are produced that later develop into tissue;
- Leaves grow out from points called ***nodes***; the distance between two nodes is called the ***internode;***
- At each node there is an ***axillary bud***; this can grow into a ***branch***. Axillary or lateral buds are located on every stem, in the axils of the leaves. Some lateral buds are large and fleshy, while others are almost invisible. The lateral buds of gymnosperms (conifers) lose their ability to sprout after a short time. The lateral buds of *Hebe* species, on the other hand, can grow after many years' dormancy!

At certain times of the year, plants produce flowering buds, which give rise to the following season's fruit. At pruning, training and disbudding time, you need to be able to recognise fruiting buds.



The three most important functions of a stem are:

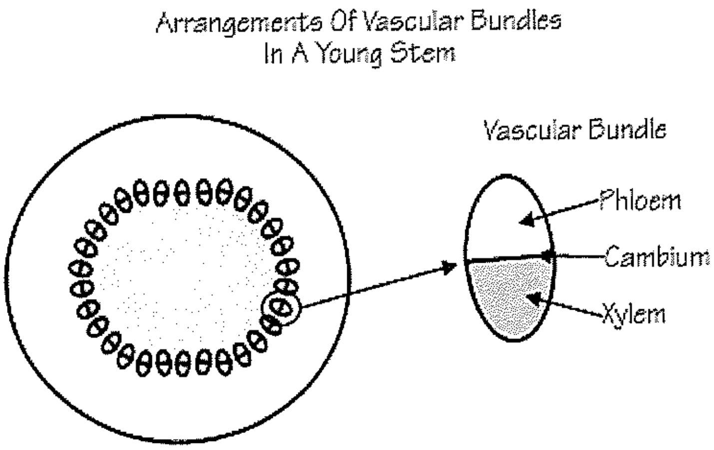
- ***Support*** - the stem holds the leaves, flowers, cones and fruit in the best position for them to carry out their functions.
- ***Conduction*** - the vascular system of the stem connects the roots with the leaves and flowers and provides the pathway for the movement of water, nutrients, food and hormones.
- ***Growth*** - the stem provides for upward growth and the formation of new leaves and shoots. Some dicotyledon plant stems grow outwards, increasing in thickness, thus providing extra support to the plant.

Growth in the ***length of stems*** takes place at the ***tips of shoots***. All stems grow in length by adding new tissue at shoot tips. Some stems of some plants grow in thickness, new tissue being added to increase the circumference of the stem. All stems that grow in thickness grow in ***length first***. The initial growth in length is called ***primary growth***. Any growth in thickness is called ***secondary growth***. Secondary growth is responsible for producing:

- extra support for the plant;
- tissue to transport materials inside the plant (*phloem and xylem*)

Secondary growth is only found in angiosperms that are woody and gymnosperms. With few exceptions, the stems of all other plants do not increase in thickness.

When a plant has finished its primary growth, some ***meristematic cells*** (*cells that are capable of dividing to produce new cells*) remain between the primary xylem and phloem in the vascular bundles. This is called the ***cambium layer***.



A layer of cells between the vascular bundles changes its function, and becomes ***meristematic*** (*these are cells that divide to produce new cells*). They divide and produce cambium cells. As a result, a complete cylinder of cambium is formed, which is called the ***vascular cambium.***

As the stem of the plant grows longer, it starts to become firm around the base and increases in thickness. The stem becomes firm because of the addition of new phloem and xylem tissues. The new tissue supports the increased weight of the plant. This new tissue results from ***secondary growth***. It is produced by the activity of two meristematic tissues:

- ***vascular cambium*** - which is between the phloem and xylem
- ***cork cambium*** - which develops underneath the epidermis and produces cork.

In each growing season, the vascular cambium produces new xylem on the inside and phloem on the outside of the stem. The new xylem is what is known as ***wood***. The cork cambium produces new cork tissue to cope with the increase in stem thickness. As the stem becomes thicker, the pith and primary xylem loses its importance as new xylem is produced (called ***secondary xylem***). Secondary growth is the process by which plant stems become woody.

The cells in the centre of the stem receive nutrients from the phloem by means of special cells called ***rays*** (also known as ***medulla rays***). These cells run ***horizontally*** across the stem and transport food from the phloem, through the xylem to the pith. New ray cells are formed by the vascular cambium as the stem increases in thickness.

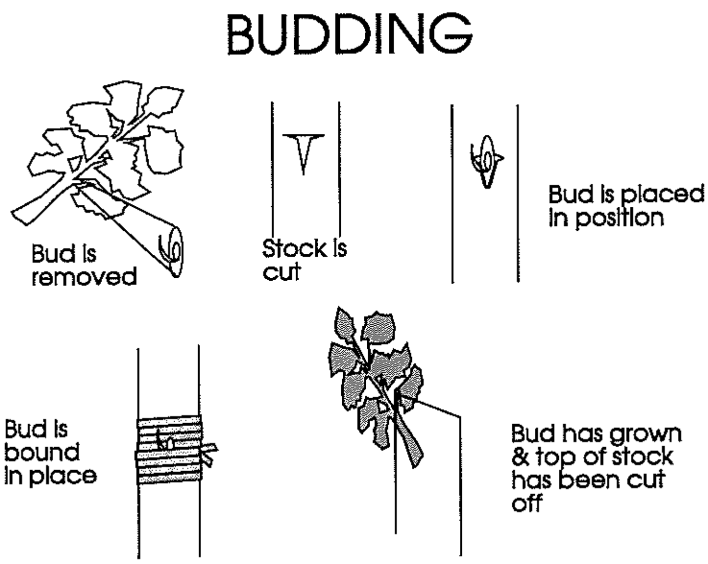
Propagation using stems

Lateral buds are used in horticulture to propagate plants vegetatively. Stem cuttings are made from short lengths of stem, with the lateral buds intact. The bud produces the new growth after the cutting has developed roots.

Rhizomes and tubers can be cut up and replanted to produce new plants, as long as each piece has a lateral bud on it. Stolons, at their terminal buds, produce new plants with adventitious roots. A stolon is a long horizontal stem which sits above ground.

Budding

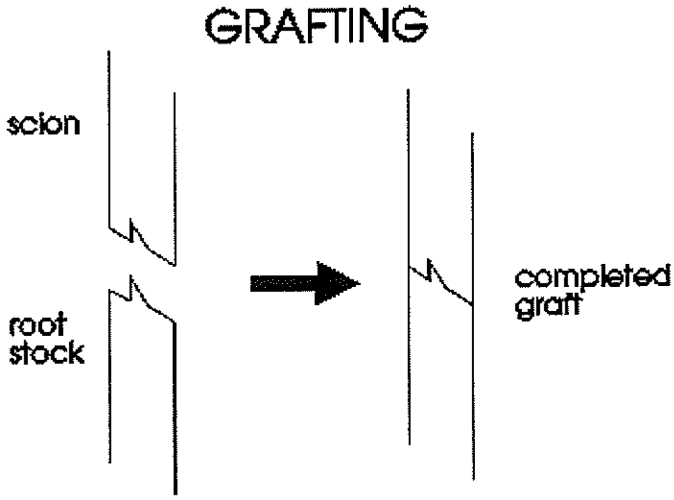
Budding is a type of grafting in which a single bud is joined to a root stock. The bark of the root stock is cut, and a bud is inserted behind the bark. The development of the plant occurs in the same way as with grafting.



Grafting

Grafting is the joining together of the parts of two different plants. A shoot (called the ***scion***) is joined with a root system (called the ***root stock***). It is very important that the cambium layers of each plant are joined together because it is the cambium layers which will grow together and allow water and nutrients to move between the scion and the root stock. This is achieved by cutting the scion and root stock so that when joined together, their cambium is in complete contact.

Both budding and grafting have to be done quickly, otherwise the plant material will dry out. It is also important that the root stock must be actively growing, while the scion needs to have no leaves and large amounts of stored food reserves.



This is so it will survive until the cambium tissue has joined with the cambium tissue of the root stock, and nutrients and water are able to move freely. For this reason, most grafting and budding is done in the spring.

Grafting and budding is most often done because the root stock plant has the ability to resist pests and diseases, or grows larger or smaller than the scion plant, so by joining them together, the best attributes of both plants are available in a single plant. All fruit trees are grafted, while most roses are budded.

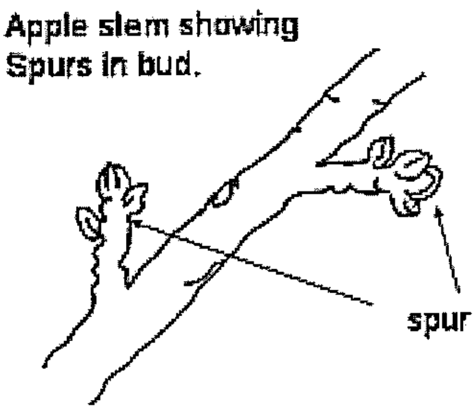
Pruning and training

It is important to be able to locate a lateral bud when pruning and training plants. Pruning generally stimulates the growth of lateral buds: When a stem is cut, the bud immediately below the cut is stimulated to grow. This bud will grow out to produce a shoot which takes over the job of the apical bud, suppressing the dormant lateral bud/s below it on the stem.

This is the principle behind such pruning techniques as pinching out and clipping.

Fruit buds and vegetative buds

The buds which are going to produce flowers and fruit look different from vegetative buds. On pip and stone fruit trees, fruiting buds are rounder and fatter than their vegetative counterparts. Apple trees produce their fruiting buds on specialised stems called spurs. A spur is a shortened stem which bears the fruiting buds. Pruning and training an apple tree involves maximizing the number of fruiting spurs.



Test Yourself #3

ANSWER THESE QUESTIONS BY SELECTING THE CORRECT STATEMENT

1. Grafting is
   a) the joining of two different plants
   b) commonly used to propagate roses
   c) a way of breeding new plants

2. Budding is
   a) the joining of a scion with a root stock
   b) commonly used to propagate roses
   c) a way of breeding new plant varieties

The whole area of the stem ***outside*** the vascular cambium is called ***bark***. It is made up of secondary phloem, cortex tissue and cork tissue. Bark has two parts:

- ***Soft Bark*** - is made up of the secondary phloem, which transports nutrients, and the cortex tissue, which stores nutrients.
- ***Hard Bark*** - is made up of cork tissue. This tissue consists of dead cells.

The functions of the hard bark are as follows:

- to prevent physical damage to the plant;
- to prevent bacteria, fungi or viruses from entering the plant;
- to prevent water loss;
- to prevent rapid temperature changes which could damage the tissues of the stem

Ring barking a tree means removing a complete ring of the bark as deep as the cambium layer. This will have two results. The downward movement of nutrients through the phloem will be stopped, and the growth of new wood and phloem is prevented because of the damage to the cambium.

The most noticeable aspect of looking at the cross section of a tree trunk is the ***annual*** or ***growth rings***. The annual rings give an indication of the growing conditions that the tree has gone through. The distinct rings are visible because the amount of xylem tissue produced during the spring is large and light coloured, while the amount of xylem tissue produced during the autumn is small and dark coloured. The annual rings are a good general guide to the age of the part of the tree where they are seen.

The annual rings are therefore an indicator of a year's growth, and the number of annual rings at the base of a tree trunk gives the age of the tree. The thickness of each ring is the amount of wood produced during the growing season. This amount depends on several factors:

- tree species - fast growing tree species have thicker rings than slower growing species
- tree age - annual rings produced early in the life of a tree are thicker than those produced later
- the amount of competition from other trees for light, space and nutrients
- changes in temperature or rainfall

When you look at the cross section of a tree trunk, as well as the annual rings, you should also be able to notice two distinct 'zones' of wood;

- a light coloured outer zone - called ***sapwood***
- a dark coloured inner zone - called ***heartwood***

The sapwood transports nutrients and stores food, while the heartwood provides support for the tree. Sapwood is slowly transformed into heartwood. This occurs when various substances (tannins, gums and pigments) move into the sapwood tissues.

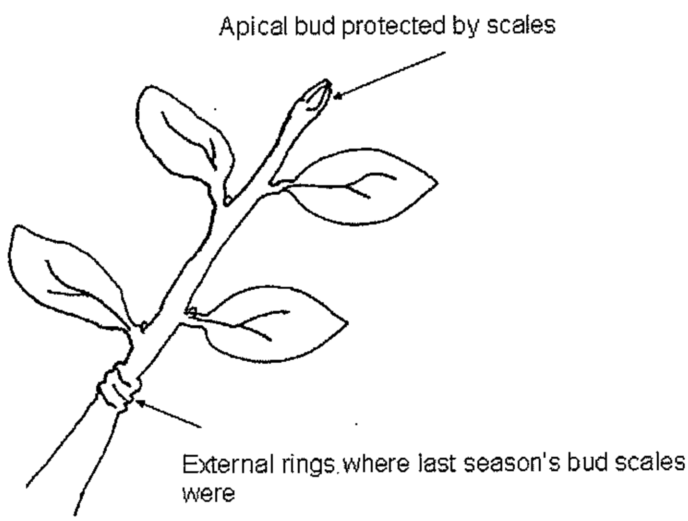
External rings on shoots

The age of a woody shoot can be determined by looking at the bud scars on the outside of the stem.

This is because the terminal buds of woody species, such as apples and pears, are protected by bud scales during winter, when the bud is dormant. In spring, the bud bursts and the scales fall off, leaving horizontal scars on the shoot. By counting the number of these groups of scars, you can see how many winters, or years old, the shoot is.

This ageing method only works with young shoots because, as the stem thickens, the bud scars tend to become obscured and difficult to see.

Diagram of a shoot showing the **current season's growth** above the bud scars, and the previous season's growth below the bud scars



Practical activity

Carefully prune a small branch of plum, apple, or other deciduous tree species.

Bring it inside and identify the following:

- Axillary bud
- Terminal bud
- Flowering bud - this will be easiest to see in autumn/winter

Can you work out the age of the branch by counting bud scars? Go back as far as you can.

Cut through the branch and peel back the bark.

Locate:

- The hard bark - note the colour
- The soft bark - note the colour

Modifications

In some plants, the stem will look completely different to the way we might think a stem should look, but it is still a stem, made up in completely the same way and functioning in the same manner:

Runners

In some plants, the stem lies flat (***prostrate***) along the top of the ground. This type of stem is called a ***runner*** and can be found in plants like Black Medic (*Medicago lupulina*) and Subterranean Clover (*Trifolium subterraneum*).

Stolons

Some types of plants also have prostrate stems, but they have roots (called ***adventitious roots***) growing at each node. This type of stem is called a ***stolon***. Plants with stolons include White Clover (*Trifolium repens*) and the Strawberry (*Fragaria species*).

Rhizomes

Another type of stem is found growing underground. It has leaves, axillary buds and adventitious roots like other stems. Stems that grow underground are called ***rhizomes***. Couch (*Elytrigeria repens*) and yarrow (*Achillea millefolium*) are plants which have rhizomes.

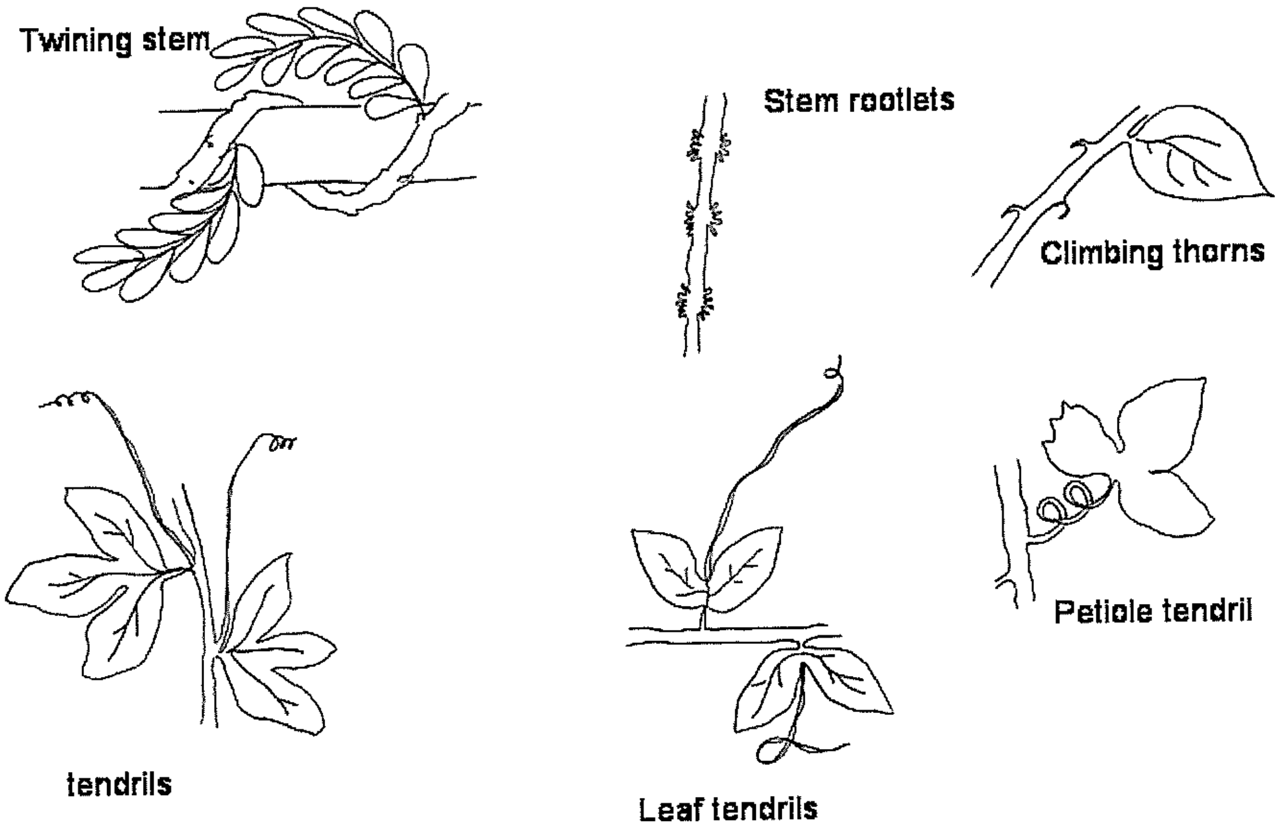
Tubers

A ***tuber*** is a highly modified form of underground stem. It is a stem which has become swollen with food reserves for the plant. The leaves on the tuber have been reduced to simple 'scars', while the axillary buds are found as the eyes of the potato. In fact the potato plant has three types of stem: the above-ground stem; rhizomes that produce the tubers; and the tubers.

Bulbs and corms

Two other types of underground stems are bulbs and corms. They are both types of food-storage structures. With bulbs, a short, flattened stem is attached to fleshy, leaf-like scales which enclose the shoot/flower. Corms are very similar in structure to bulbs except the scale leaves are not fleshy.

Other stem modifications include those which help plants climb (twisting stem - Runner Bean (*Phaseolus coccineus*); tendrils - Passion Vine (*Passiflora* species).



Test Yourself #4

COMPLETE THESE SENTENCES BY SUPPLYING THE CORRECT WORD(S)

1. The top of the ______________ is called the ______________ point; leaves grow out from the stem at points called ______________; at each node there is an ______________ bud.

2. The ______________ of the stem are to ______________ the plant; transport nutrients and ______________; provide upward and ______________ growth for the plants.

3. Stems grow in ______________ first, and this is called ______________ growth. Any growth in the ______________ of the stem is called ______________ growth.

4. The ______________ layer is situated between the primary ______________ and xylem. It is ______________ which means it is capable of producing new ______________ by cell division.

5. Secondary ______________ in a stem is produced by the activity of two meristematic tissues, the ______________ cambium and the cork ______________.

6. In each growing ______________, vascular cambium produces ______________ xylem and ______________, while the cork ______________ produces new cork tissue.

7. Bark is the area ______________ the vascular cambium and is made up of ______________ xylem, ______________ and ______________ tissue.

8. Growth ______________ indicates the years ______________ of a tree and the size depends on the amount of ______________ produced during the growing ______________.

9. How can you tell which is the current season's growth by looking at a shoot? __________

____

The leaf

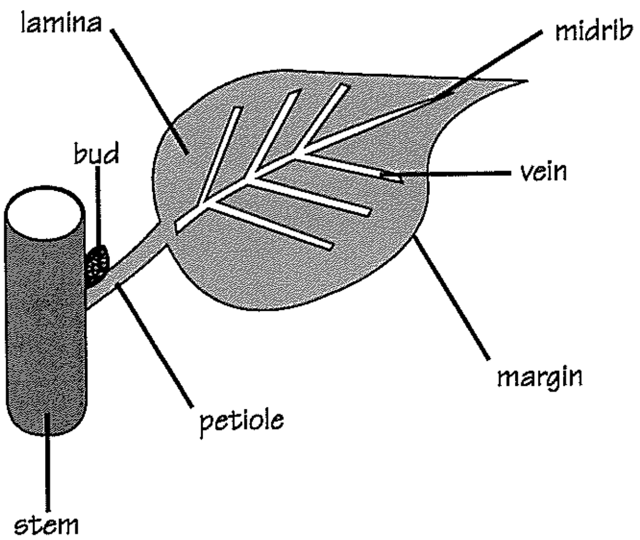
The leaf of a typical dicotyledon plant is a flat structure carried by the stem in a more or less horizontal position. Because the leaf is flat and horizontal, the maximum area is exposed to the sunlight, enabling the plant to perform photosynthesis. (This will be covered in another module)

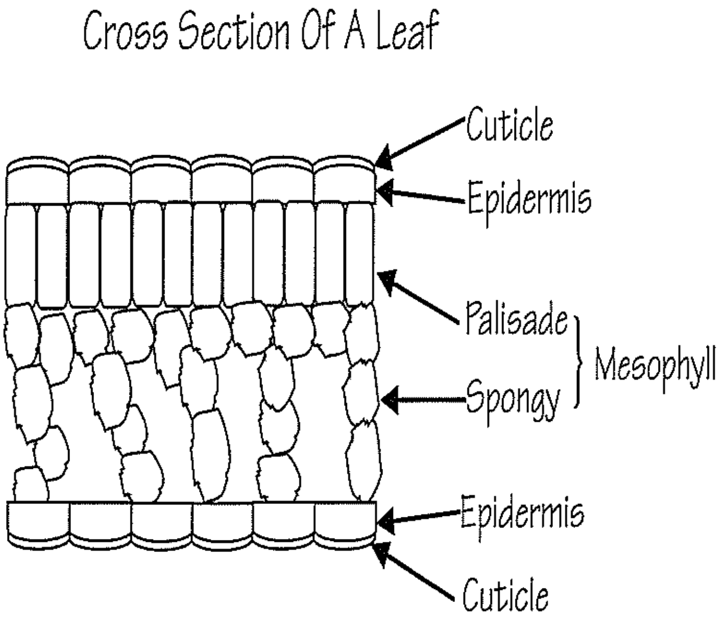
Leaves of gymnosperms, e.g. conifers, are slightly different. They are long and thin, and are called needles. They do have the same internal structure as dicotyledon leaves and perform the same functions.

Most leaves have two parts, which are made up of the same tissues, which make up the stem of the plant.

- ***Leaf Blade*** - is usually broad and flat, and often very thin. The blade is supported by veins, which contain vascular tissues.
- ***Petiole*** - this is the stalk that connects the leaf blade to the stem of the plant. The petiole supports the weight of the blade and holds it in a horizontal position.

Parts Of A Leaf

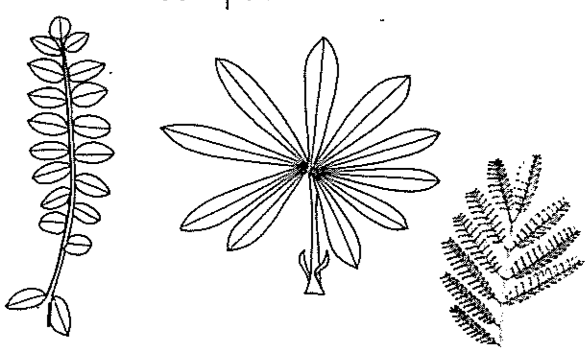




Leaves vary considerably in their shape. The most familiar leaf type is the ***simple leaf*** which consists of a thin, flattened green blade, which in many plant species is attached to the stem by a ***stalk*** (*petiole).*

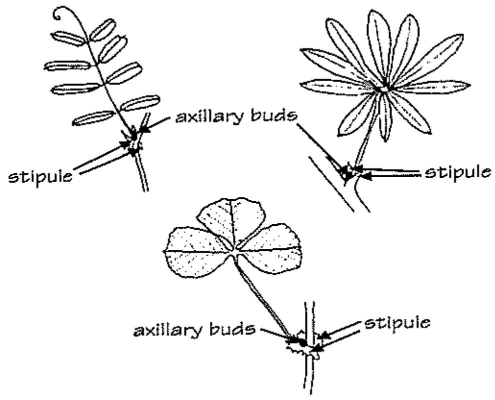
Where there are two or more blades that make up a leaf, the leaf is called a ***compound leaf***. The leaf blades are called ***leaflets***.

Compound Leaves

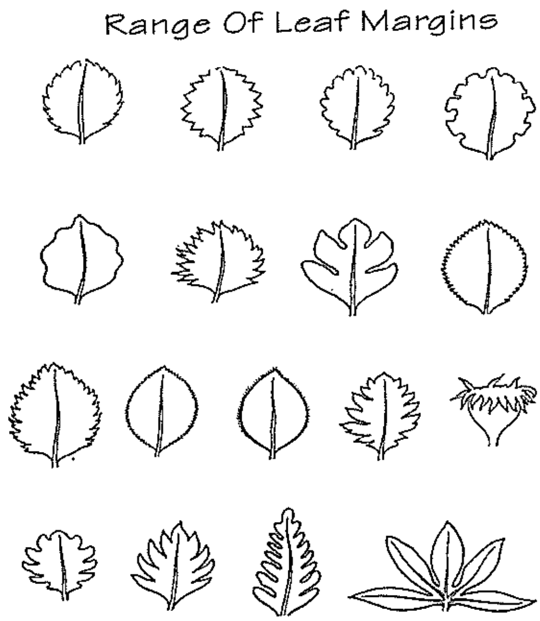


There are a number of different types of compound leaves. Where the leaflets are arranged around a central point, the leaf is called ***palmately compound***. Where the leaflets are arranged along a petiole, the leaf is called ***pinnately compound***. Where there are only three leaflets, the leaf is called ***trifoliate compound***.

Many leaves have structures at the base of the petioles called ***stipules***. The shape and size of stipules varies considerably amongst plant species.

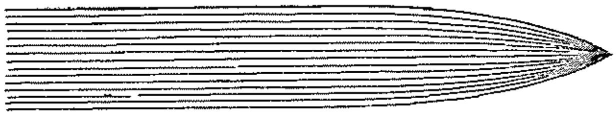


The edges of leaves, (called the ***leaf margin***), will also vary. Simple leaves may be lobed, or have a jagged edge. Compound leaves will also have a range of different leaf margins.



The arrangement of veins in leaves (called ***venation***) is also variable. In some plant species, such as *Iris* species the veins run along the length of the leaf. These are called ***parallel veins.***

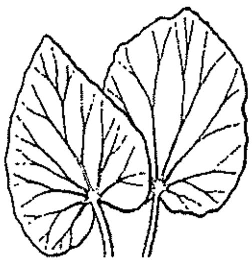
Parallel Veined Leaf



Where the veins develop out of one area, usually at the base of the leaf where it joins the petiole, then this arrangement is called ***palmately veined***.

Where there is one central vein running along the length of the leaf with other veins branching out from this central vein, then this arrangement of leaf veins is called ***pinnately veined***.

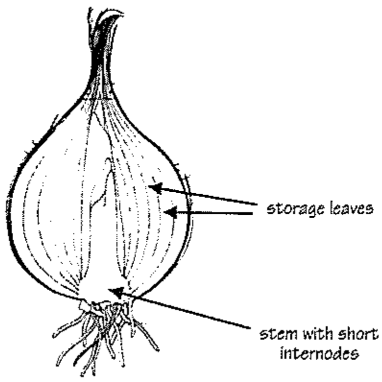
Palmate Veined Leaves



Pinnate Veined Leaves

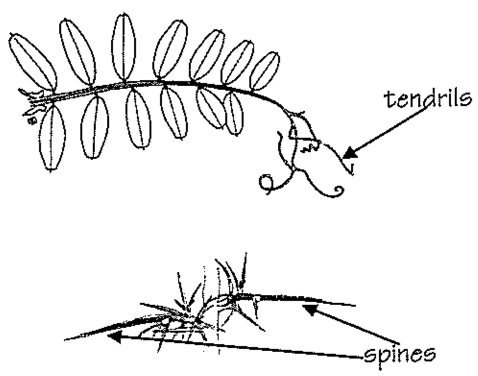
Leaves can also be modified to carry out other functions. They may act as food storage organs e.g. daffodil (*Narcissus* species) and lily (*Lilium* species).

Cross Section Of Daffodil (*Narcissus* sp.)



Leaves may also be modified to enable a plant to climb. Whole leaves or leaflets may be formed as ***tendrils*** which will twist tightly around any available support e.g. sweet pea (*Lathyrus odoratus*). Some plant species, especially those growing in very dry areas, may have almost no leaves, or leaves that are reduced to spines to reduce the amount of water they lose e.g. gorse (*Ulex europaeus)*.

Tendrils and Spines

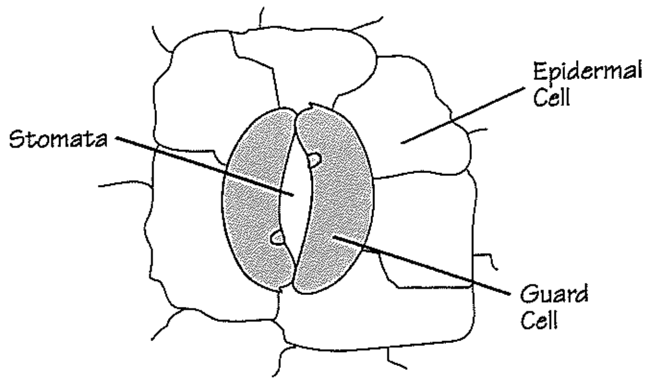


The three main tissues in a leaf are:

The epidermis

This is a one-cell-thick layer that covers the whole leaf surface. The cells of the epidermis produce a waxy covering (called a ***cuticle***) on the outside of the leaf. This protects the leaf in the same way as bark protects the stem. The gases that the plant needs for photosynthesis and given off during respiration enter the leaf through pores in the epidermis called ***stomata***.

STOMATA ON LEAF SURFACE



Each stomata is formed by two guard cells, which are sausage shaped and attached at each end. They are important in providing the opening and closing mechanism for the stomata.

Mesophyll tissue

Between the two layers of epidermis is the mesophyll tissue, in which photosynthesis takes place and where gasses and water vapour freely circulate. There are two types of mesophyll tissue.

Palisade cells are found under the epidermis and are long and narrow. They contain large numbers of chloroplasts. There are small air spaces between these cells which allow gases to move within the leaf. The next layer is called the ***spongy leaf parenchyma cells.*** They contain less chloroplasts than the palisade cells and are loosely arranged with large air spaces between. This layer extends to the lower epidermis.

Vascular tissue

At the nodes of stems, vascular tissue (*xylem and phloem*), branch into the leaf petiole. Once in the leaf blade, the vascular tissue branches out to form a network of smaller veins. The veins of the leaf run through the layer of spongy parenchyma cells. The large veins have a similar structure to the vascular bundles of the stem. They are often supported by extra strengthening cells. The large veins branch into smaller and smaller veins, and eventually consist of only a few conducting cells. The fine endings of the veins are so numerous that no part of the leaf is far from one of them.

Test Yourself #5

COMPLETE THESE SENTENCES BY SELECTING THE CORRECT STATEMENT (A, B or C)

1. The most familiar type of leaf is the
   a) simple leaf
   b) compound leaf
   c) palmate leaf

2. A compound leaf is made up of
   a) a number of leaflets
   b) a single leaf blades
   c) 3 leaflets

3. A palmate leaf is made up of
   a) a number of leaflets
   b) leaflets arranged around a central point
   c) leaflets arranged along a petiole

4. A pinnate leaf is made up of
   a) a number of leaflets
   b) leaflets arranged around a central point
   c) leaflets arranged along a petiole

5. A trifoliate compound leaf is made up of
   a) Three leaflets
   b) leaflets arranged around a central point
   c) leaflets arranged along a petiole

6. Stipules are structures that develop at the base of
   a) leaves
   b) petioles
   c) leaflets

7. The edges of leaves are called
   a) margins
   b) venation
   c) lobed

8. Parallel veins
   a) run along the length of a leaf
   b) develop out of an area of a leaf
   c) branch out from a central vein

9. Pinnate veins
   a) run along the length of a leaf
   b) develop out of an area of a leaf
   c) branch out from a central vein

10. Palmate veins
   a) run along the length of a leaf
   b) develop out of an area of a leaf
   c) branch out from a central vein

The flower

The flower is the reproductive organ of angiosperms. Its main function is the production of new plants. The various parts of the flower carry out this overall function by:

- producing the reproductive cells;
- overseeing the development of seed;
- producing fruit, which contains the seed;
- dispersing the seed.

Although all flowers have the same basic shape, they vary greatly in size, colour, shape and the arrangement of parts. Flowers with both male and female parts are called ***complete flowers***. Flowers with only male or female parts are called ***incomplete flowers***.

Some plants, e.g. pumpkins, produce separate male and female flowers on the same plant. These plants are called ***monoecious***. Other plants produce male and female flowers on separate plants, are called ***dioecious***.

Examples of dioecious plants include kiwifruit, poplars and willows.

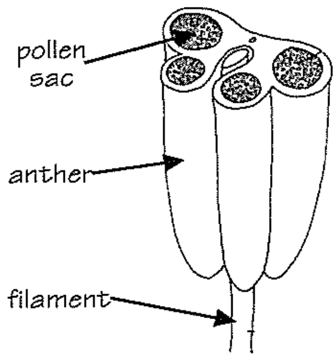
The flower is attached to the plant by the receptacle, a specialised shoot tip at the end of the flower stalk. The flower is made up of sexual and non-sexual parts. The non-sexual parts are not essential in the reproductive process.

The non-sexual parts are:

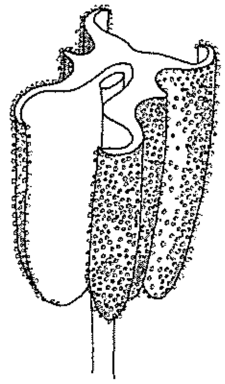
- ***the sepal*** This is the green, leaf-like outer layer of the flower. Its role is to protect the flower.
- ***the petals*** These are the brightly coloured leaf-like structures.
- ***the receptacle*** This supports the sepals, petals, stamens and style.

Inside the ***petals*** are the ***stamens***. All the stamens together in a flower are called the ***androecium***. The androecium is the male part of the flower. Each stamen is made up of an anther, held up by a stalk (called a filament).

The anther is made up of four pollen sacs, which contain the pollen. When the anther is ripe, it splits down the middle and the pollen is released.



Anther before pollen is released



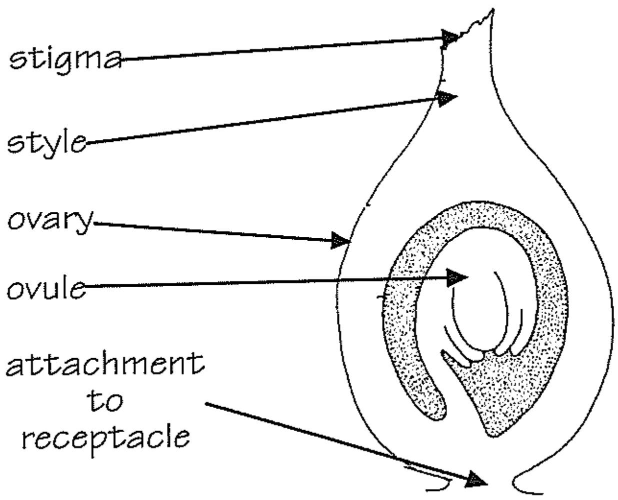
Anther after polle is released

In the centre of the flower is the gynoecium which is the female part of the flower. It is made up of many carpels, which are the female equivalent of the stamens.

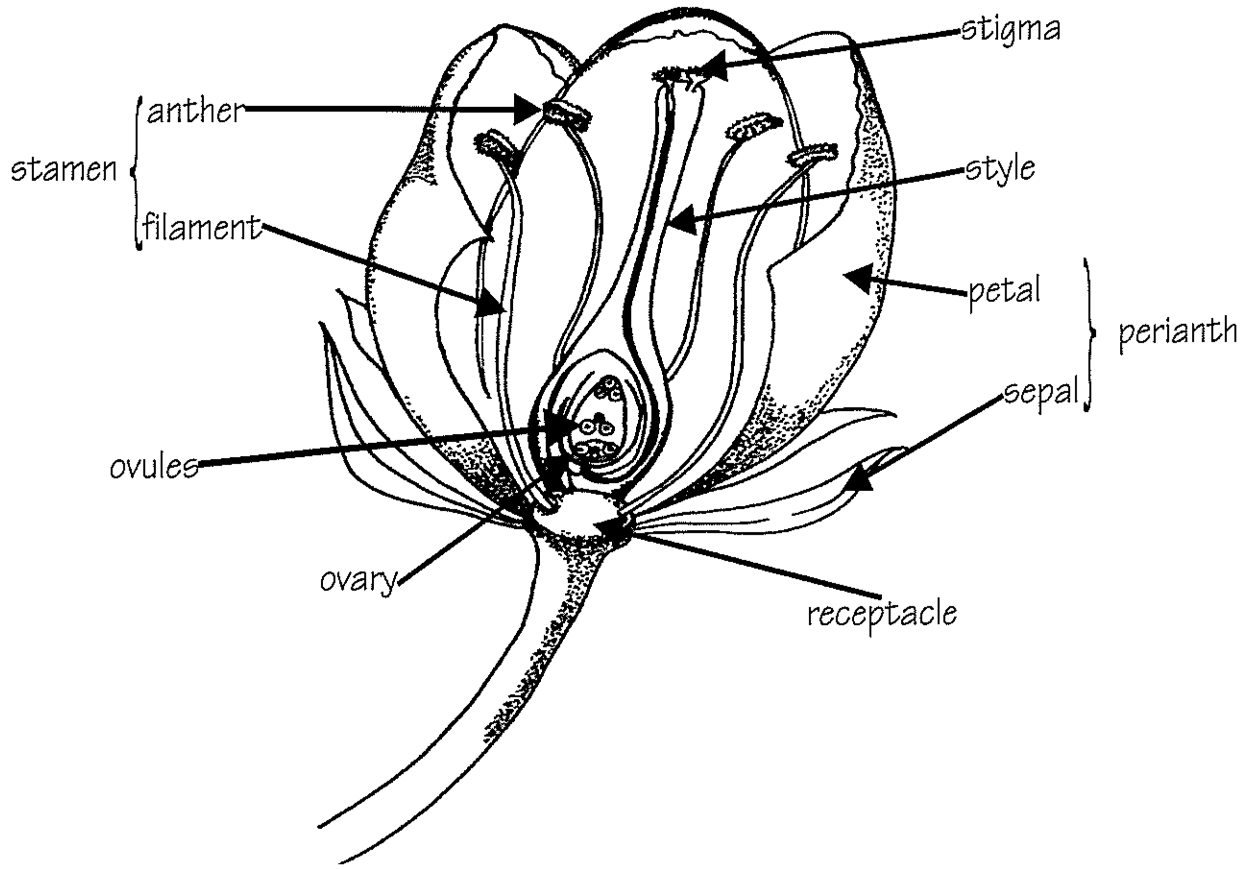
Each carpel is made up of three parts:

- ***stigma*** (receives the pollen)
- ***style*** (stalk that holds stigma)
- ***ovary*** (contains ovules which when fertilised develop into seed).

Cut-away View Of A Carpel



Cross Section Of A Flower



The sexual parts of the flower are:

a) ***the anther*** The anther is where the pollen is produced.

b) ***the filament*** The filament is the structure which supports the anther.

c) ***the stigma*** This is where pollen lands during pollination.

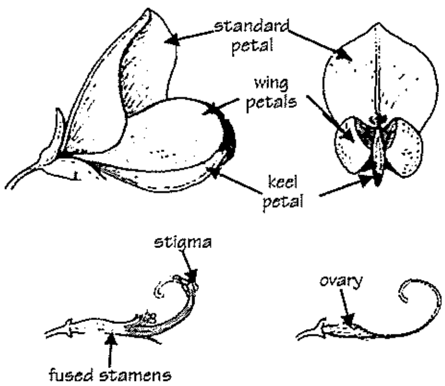
d) ***the style*** This supports the stigma.

e) ***the ovary*** This is at the base of the carpel. It holds the ovules.

f) ***the ovules*** The ovules contain the female cell, which when fertilised develops into the seed.

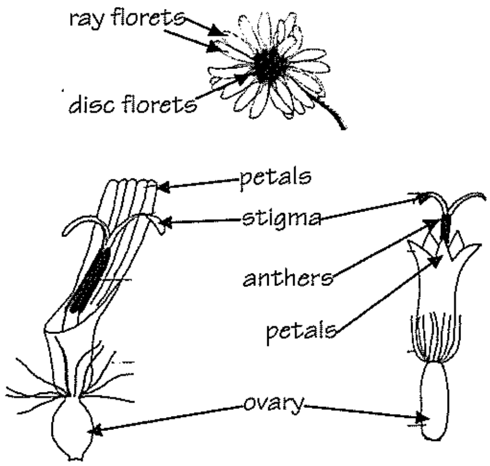
The form and the shape of flowers varies considerably amongst plant species. Flowers of plants belonging to the ***Leguminosae Family*** (*legumes*) have highly modified petals.

Legume Flower



Flowers of plants belonging to the daisy family (*Compositae*) are a little different. They are in fact two flowers in one. What appear to be the white petals are in fact complete flowers called ***ray florets***. The inner part is made up of another flower type called ***disc florets***.

Composite Flowers



Flowers may occur ***singularly*** (on their own) or in ***groups*** called ***inflorescences***. There are many different types of inflorescences, but a few of the more common ones are:

- *Raceme*: this is an inflorescence with a central axis bearing lateral branches, each which bears a flower.
- *Corymb*: this is a type of raceme, but the lower, older flowers develop on longer stalks than the higher, younger flowers.
- *Spike*: this is another type of raceme with the flowers not having any stalks.
- *Catkin*: a catkin contains only unisexual flowers (either male or female).
- *Panicle*: this is a compound raceme where the main axis bears branched laterals, and each lateral has a raceme.
- *Umbel*: an umbel has many lateral branches developing out of a central axis.
- *Capitulum*: flowers of the family *Compositae* are grouped together into an inflorescence called a ***capitulum***.

Test Yourself #6

JOIN UP THE TERMS ON THE LEFT WITH THEIR CORRECT DESCRIPTION ON THE RIGHT

Raceme	contains only unisexual flowers
Corymb	many lateral branches developing out of a central axis
Spike	central axis bearing lateral branches, each bearing a flower
Catkin	older flowers develop on longer stalks than younger flowers
Panicle	flowers of the family *Compositae*
Umbel	flowers not having any stalks
Capitulum	main axis bears branched laterals, each with a raceme

ANSWER THESE QUESTIONS EITHER TRUE OR FALSE

1. Dicotyledon leaves are usually flat
2. Leaves of gymnosperms have a different internal structure to the leaves of dicotyledon plants.
3. Most leaves have two parts, the leaf blade and the petiole
4. Leaves are made up of three tissue types: epidermis, mesophyll and vascular
5. The vascular tissue is where photosynthesis takes place
6. Flowers with only male parts are called incomplete flowers
7. Poplars and willows are classed as dioecious plants
8. Pollen is produced by the anther

Fruit

Before fertilisation, the ovary and ovules in the flower are very small. After fertilisation, the ovary and ovules change. The ovary develops into a fruit, and the ovules into seeds. The ovary will grow and increase in size. The outer wall of the ovary also changes and develops into the fruit wall, called the ***pericarp***. In some plants, the pericarp will become dry and hard (e.g. nuts) or soft and succulent (e.g. apples and peaches). You may think that a fruit is just an edible object like an apple or cherry, but vegetables such as beans and tomatoes, and grains like corn and wheat are also fruits. The botanical definition of a fruit is ***"a ripened ovary or group of ovaries that contain a seed or seeds"***.

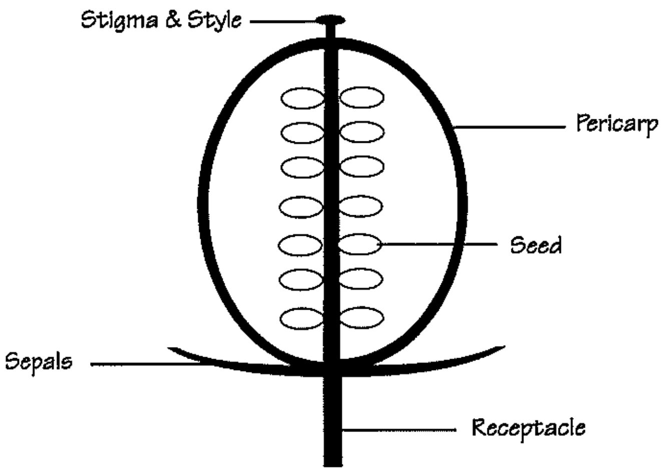
The main role of the fruit is to protect the developing seed(s). Fruits will often have spines or a hard surface to protect the seeds from animals. Other fruits will be bitter to eat until the seed is fully developed. When the seed is fully developed, the fruit will often change colour. This is to attract animals which will eat the fruit and disperse the seed. Dispersal (spreading) of the seed is another important role performed by the fruit. Most seed is dispersed by animals, the wind, or by water.

There are three main types of fruits:

Simple fruits

These develop from a single ovary of one flower. The flower may only have one carpel (stigma & style) or several carpels.

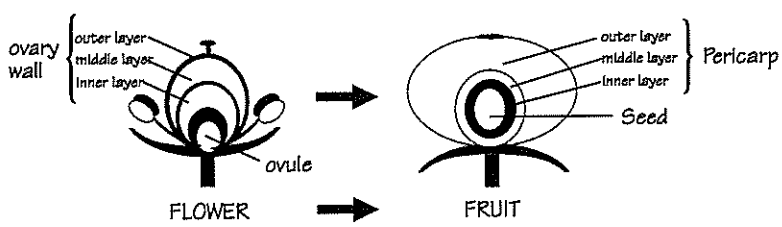
Cross Section Of A Simple Fruit



Most plant species have simple fruits, so there are a wide variety of fruit forms, shapes and sizes. However, there are two main kinds of simple fruits:

- ***simple dry fruit*** - where the mature fruit wall is dry and woody. These fruits may be single or multi-seeded. In these fruits, the seed stays in the pericarp when they are mature. Examples of this type of fruit are nuts and the fruits of grasses and cereals.
- ***simple succulent fruit*** - where the pericarp is fleshy and is made up of three layers. These fruit may be single or multi-seeded. Examples of this type of fruit include the apple, cherry, tomato and grape.

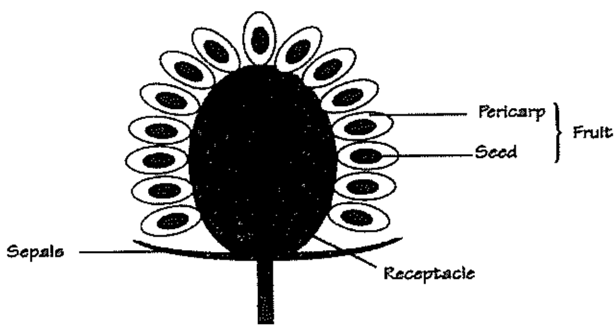
Development From Flower To Fruit



Aggregate fruits

Aggregate fruits are made up of many small fruits that develop out of the separate carpels of a single flower. Plants that have this type of fruit include the strawberry, rose, raspberry and blackberry.

Cross Section Of An Aggregate Fruit



Composite fruits

These fruits are made from the ovaries of several flowers. The part of a composite fruit that we eat is an enlarged receptacle. The flowers that develop into this type of fruit are very small, and are attached to the inner wall of the receptacle. Examples of plants with this type of flower include the fig, pineapple and mulberry.

Cross Section Of A Composite Fruit