Agriculture in Vanuatu

PLANT BIOLOGY

Ministry of Education
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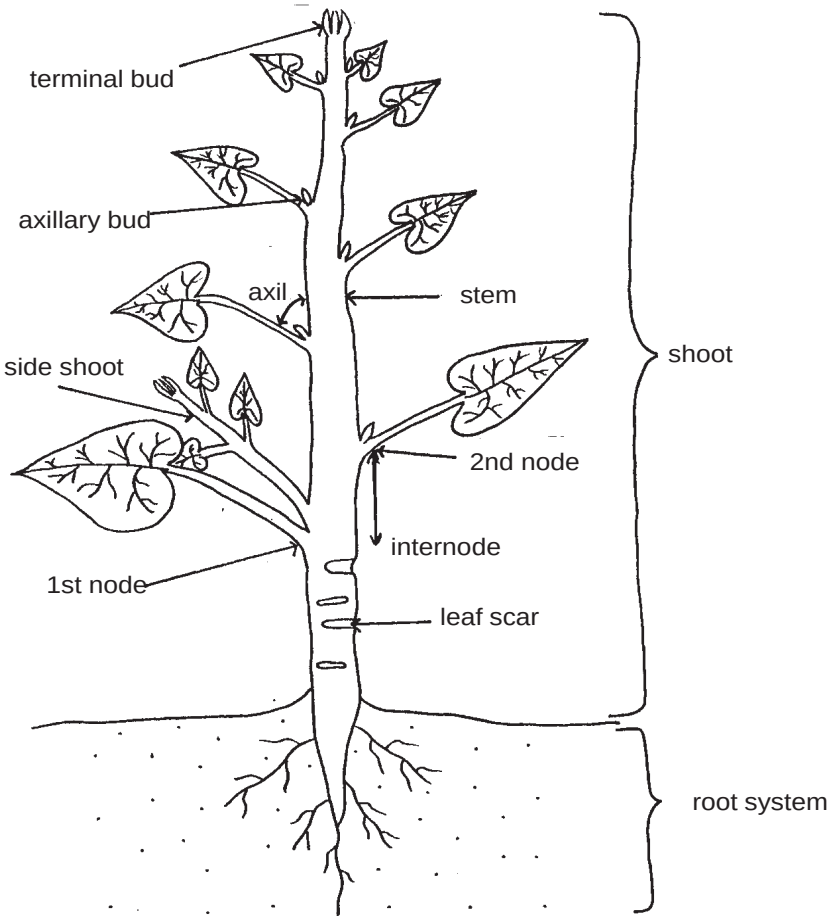
Contents

1. Parts of a plant

A plant is made up of many parts or structures. In order to understand how a plant works we must learn about these different parts.

Figure 1 **Parts of a plant**



Shoot	the part of the plant growing above the soil. It consists of **stems**, plus **buds** and **leaves**.
Main shoot	the first shoot to grow, and usually the biggest.
Side (lateral) shoots	These grow later from the **axils** of the **main shoot**. They are usually smaller and sometimes called **branches**.
Axil	the gap between a **leaf** and the **stem**. **Axillary buds** are found here.

Node	the position where a **leaf** joins the **stem**. The lowest node is the **1st node**, next one up the **2nd node**, and so on.
Internode	the gap between two **nodes**.
Buds	these produce new cells to make the plant grow. They can produce **shoots**, **flowers**, or **fruits**. They are sometimes called the **growing points**.
Terminal bud	this is found at the top of the **main shoot**. It makes the plant grow tall and straight.
Axillary buds	these occur in the **axils**. They sometimes make the plant grow "bushy" by producing **side shoots**.
Leaf scar	a mark on the stem showing from where a **leaf** has fallen.

Practical work

After the introduction of this topic, students should make a collection of different plants from the garden or bush. They should try to identify the various structures present on these plants.

2. Leaves

Function

The main function of leaves is to catch **sunlight**, and make plant food by **photosynthesis**.

Types

There are two main types of leaf:

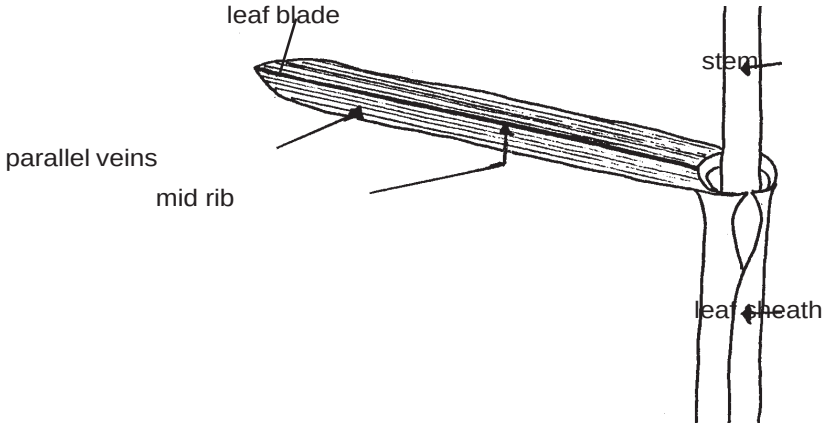
1. Narrow Leaves

These have straight parallel veins and a leaf sheath.

Plants with leaves like this are called **monocots**.

For example: corn and grasses

Figure 2 **Parts of a narrow leaf**

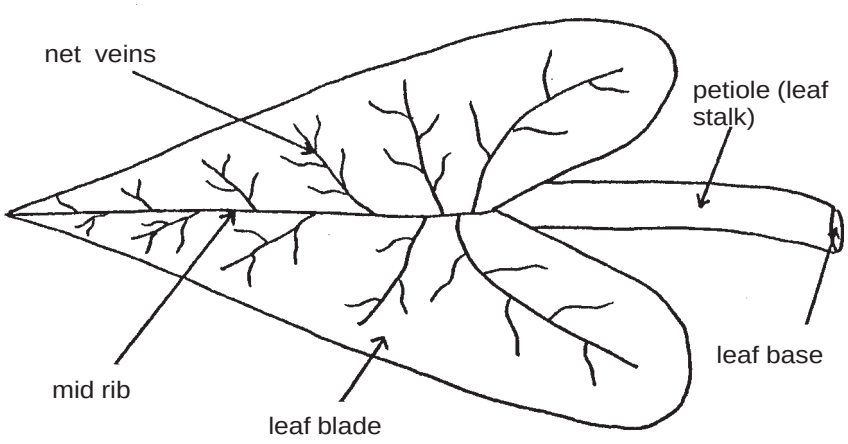


2. Broad Leaves

These have branching veins, sometimes called **net veins**, and they have a **petiole (leaf stalk)**. Plants with leaves like this are called **dicots**.

For example: taro and pawpaw

Figure 3 **Parts of a broad leaf**



Leaf veins carry **water**, **nutrients** and **plant food** through the leaf. The main vein in the centre of the leaf is called the **midrib**.

Leaf blade is the main part of the leaf structure. It is **flat** and **thin** to allow it to catch plenty of **sunlight**.

The top of the leaf blade is **dark green**, this is because it contains a substance called **chlorophyll**. Chlorophyll helps the leaf absorb sunlight energy.

The **bottom** of the leaf blade is full of small holes called **stomata**. These are too small for us to see, but very important, because they allow **water** and **gases** to move in and out of the leaf.

Practical work

Students should make a collection of different leaves from the garden or bush. They should try to classify them as Broad or Narrow leaves and identify the various parts.

3. Transpiration

This is the loss of **water** from plants. It occurs mainly in the leaves.

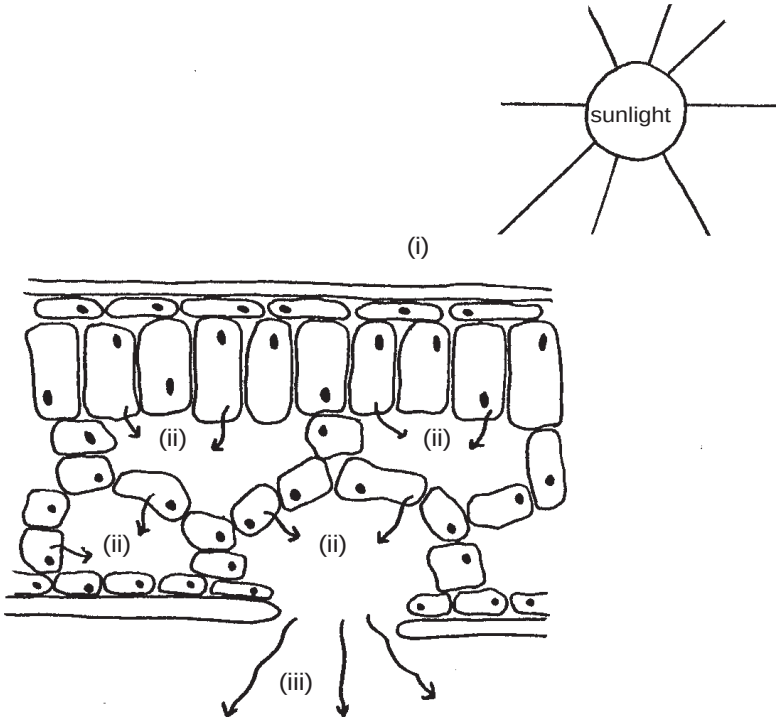
The transpiration process

(i) **Sunlight** falls onto plant leaves.

(ii) The heat of the sun turns the water inside the leaf cells into **water vapour**. The water vapour moves from the cells into the **air spaces**.

(iii) The water vapour moves out of the leaves through the **stomata** and is lost to the air by **evaporation.**

Figure 4 **Transpiration process in a leaf**



A small amount of water is lost from plant stems through tiny holes called **lenticels**.

Transpiration helps to keep leaves cool (like sweating in animals).

Conditions which speed up transpiration

The following weather conditions accelerate the loss of water from leaves:

1. **Sunlight**

   because sunlight heats up the water inside leaves.

2. **Wind**

   because wind increases the rate of evaporation from stomata.

3. **Dry Atmosphere**

   because it is easier for water to evaporate into dry air than humid air. This is because humid air already contains a lot of moisture.

In these weather conditions it is therefore very important to keep crop plants supplied with plenty of water. If plants become short of water, they wilt and die.

Practical work

The following is a very simple demonstration of transpiration.

Procedure

(i) Take two, clear, dry plastic bags.

(ii) Place one of these over a small branch of a plant growing in the sun and tie the mouth of the bag tightly around the stem (see Figure 5).

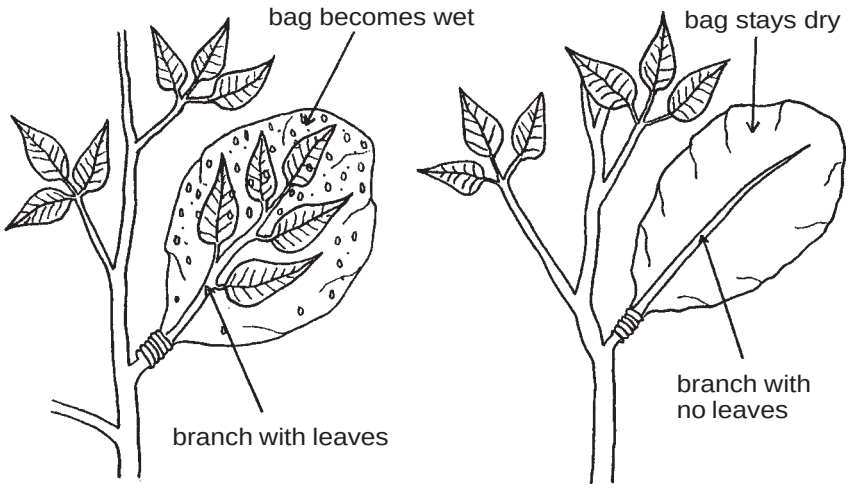
(iii) Place the second bag over a similar branch which has had all its leaves removed (see Figure 5).

(iv) After 2 hours return to the plant and examine the bags carefully.

(v) Observe the presence of water on the inside of the plastic bag covering the leafy branch, whilst the bag covering the leafless branch is dry.

Explain to students that this demonstrates that water is lost from the leaves.

Figure 5 **Transpiration Demonstration**



4. Photosynthesis

This is the name given to the process by which plant leaves use **sunlight energy** to make **simple foods**.

These simple foods are called **carbohydrates**, and they are rich in **energy**.

The carbohydrates we find in plants are **sugars** and **starch**.

The photosynthesis process

(i) **Sunlight energy** is absorbed by **chlorophyll** at the top of the leaf.

(ii) **Carbon dioxide** gas enters the leaf through the **stomata** at the bottom.

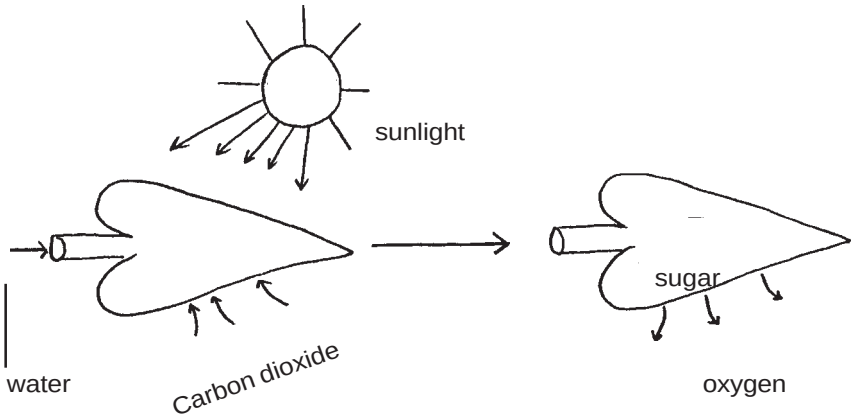
(iii) **Water** enters the leaf through the **veins**. (It enters the plant through the roots.)

Then **sunlight**, **carbon dioxide** and **water** react together to make **carbohydrate (sugar)** and **oxygen**.

The photosynthesis equation

sunlight energy + carbon dioxide + water = carbohydrate (sugar) + oxygen

Figure 6 **Photosynthesis in the leaf**



Oxygen gas produced by photosynthesis moves out into the air, through the Stomata.

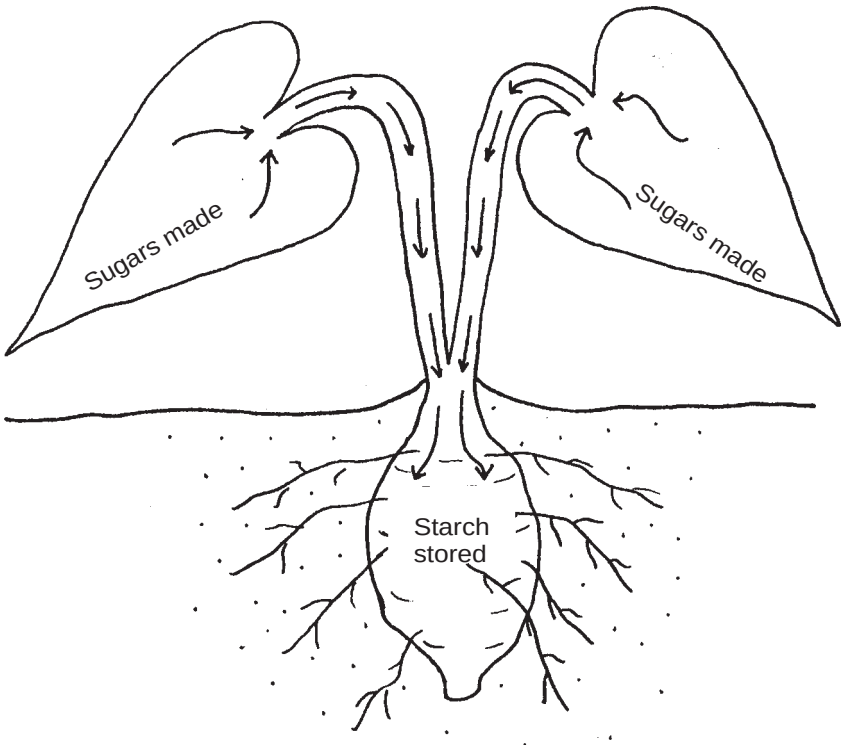
Sugars produced by photosynthesis can be used in two ways:

(i) To give plants **energy** to grow (see notes on **respiration**).

(ii) They can be moved to another part of the plant (usually the root or stem) and changed into **starch**. This happens in many of our food crops.

e.g. yam, taro, manioc and kumala **starch** acts as a **store of energy**.

Figure 7 **Starch storage in taro**



Practical work

Students can carry out the following experiment to demonstrate that light is needed for photosynthesis.

Procedure

(i) Cover the leaf of a tree that is growing in sunlight with a strip of silver paper (see Diagram 8).

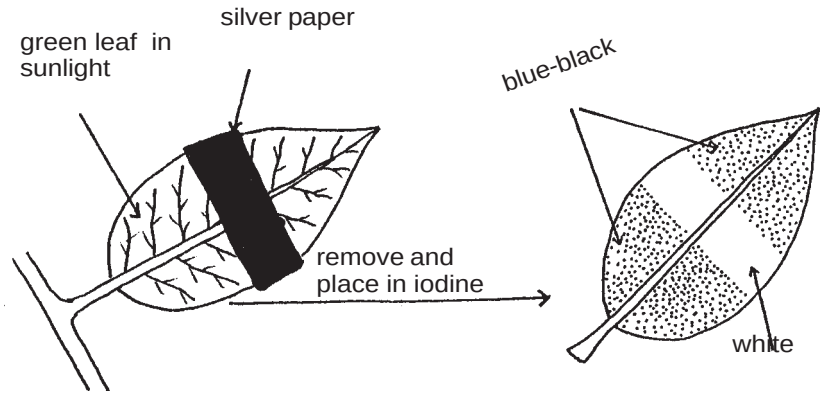
(ii) After 3 days remove the leaf from the tree, take off the silver paper and kill the leaf by boiling it in water.

(iii) Remove the chlorophyll from the leaf by washing it with methylated spirits.

(iv) Place the leaf in iodine solution and observe how the part of the leaf not covered by silver paper turns a blue-black colour.

Explain to the students that iodine only turns blue-black in the presence of starch. The reason why the part of the leaf under the silver paper does not turn blue-black is because there was no sunlight for it to make starch by photosynthesis.

Figure 8 To show that light is required for photosynthesis



5. Respiration

This is the process which **all plants (and animals)** use to obtain **energy** from **simple food (carbohydrate)**.

Energy is required by plants for growth, movement and other processes which take place inside them.

The respiration process

Respiration takes place inside the living plant cells. For respiration to occur, the cells require:

(i) **Carbohydrate**: this is made by plant leaves during photosynthesis.

(ii) **Oxygen**: this is taken in from the air through the stomata.

During the respiration process the carbohydrate is broken down to release the energy stored inside it.

The respiration equation

oxygen + carbohydrate ⟶ energy + water + carbon dioxide

The carbon dioxide gas is released back into the air through the stomata.

N.B. Photosynthesis and respiration are "reverse processes":

- during **photosynthesis**, energy from the sun is **taken in** by plants and **stored** in simple foods.

- during **respiration** that energy which was taken in is **released** from the simple foods, and used by the plants for growth, movement etc.

$$\text{CARBON DIOXIDE} + \text{WATER} \xrightarrow[\text{sunlight}]{} \text{CARBOHYDRATE} + \text{OXYGEN}$$

$$\text{CARBOHYDRATE} + \text{OXYGEN} \longrightarrow \text{CARBON DIOXIDE} + \text{WATER} + \text{ENERGY}$$

(ENERGY: growth, movement etc.)

Practical work

It is not easy to demonstrate respiration in plants. After explaining that plants breathe out the same gases as humans, the following limewater test for carbon dioxide can be carried out:

Procedure

(i) Heat Calcium Carbonate (coral) strongly to change it to quicklime (Calcium Oxide).

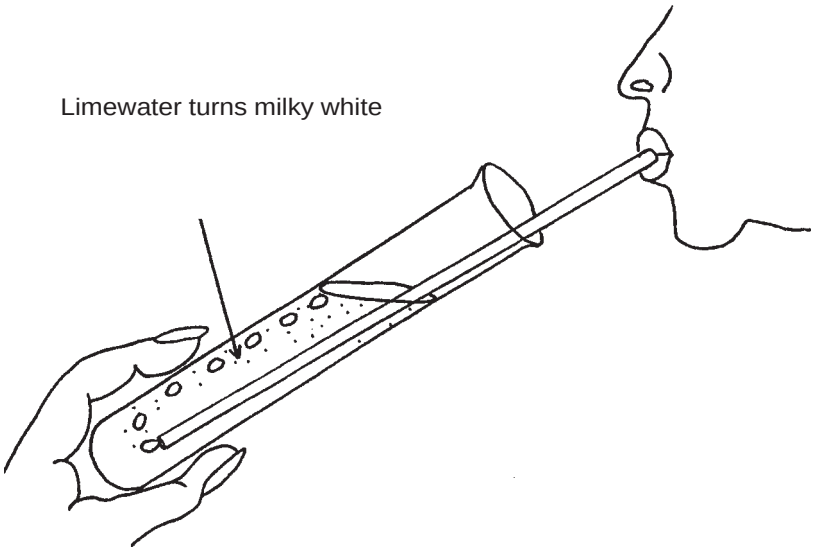
(ii) Add the quicklime to water, shake and stand for a few days in a covered container until the top of the liquid is clear. If possible, filter it.

(iii) Add some of the clear liquid to a test tube or small bottle and breathe into it using a straw or thin tube (see Figure 9).

(iv) Observe the clear liquid turn a milky-white colour.

Explain to the students that this change occurs only in the presence of carbon dioxide.

Figure 9 Limewater test for carbon dioxide



6. Stems

Functions

Stems have three main functions:

1. Support

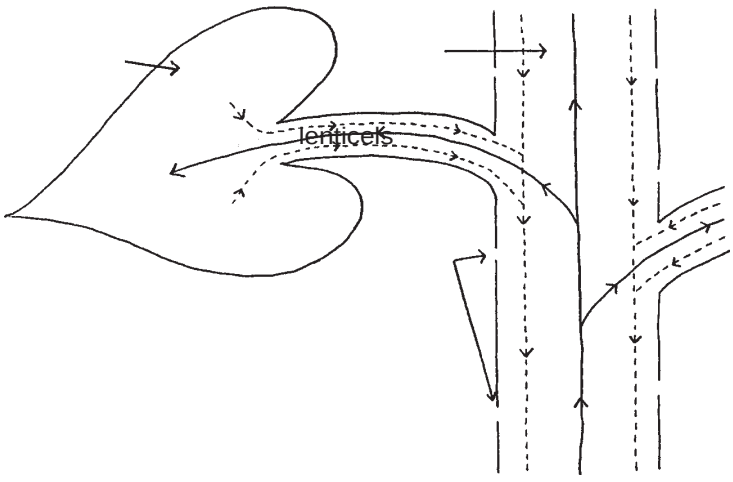
They hold up other parts of the plant that are above the soil. eg. leaves, flowers and fruits.

2. Transport

(i) **Water** and **nutrients** move **upwards** through the centre of the stem.

(ii) **Sugars** move **downwards**, from the leaves, through the **outside** of the stem.

Figure 10 **Transportation in a stem**



Key

-----> sugars from the leaves

> water and nutrients from the roots

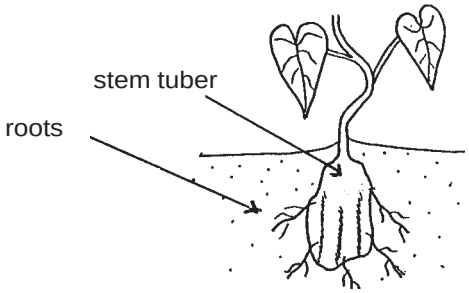
3. Food Storage

Most juicy stems store some food. Some have special forms for this purpose. The food is usually stored as **starch**. Starch is a **carbohydrate** made during photosynthesis and is rich in **energy**. Here are some examples:

(i) Stem Tubers

These are swollen underground stems. eg. Yam

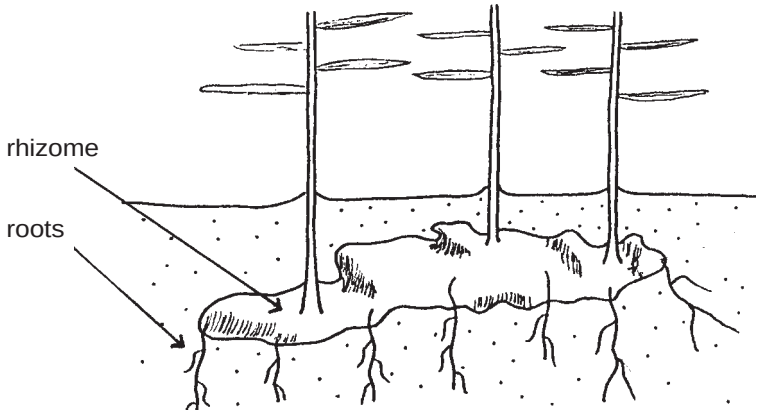
Figure 11 **Stem tuber**



(ii) Rhizomes

These are swollen underground stems which are horizontal. e.g. Ginger

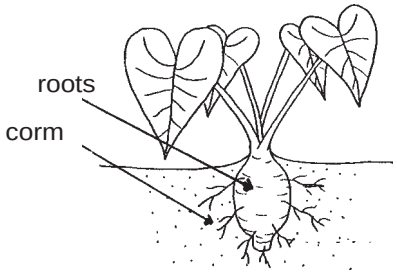
Figure 12 **Rhizome**



(iii) Corms

This is a swollen stem base. eg. Taro

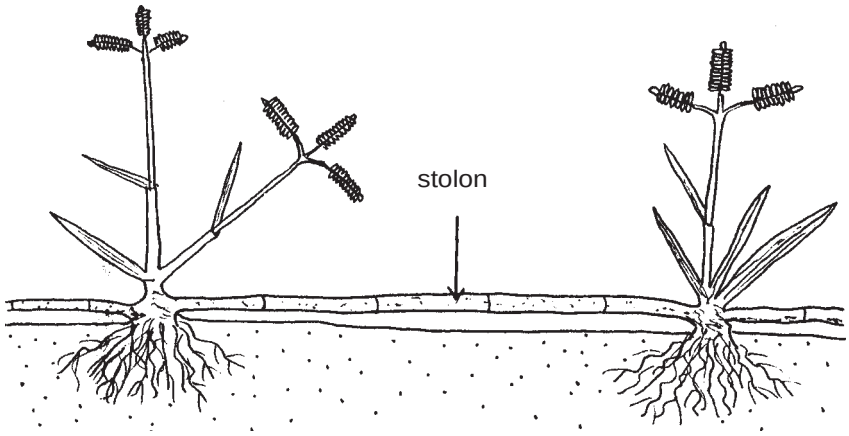
Figure 13 **Corm**



Stolons

These are horizontal stems which grow just above the soil. Usually they do not store food, but help the plant to spread out and cover the round, eg. buffalo grass, watermelon.

Figure 14 **Stolon**



Practical work

1. Students should make a collection of the different kinds of stems outlined in the notes, and draw labelled diagrams.

2. The following simple experiment can be used to demonstrate the pathway of water through the stem:

Procedure

(i) Pick several small leafy plants and cut across the bottom end of their stems.

(ii) Place the cut ends of the stems in a coloured solution such as neutral red or methylene blue.

(iii) After five minutes remove one of the plants and slice across the bottom of the stem. Observe the water vessels which will have been stained by the coloured solution.

(iv) Cut sections higher and higher up the stem until the colour can no longer be seen. This will show the height to which the solution has risen in that time.

(v) Remove another plant after ten minutes, then another after fifteen minutes and so on repeating the procedure (iv). This will show the rate at which the solution is rising up the stem.

7. Roots

Functions

Roots have 2 main functions:

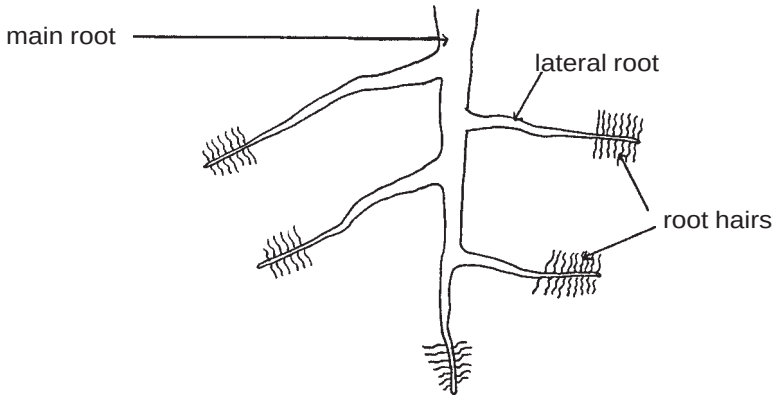
1. **Anchorage:**

   They hold plants firmly in the soil.

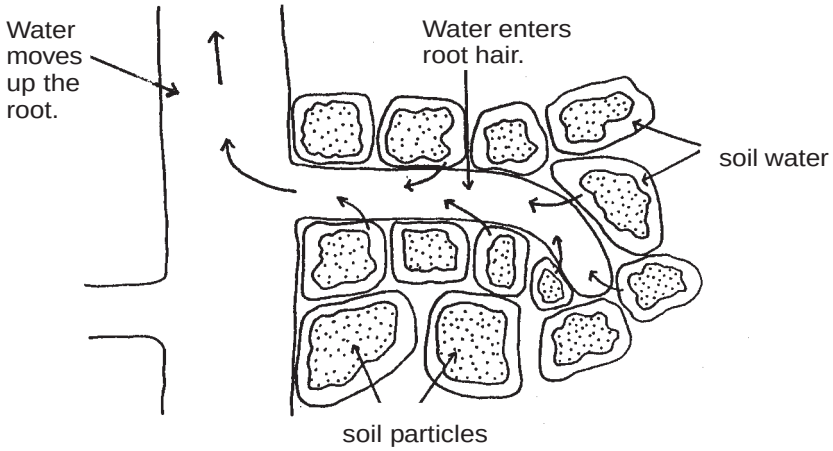
2. **Absorption:**

   They absorb **water** and **nutrients** from the soil. This is done by the **root hairs**. These are found at the end of the main roots. These are small and easily damaged.

Figure 15 **Position of root hairs**



The root hairs absorb water and nutrients from the layer of water which surrounds the soil particles.



Root systems

There are two main types of root systems:-

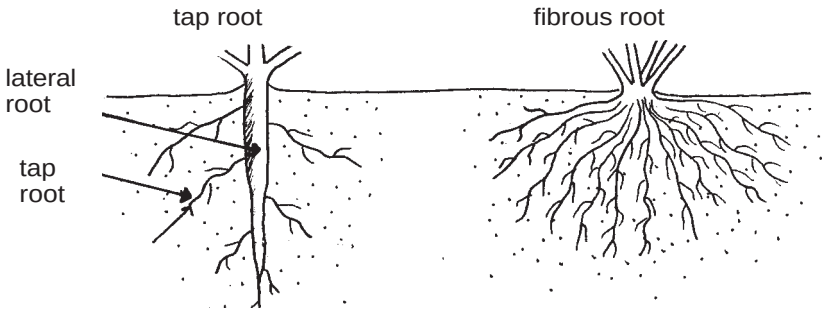
(i) **Tap Root System**

This system has one main root which can grow quite deep, and is often thick. Other smaller roots called **lateral roots** branch from it (see Figure 17).

(ii) **Fibrous Root System**

This system has roots which all grow to about the same size and length. This system is usually not as deep as a tap root system (see Figure 17).

Figure 17 **Types of root system**



Food storage in roots

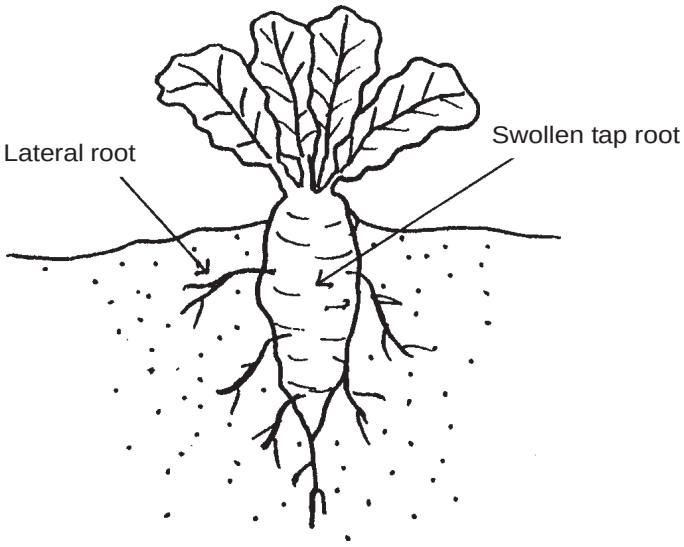
Some plants use their roots to store food. The food is usually stored as **starch**. Starch is a **carbohydrate**, rich in **energy**.

The two main types of root structures which store food are:

(i) **Swollen Tap Roots**

The tap root of the plant becomes swollen with starch. eg. carrot, beetroot, radish.

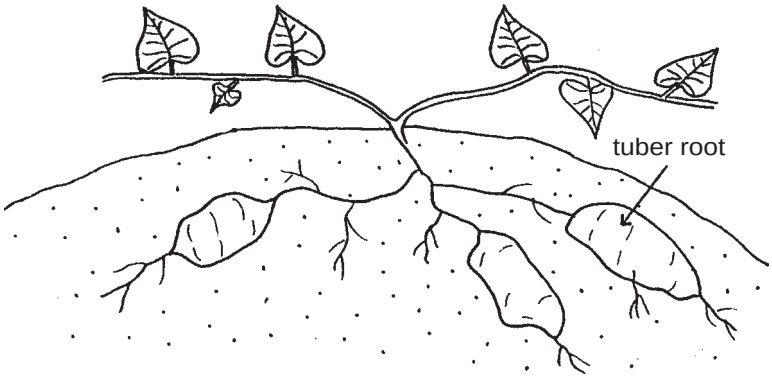
Figure 18 **Tap root of a radish plant**



(ii) **Root tubers**

Parts of the root system become swollen with starch, eg. kumala, manioc.

Figure 19 **Tuber roots of kumala**



Practical work

Students should make a collection of different plants to discover if they have Tap Roots or Fibrous Roots, and observe the Root Hairs. They should also observe as many as possible of the other root features outlined in the notes.

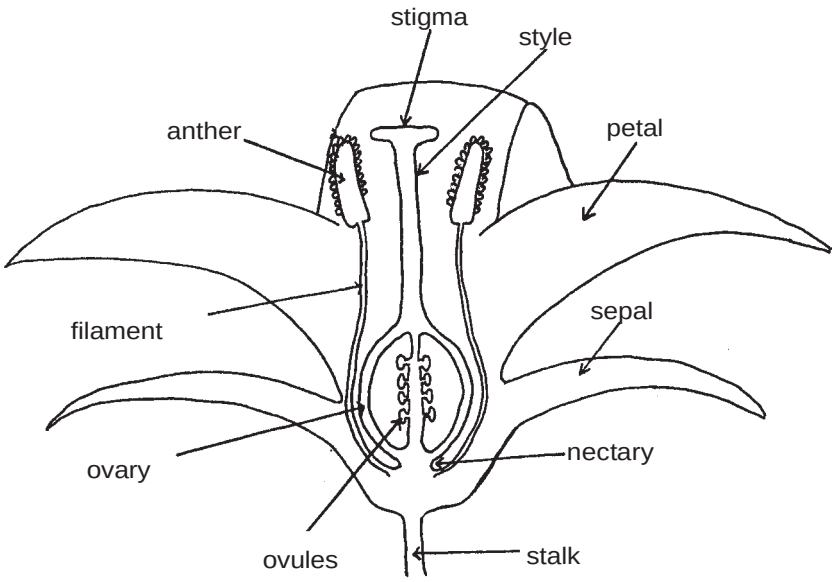
8. Flowers

Function

The function of flowers is to help the plant to reproduce by making seeds. These are usually contained in a **fruit**.

Flowers can be many different colours, shapes and sizes. Most contain male and female parts but some, for example pawpaw and corn, have separate male and female flowers.

Figure 20 Parts of an insect pollinated flower



Parts of the flower

(see Figure 20)

	Flower part	function
Female parts (Carpel)	**sepals**	protect the flower bud.
	stalk	supports the flower, and transports water and nutrients to it.
	petals	often brightly coloured to attract insects.
	stigma	collects pollen from insects or the air.
	style	supports the stigma, and pollen grows down it.
	ovary	contains ovules, and becomes the fruit.
	ovules	become the seeds.
Male parts (Stamen)	**anther**	produces pollen.
	filament	supports the anther.
	nectary	sweet sugary substance. It attracts insects (not present in all flowers).

Practical work

Students should make a collection of flowers from the garden or bush, and attempt to identify the various structures in tomato, pigeon pea, Christmas tree, funeral lily. Using a razor blade and magnifying glass, the flowers can be cut in half to observe the ovules.

Many flowers have difficult structures. It is probably best to avoid bougainvillea, hibiscus, frangipani, pawpaw and coconut.

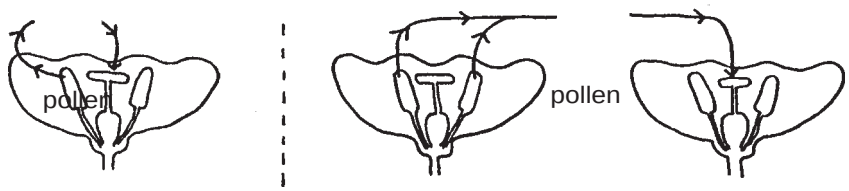
9. Pollination

This is when **pollen** moves from an **anther** to a **stigma**.

Self pollination is when pollen moves onto the stigma of the **same** flower.

Cross pollination is when pollen moves onto the stigma of a **different** flower.

Figure 21 **Pollination**



Self pollination Cross pollination

How pollen moves

Pollen is moved from an anther to a stigma by **insects** or **wind**:

1. **Insect Pollination**

   Insects are attracted to flowers with bright coloured petals and sweet smelling scents. The insects pick up pollen on their bodies as they search for nectar. This pollen can then later be brushed onto a stigma, causing pollination.

2. **Wind Pollination**

   This occurs in flowers which are usually small and have no bright coloured petals or scent. Such flowers, for example grasses, produce a lot of light pollen which can be blown from an anther to a stigma by the wind.

Practical work

Students should be asked to find 3 examples of insect-pollinated flowers, and 3 wind-pollinated flowers.

10. Fertilisation

After pollination the pollen grains on the stigma produce a pollen tube. Each pollen tube then grows down the style, until it reaches the ovary. Once inside the ovary, the pollen tube will join with an ovule, this is called **fertilisation**.

After fertilisation the following changes take place:

Sepals usually die and drop off.

Petals usually die and drop off.

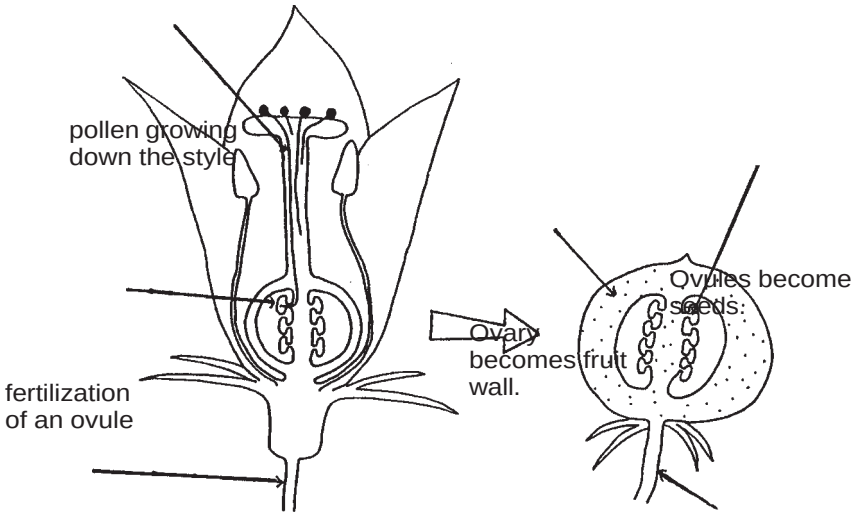
Stigma and style usually die and drop off

Anther and filament usually die and drop off.

Ovules become the **seeds**

Ovary becomes the **fruit**

Figure 22 Fertilisation of the flower



Practical work

Collect some tomato flowers and green tomato fruits. Using razor blades, students can dissect the flowers and fruits to observe the stages of fruit formation.

11. Fruits

A fruit is a swollen ovary containing one or more seeds.

Functions

The two main functions of fruits are:

1. Protection of the seeds
2. Dispersal of (scatter) the seeds.

Seed disposal

There are several methods used by different fruits to disperse seed:

(i) **Wind Dispersal**

The fruits are small and light so that they can be carried by the wind. Many weeds are dispersed this way.

(ii) **Animal Dispersal**

Succulent fruits are often eaten by birds or mammals. The seeds of these are either thrown away or they pass through the digestive system to be dispersed in the faeces, eg. tomato.

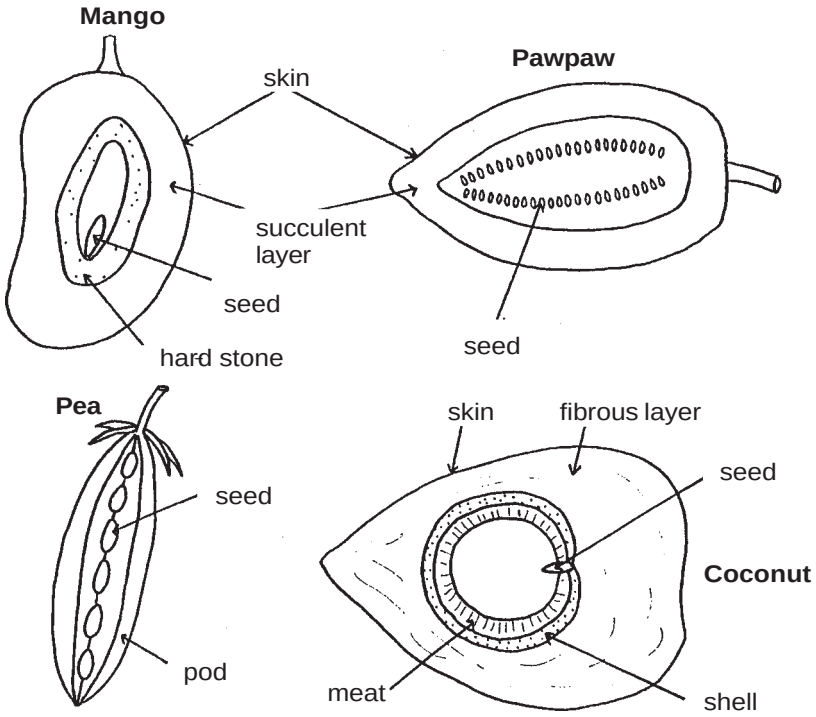
(iii) **Water Dispersal**

Seeds which float on water can be dispersed by river or sea, eg. coconuts.

(iv) **Self Dispersal**

The fruit wall dries out creating a tension. It then bursts open suddenly throwing the seeds out.

Figure 23 **Kinds of fruit**



Practical work

Students should make a collection of as many different kinds of fruits as possible. They should dissect them to observe the various features outlined in the notes. For each fruit they should attempt to determine the method of dispersal used.

12. Seeds

A seed develops from a fertilised ovule.

Function

The function of all seeds is to find new ground and grow into plants.

Types

Seeds are grouped into two types:-

1. **Monocots**

   These have 1 **cotyledon**, for example: most narrowleaved plants, such as corn, grass.

2. **Dicots**

   These have 2 **cotyledons**, for example: most broadleaved plants, such as taro and pawpaw.

Parts

A seed has three main parts:

1. **Testa**

   This is the seed coat. It protects the soft parts inside.

2. **Embryo**

   This will grow into the new plant after the seed germinates. It consists of two parts:

   (i) **radicle:** the young **root**

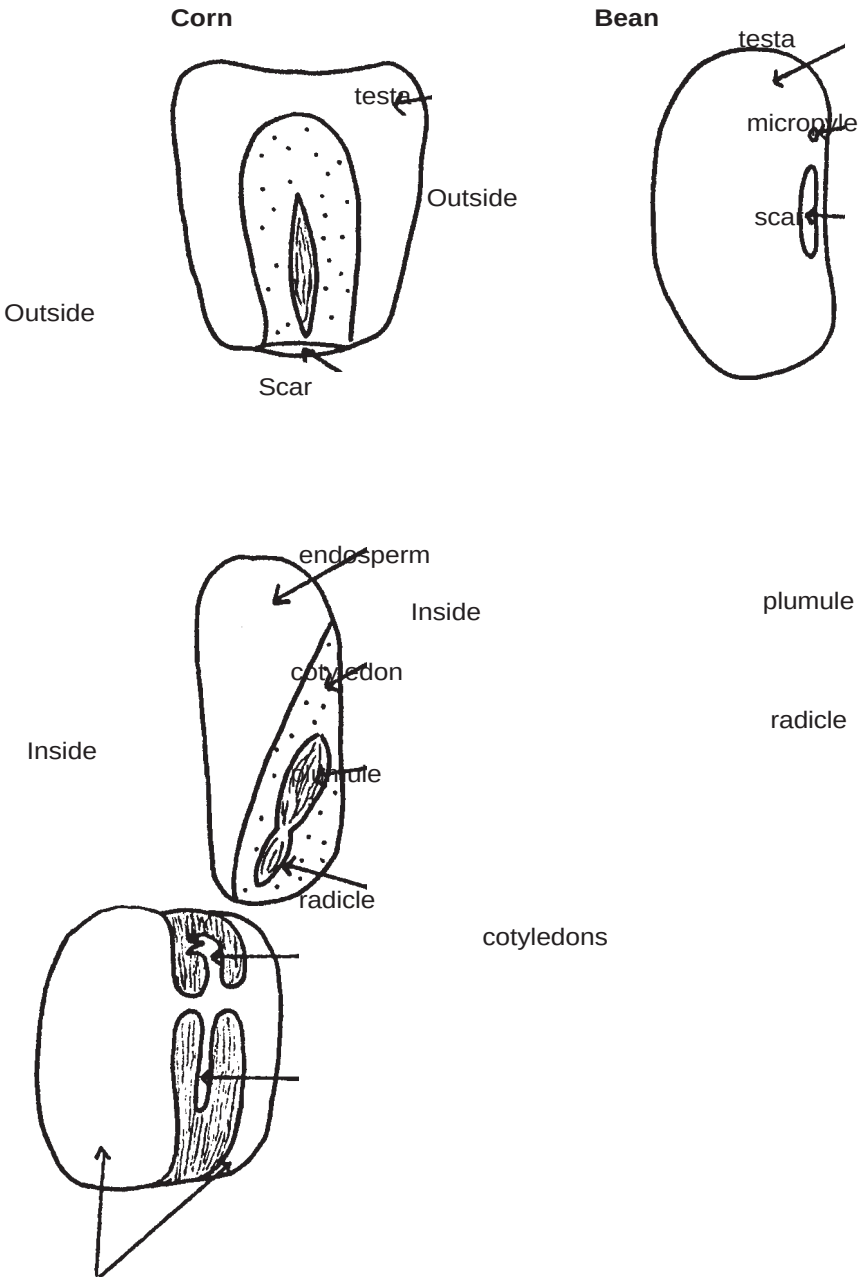
   (ii) **plumule:** the young **shoot**

3. **Food Store**

   This supplies energy to the embryo when it begins to grow. **Dicots** store food in the **cotyledons**.

   Monocots store food in the **endosperm.**

Figure 24 **Parts of seeds**



Scar: place where seed was joined to fruit.

Micropyle: hole in testa through which water and air are taken in during germination.

Practical work

Take a sample of corn and bean seeds. Get the students to soak these in water for four or five days. After this time they will be able to dissect the seed to observe the various features inside.

13. Germination

This is when the seed begins to grow into a plant.

Conditions for germination

Some seeds can remain alive in the soil for many years. For seeds to germinate they need to have enough:

- **water**
- **air**
- **warmth**

Note: Seeds do not require light to germinate and most seeds will germinate in light or dark conditions.

Stages of germination

1. The seed takes in air and water which causes it to swell up.
2. The testa splits open and the **radicle** emerges. The radicle grows down into the soil.
3. The **plumule** emerges and grows upwards towards the light.

   The energy for germination is supplied by the food store inside the seed (**cotyledons** or **endosperm**).

   As soon as the young plant has developed leaves it can make its own food by **photosynthesis**.

   The young plant is called a **seedling** (see Figure 25).

Practical work

Prior to teaching this topic plant some bean seeds out so that you have seeds at various stages of germination available for observation by the students. Start with the earliest planting at about two weeks before, and the last at about 4 days before teaching.

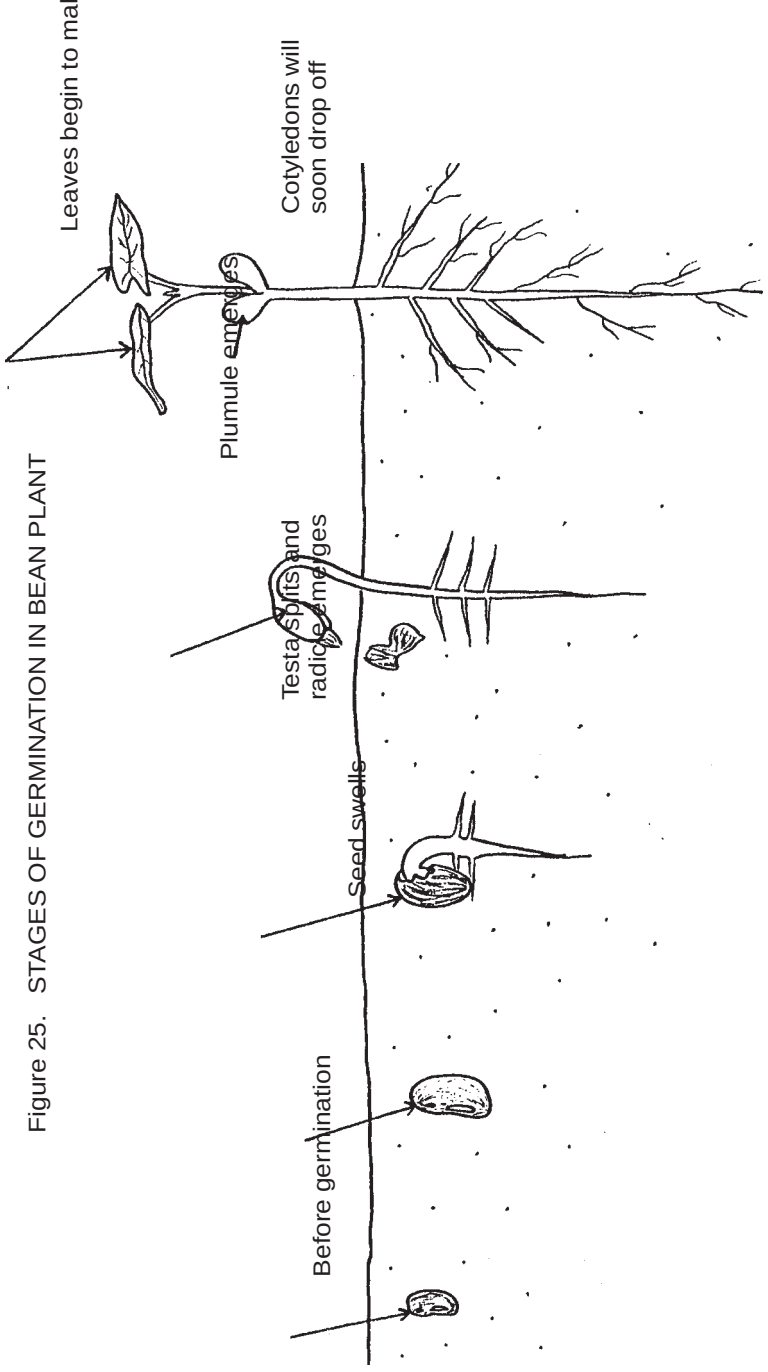


Figure 25. STAGES OF GERMINATION IN BEAN PLANT

Glossary

carbohydrate	simple food, made by plants during photosynthesis, which are rich in energy (eg. sugars and starch).
carbon dioxide	a gas, present in the air, taken in by plants during photosynthesis, and given out during respiration.
chlorophyll	a green chemical which absorbs sunlight.
corm	swollen stem base which stores food.
cotyledon	a seed leaf.
cross pollination	pollination occuring between different flowers.
dicot	plant which has two cotyledons in its seed.
embryo	the part of the seed which will grow into a plant.
endosperm	food store found in some seeds.
fertilisation	when pollen joins with an ovule.
fibrous roots	a root system where all the roots of a plant grow to approximately the same size.
germination	when a seed begins to grow into a plant.
insect pollination	pollination carried out by insects.
leaf blade	the flat part of a leaf which catches sunlight for photosynthesis.
leaf veins	tubes running through the leaf which carry water, nutrients, and plant food.

lenticels	small holes found on outside of plant stems.
micropyle	small hole in the seed coat (testa) through which water and air are taken in.
midrib	the main vein running through the middle of a leaf.
monocot	plant which has one cotyledon in its seed.
net veins	a system of branching veins found in broad leaves.
oxygen	gas, present in the air, taken in by plants for respiration and given out after photosynthesis.
petiole	leaf stalk found in broad leaved plants which attaches leaf blade to stem.
photosynthesis	the production of food by green plants.
plumule	the shoot of a seed embryo.
pod	fruit belonging to a legume plant.
pollination	when pollen moves from an anther to a stigma.
radicle	the root of a seed embryo.
respiration	process used by plants (and animals) to obtain energy from simple foods.
rhizone	horizontal underground stem.
root hair	part of the root which absorbs water and nutrients from the soil.
root tuber	swollen root containing stored food.
seedling	the young plant which emerges after germination.

self pollination	pollination occuring within a flower.
stem tuber	underground stems, swollen with food.
stolon	horizontal stem running overground.
stomata	small holes in bottom of leaf through which water and gases can pass.
swollen tap root	tap root which becomes swollen with food.
tap root	root, present in some plants, which can grow deep and become quite thick. Other smaller roots branch from it.
testa	the seed coat or outside skin of the seed.
transpiration	loss of water from plant shoots mainly from evaporation from the leaves.
wind pollination	pollination carried out by wind.