Unit 4
Food making and growth in plants

The flowering plant is a complete organism with organs carrying out particular functions.

There are four main organs of a flowering plant.

i. **Flowers**: which contain the reproductive organs**.**
ii. **Leaves: photosynthetic machine of plants.**
iii. **Stem:** provides support and a transport system for water and minerals to the leaves and flowers.
iv. **Roots:** anchor the plant to the ground and absorb water and minerals.

Structure of a typical flowering plant

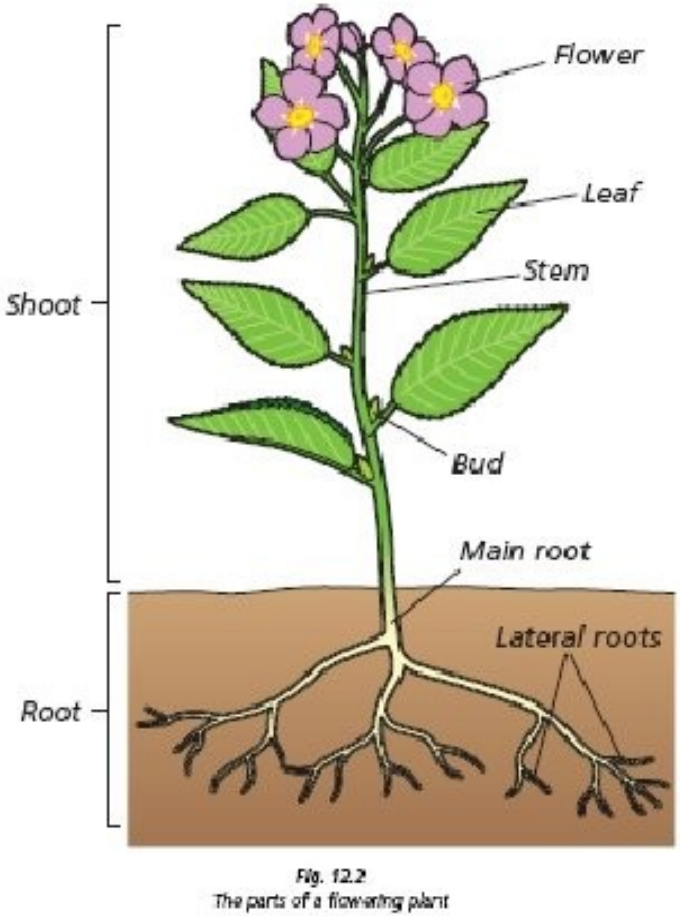


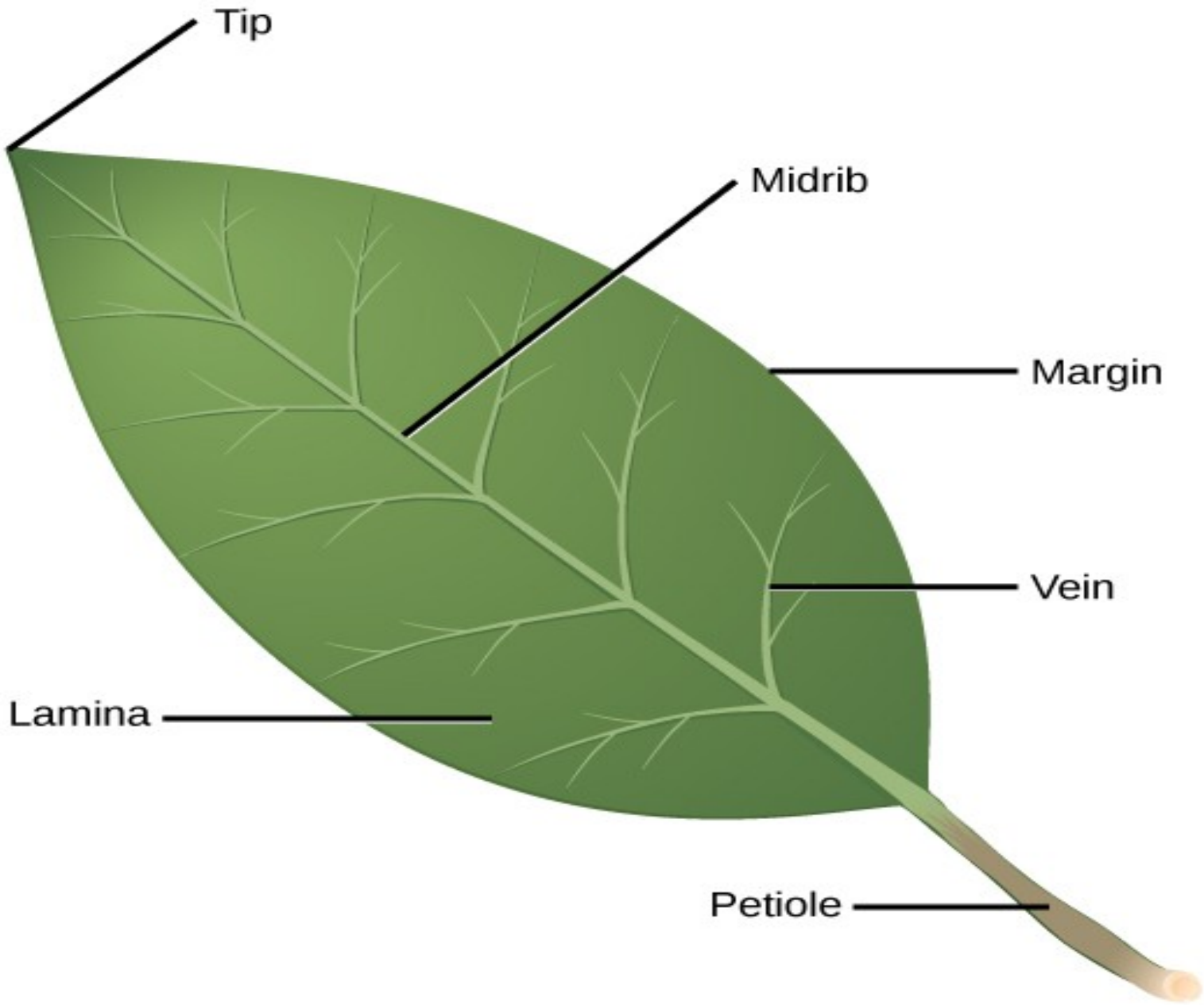
Fig. 12.2
The parts of a flowering plant

Diagram 7: From Exploring Science Teachers Resource CD

4.1. The leaf

I. External structure of the leaf

- **Blade:** is an extended surface of leaf
- **Petiole:** links the leaf to stem
- **Midrib (main vein):** the part consists of vascular tissues(xylem and phloem)
- **Margin:** the leaf border
- **Apex:** the tip of the leaf


Tip
Midrib
Margin
Vein
Lamina
Petiole

II. Internal structure of the leaf

A. The upper and lower epidermis

- Epidermal layer is composed of tightly fitting cells without chloroplast
- They are composed of waxy cuticle(waterproof layer found on the surface of many leaves to help prevent water loss)

B. The **lower epidermis** has openings known as **stomata** which allow carbon dioxide to diffuse into the leaf and oxygen and water vapour to diffuse out.

✓The **guard cells** control opening and closing of stomata & only cells in the epidermis that contain chloroplasts.

✓**Chloroplasts:** contains stacks of membranes and chlorophyll to give an increased surface area for photosynthesis to take place.

C. The **palisade mesophyll**

✓Is the main photosynthetic tissue of the plant and composed of many chloroplasts

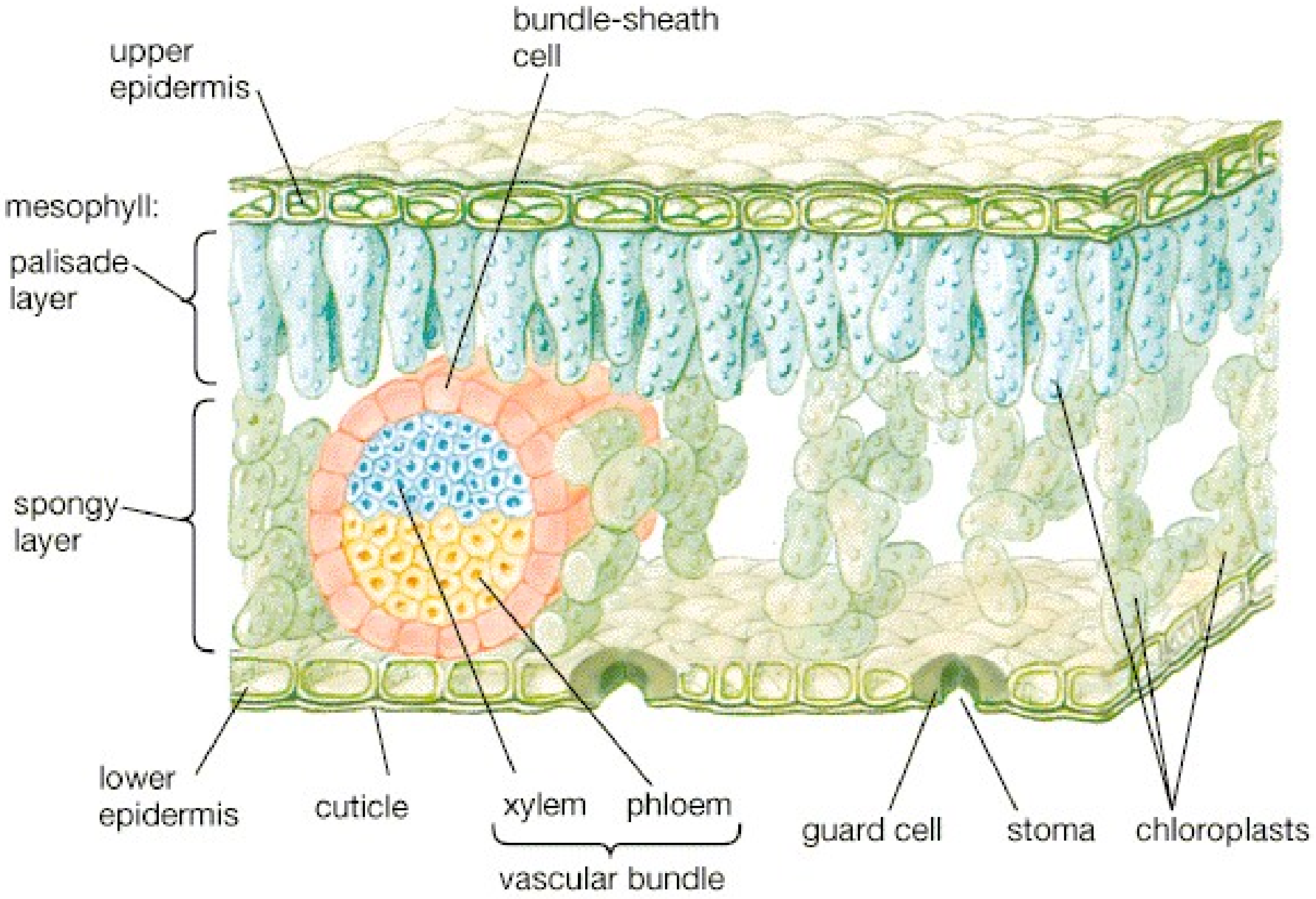
✓It consists of many closely packed cells near the surface of the leaf

D. The **spongy mesophyll**

- Have fewer cells with fewer chloroplasts.
- However, there are lots of air spaces and a big surface area for gas exchange.
- Is the main gas exchange tissue of a leaf

E. The **vascular bundles**

- Contain the **xylem**, dead tissue which brings water from the soil to the cells of the leaves, and the **phloem**, living tissue which carries the products of photosynthesis away from the leaves to all of the cells of the plant.


upper epidermis
bundle-sheath cell
mesophyll:
palisade layer
spongy layer
lower epidermis
cuticle
xylem
phloem
vascular bundle
guard cell
stoma
chloroplasts

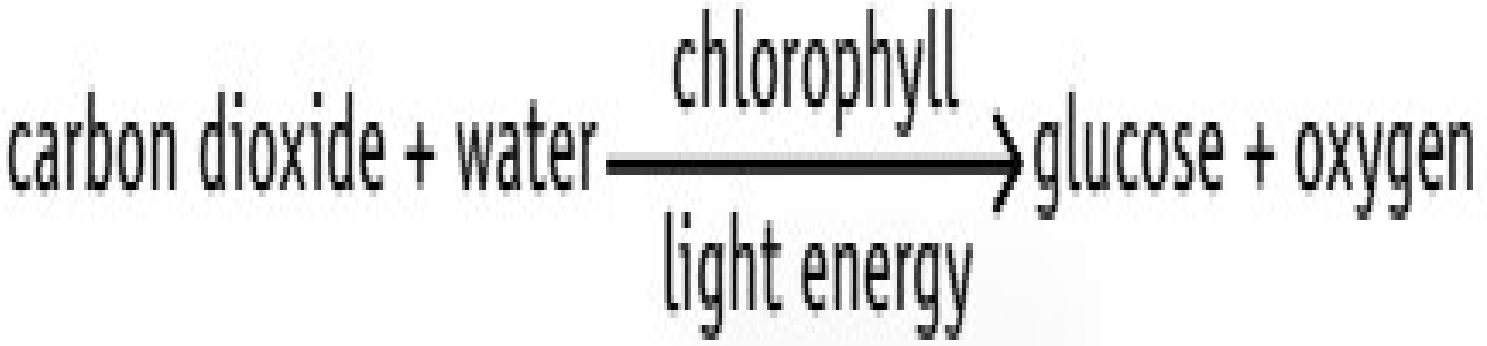
4.2. Photosynthesis

- Like all living organisms plants need food to provide them with the energy for respiration, growth and reproduction and produce their own food in a process known as **photosynthesis**.

- They are known as **autotrophs** (feeding themselves)
- **Photosynthesis: is** chemical process of making food (sugars) and oxygen, from carbon dioxide and water, in the presence of light.

❖ During photosynthesis plants require:

- ✓ Chlorophyll –the light absorbing pigment
- ✓ Water-from soil
- ✓ Carbon dioxide- from air
- ✓ Light –from the sun
- ✓ Photosynthesis can be summed up in the following equation:



Stages of photosynthesis

- Photosynthesis occurs in two main stages. these are:

1. Light dependent stage (light reaction)

- It is the stage at which light is required to split water molecules into hydrogen ion and oxygen.

$$12H_2O \rightarrow 24H^+ + 6O_2$$

- The hydrogen ions are trapped by hydrogen acceptor substance called $NADPH_2$ in order to be used in the light independent stage.

- Some amount of light energy is changed into a form of chemical energy called ATP which provides energy for light independent stage
- It takes place in the grana of chloroplast

2. Light independent stage(dark reaction)

It is the stage at which light is not required

Involves the use of products from light dependent stage and carbondioxide from air to form sugar

$$24H^{+} + 6CO_2 \rightarrow C_6H_{12}O_6 + 6H_2O$$

- It takes place in the stroma of chloroplast
- The overall reaction of photosynthesis is:

✓ $12H_2O \rightarrow 24H^+ + 6O_2$

✓ $24H^+ + 6CO_2 \rightarrow C_6H_{12}O_6 + 6H_2O$

$$6CO_2 + 6H_2O \xrightarrow[\text{light energy}]{\text{chlorophyll}} C_6H_{12}O_6 + 6O_2$$

- Some of the glucose produced during photosynthesis is used immediately by the cells of the plant for respiration to provide energy for cell functions, growth and reproduction

❖The energy released in respiration is used to build up smaller molecules into bigger molecules from the rest of glucose molecules such as:

✓Starch for storage which is stable and insoluble

✓Fructose and sucrose to be transport around the plant

✓Cellulose to make plant cell wall

✓Amino acids along with nitrates and other nutrients

✓Fat and oils for storage in seed and make part of cell membranes

✓To build up important molecules.

Testing leaf for starch

- After photosynthesis starch is temporary in the leaf, to check whether the leaf is photosynthesizing or not it is possible to add Iodine solution which turns it to blue black in the presence of starch.

The need for photosynthesis

1. The need for light

- The light energy is absorbed by chlorophyll molecules through activation of their electrons and used to split water molecules into hydrogen and oxygen.

- The simplest way of demonstrating the need of a plant for light is to deprive it of light and keep a whole plant in the dark for two to three days – this is called **destarching** the plant.

2. The need for carbondioxide

✓ A source of carbon is needed for the plants to synthesise sugars

✓To demonstrate that plants need carbondioxide for photosynthesis

✓Remove the carbon dioxide from the air surrounding a leaf or a plant using potassium hydroxide, which absorbs CO2.

✓Change the levels of carbon dioxide in the air surrounding a plant in high-intensity light and measure the changes in the rate of photosynthesis.

✓As the carbon dioxide level increases, the rate of photosynthesis goes up.

3. The need for water

- Water is needed during photosynthesis as a source of hydrogen found in glucose molecule formed

- To demonstrate this- supply a plant with a heavy water containing the 18 O isotope of oxygen, these atoms are radioactive and the radiation they produce can be detected as it is taken up and used by the plant.

- This experiment not only shows that water is need for photosynthesis, but also the oxygen gas produced during photosynthesis comes from the splitting of water molecules.

4. The need for chlorophyll

- Chlorophyll is needed to capture the energy from the sun for photosynthesis.

- The simplest way to demonstrate that chlorophyll is needed for photosynthesis to take place is to consider the leaves of a variegated plant.

- **Variegated leaves** have areas that contain chlorophyll and areas that do not.

4.3. Transport in plants

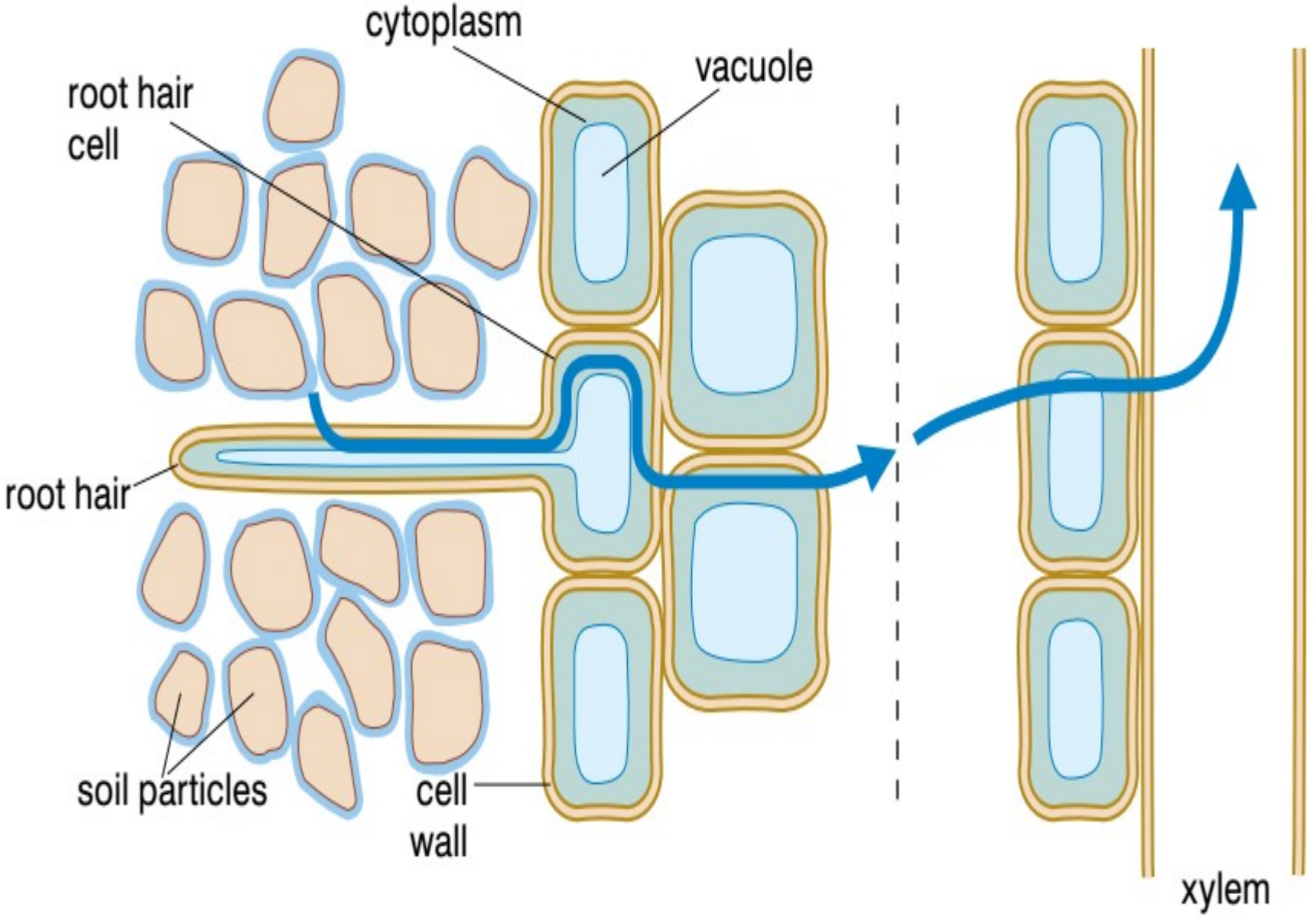
- Trees are supported by their wood trunks , but the plants do not have the wood tissues rely having cells , which are rigid and firms that are maintained by the movement of water into the cells by osmosis to create turgor pressure

❑How does water enter the plant body?

- Water enters the root hairs from the soil by osmosis
- Root hairs: Hair like extensions which cover the root that increase the surface area.

✓Once water has moved into the root hair cells , the cytoplasm of the root is more dilute than the cytoplasm of surrounding cells

✓Water moves into the neighboring cells and it moves on by osmosis until it reaches the xylem and the transpiration stream.


cytoplasm
vacuole
root hair cell
root hair
soil particles
cell wall
xylem

❑ Active transport in plants

- Plants absorb mineral ions from the soil which are usually found in very dilute or less concentration into more concentration of plant cells by active transport.

❑ Transport of materials around the plant

- Plants need a transport system to move substances around their bodies.

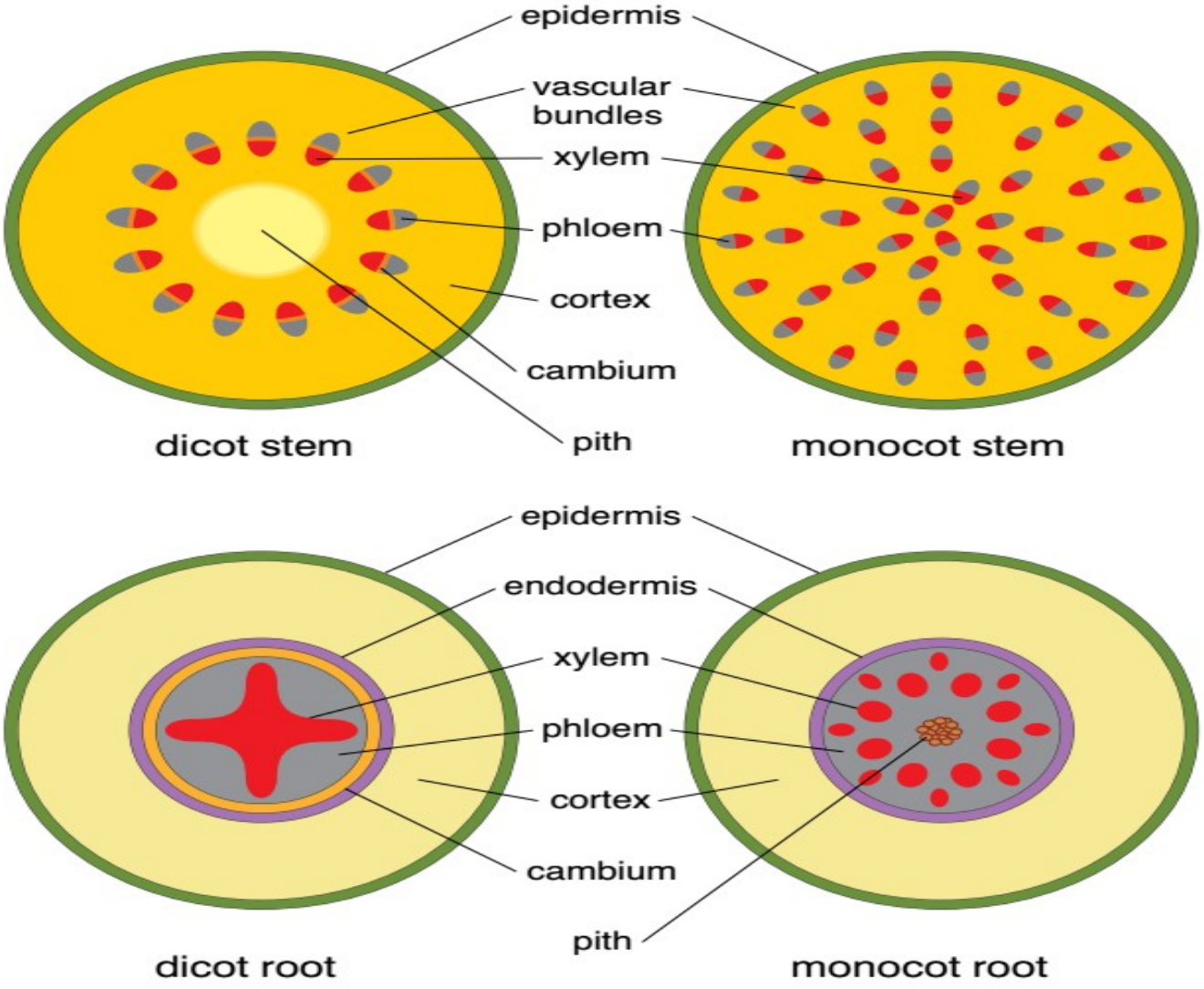
❖ A double transport system

- A double transport in plant is achieved by xylem and phloem.
- The phloem is involved in transport products of photosynthesis from the leaves to the rest part of the plants.

- Phloem tubes are thin walled, living tissues and regularly replaced when they are worn out, they contain liquid rich in sugar.

- Transport system in phloem is active transport; the plant has to use energy to move substances around the phloem, both upwards and downwards.

- In dicot stems ,xylem and phloem are found in rings but in monocot stems they are scattered
- Dicot stems have pith but monocot stems have no pith on the other hand monocot roots have pith but dicot roots have no pith.


epidermis
vascular bundles
xylem
phloem
cortex
cambium
pith
dicot stem
monocot stem
epidermis
endodermis
xylem
phloem
cortex
cambium
pith
dicot root
monocot root

- The In woody plants like tree, xylem tissue makes up the bulk of the wood & phloem is found in a ring underneath the bark.

- xylem carries water and minerals from the roots upwards to different parts of plant.

- The xylem tissue is dead and there is no active transport taking place .the movement of the water in the xylem is due to transpiration.

❑ The need for transport in plants

- Transport in plants move glucose for cellular respiration for growth and for storage as starch.

- If cells have lots of sugars, more water move into cells by osmosis and would be turgid, so sugars are converted into starch.

- Starch is stored in storage organs such as root tubers, stems, seed, leaves and fruits.

- The movement of minerals is needed for production of proteins and other molecules within the cells.

- The movement of water is needed for photosynthesis & for young and non woody plants; it is the main method of support.

- It is also very important in keeping the leaves firm & spread out to catch light.

❑How does water travel within the plant body?

✓ The transport of water through the plant is the result of transpiration stream

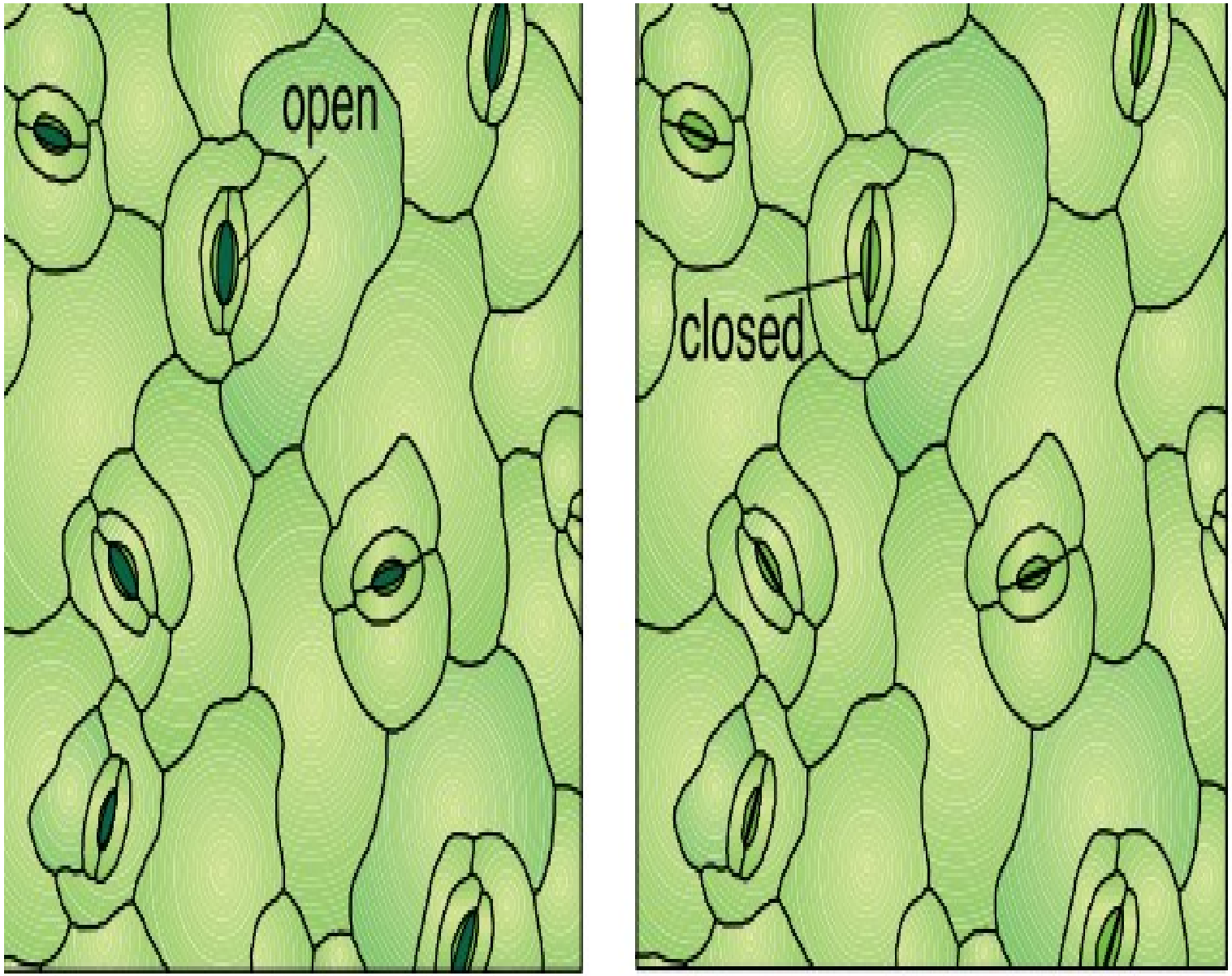
- Plants lose water vapor from the surface of their leaves .this loss of water is known as transpiration.

- Most of transpiration takes place through stomata. Losing water through stomata is side effect of opening them to let carbondioxide, but it is vital for transpiration, most of the stomata are found on the underside of the leaf.

- **What affects the opening and closing the stomata?**

✓Guard cells contain chloroplasts so they can photosynthesize. When there is light, the concentration of sugar in guard cells goes up water moves into guard cells by osmosis become very turgid; as they swell up they bend, opening the gap –the stoma between them. The pore closes by reverse process.

- **Transpiration stream:** as water evaporates from the surface of the leaves, water is pulled up through the xylem to take its place.


open
closed

- ✓ The constant moving of water molecules through the xylem from roots to the leaves is known as transpiration stream.

- ❑ **The movement of water in plant is by:**

•**Root pressure:** it is created by osmosis takes place in root hairs and pushing the water up from the bottom.

•In the xylem, two physical forces help the water to move up wards.

- The adhesive forces: the force between the water molecule and the wall of the xylem which support the whole column of water and as molecules evaporates away from the surface of the leaf.

- The following molecules are pulled up by cohesive forces between water molecules, the water molecules tend to stick together and get pulled upwards.

- The tendency of water to rise in a thin tube is called capillary action however the main pull which moves water up from the roots to the leaves is a constant evaporation of water from the leaves.

- When water reaches the xylem in the leaves, the reversal of situation in the roots

❖ Factor affecting the role of transpiration

- Anything which affects the rate of evaporation will affect transpiration because transpiration stream is driven mainly by evaporation of water from the leaves.

- Conditions which increase the rate of evaporation also increase the rate of transpiration. These are: plenty of light, dry air, temperature and wind but humidity decreases it.

❑ Adaptation of plants to reduce water loss

✓Plants which live in very hot areas have very thick, waxy cuticles

✓Others have developed very hairy leaves, which trap a micro atmosphere around the stomata and reduce water loss.

✓Some plants have very narrow spikes to reduce surface area of the leaves over which water may be lost.

✓The stomata of some are sunken on the underside of the leaves to prevent excessive transpiration.

✓Plants like grasses prevent water loss by rolling their leaves trapping a microenvironment of moist air inside.

✓Some plants have spiny leaves to reduce water loss, other have succulent stems, roots and leaves to store water.



Figure 4.19 *Aloe vera – this plant stores water in its fleshy leaves.*

❖ Transpiration and agriculture

- From the amount of water absorbed by plants only 1% is used by cells. The rest is lost by transpiration; therefore transpiration is a problem in arid and semiarid regions.

- So to overcome the problem it is possible to use different methods. These are:
- Use irrigation system and water reservoirs

- Select growing of plants that use and transpire less water
- Growing of crops in relatively sheltered places

- Transpiration is necessary to plants because:
- It results in transpiration pull
- It helps to cool the plant down

4.4. Response in plants

- Plants respond to changes in their surrounding environment through their own coordinating mechanisms

Germination of seed

- germination is the process by which a seed changes into a seedling.
- it requires oxygen, moisture(water),optimum temperature.

❖ **a seed contains the following structures:**

i. **Endosperm :**food storage tissue of a seed

ii. **Embryo:** a part which develops into a main plant. It has 3 main parts

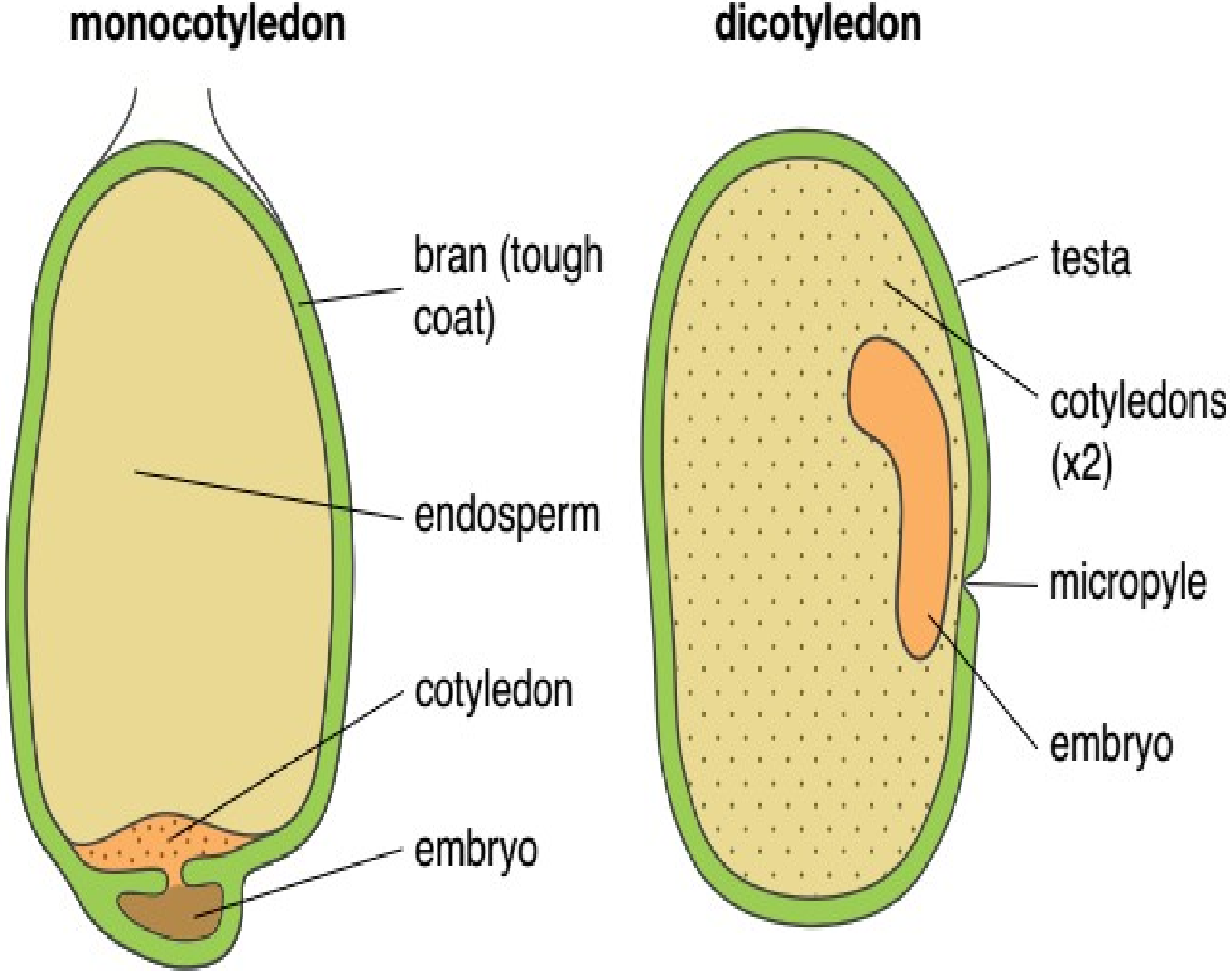
   a. **Plumule (embryonic shoot):**develops into the shoot system

   b. **Radicle (embryonic root):** develops into the root system

   c. **Cotyledons (seed leaves):**provide for storage of starch mainly in dicot

iii. **Testa(seed coat):** protective cover of seed

iv. **Microphyle:** tiny hole through which water & oxygen enters the seed


monocotyledon
bran (tough coat)
endosperm
cotyledon
embryo
dicotyledon
testa
cotyledons (x2)
micropyle
embryo

- A summary of changes occurring during germination of a seed
- Seeds absorb water through the Microphyle
- The Testa bursts , the radicle emerges out first, forming Epicotyl
- The Plumule emerges out from Epicotyl between the cotyledons produce the first true leaves and become seedling
- Hypocotyl: is a region on the stem below the cotyledons which give rise to radicle
- Epicotyl : is a region above cotyledons which give rise to Plumule
- Coleorhizae are the sheath of radicle and coleoptiles are the sheath of Plumule.

❑**There are two types of germination**.

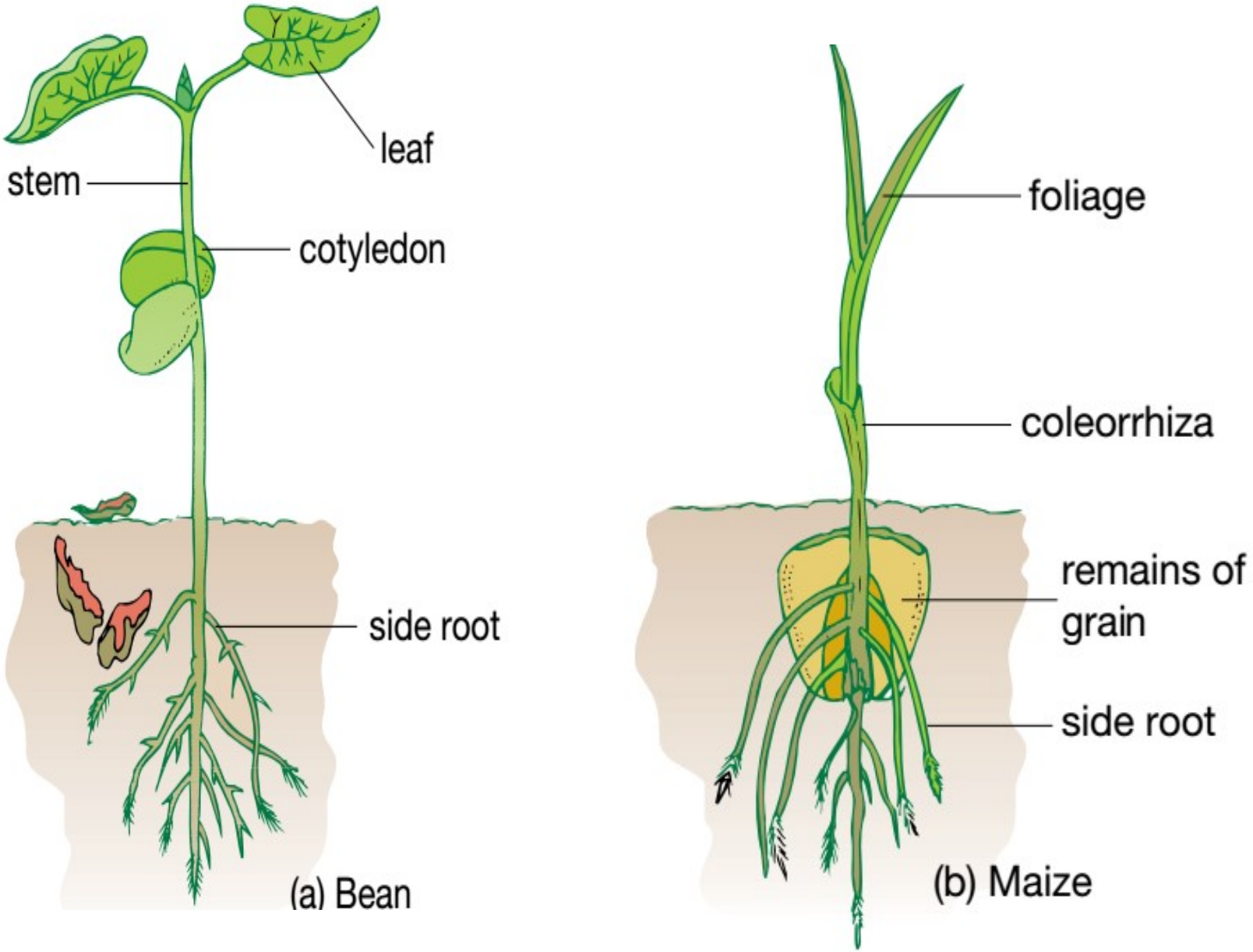
These are:

i. Epigeal germination: is the elongation of Hypocotyl bringing the cotyledon above the ground.

- This type of germination is exhibited in most dicot plants and a few monocots such as onions & lilies.

ii. Hypogeal germination: is the elongation of Epicotyl leaving the cotyledon below the ground.

- It is the germination of most monocotyledons such as wheat, sorghum and a few dicots such as kidney bean and broad bean.


leaf
stem
cotyledon
side root
(a) Bean
foliage
coleorrhiza
remains of grain
side root
(b) Maize

- In monocot cotyledons do not store food , instead they absorb food from the endosperm and pass it onto the developing embryo

- In dicot the endosperm moves food into cotyledons which become the main food store.
- Once the seed store its food & the embryo have develops the seed dehydrates and become dormant.

❖Plant hormones and growth

- Growth in plant is influenced by chemical message called hormones plant hormones are also called phytohormone.
- Examples of plant hormones are Auxin, Giberellic acid, Cytokinin, ethylene & Abscisic acid.
- Some of these hormones promote growth, others inhibit it, and some of them will promote the growth in one type of plant and inhibit it other.

A. Auxin (IAA)

- ✓ Involved in general plant growth.
- ✓ It stimulate the elongation of the new plant cells
- ✓ It is also involved in apical dominance

- IAA is made at the tip of the main shoot and developing leaves and as it moves down the stem it slows down the growth of side shoots.

- **Apical dominance**: is the growth of tips of stem by inhibiting the lateral buds.

- If the growing tip of plant is cut it will bush out. the side shoots grow quickly.

- Auxin also stimulates the growth of roots, delays fruit formation and inhibits the dropping of fruits from the plant. If it is applied to cut stem it will stimulate new roots to grow.

- It is also involved in the response of plants of plants to the world around them. This reaction of plants to stimulus is called tropism.

B. Gibberellins

- It stimulates the growth of plant stem (cell elongation and cell division) dwarf plants often lack either the genes for gibberellins production or the genes for gibberellins protein receptor.

- It also help seeds to breakdown their dormant period and start to grow by stimulating the production of enzymes needed to breakdown the food stores in the seeds.

C. Cytokinin

- Stimulates cell division in plants by stimulating the production of protein so they are very important in plant growth.
- The balance between Auxin and cytokinins in a tissue culture of plant cells decides whether roots or shoots will grow.

D. Ethylene

- Is a gas at room temperature and it causes fruit to ripen
- It is found in ripened fruit, leaves and flower.
- It also causes fruit and leaves to fall from the plant in some species.

E. Abscisic acid (ABA):

- ✓ it inhibits growth and plays a major role in leaf fall.
- ✓ It is also involved in seed dormancy
- ✓ It may be involved in geotropism and control stomata closure

Tropic responses

- Plants need light for photosynthesis and they grow towards light when a seed germinates the root grow downwards & the shoot grow upwards.

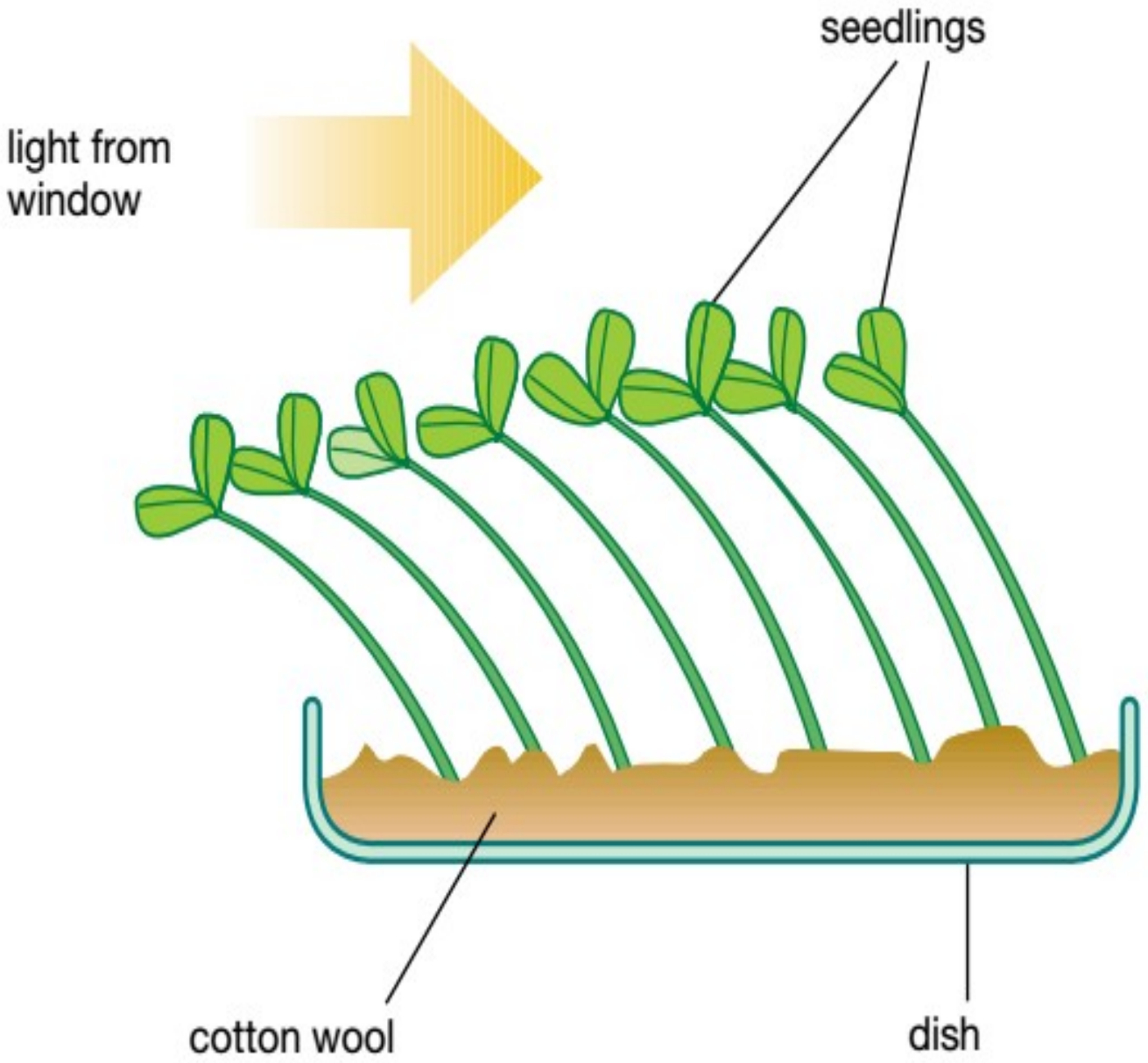
- Response comes from one direction is known as tropism (tropic response).

- If the growth response is towards a stimulus it is positive tropism & if it is away from the stimulus, it is negative tropism.

Types of tropism

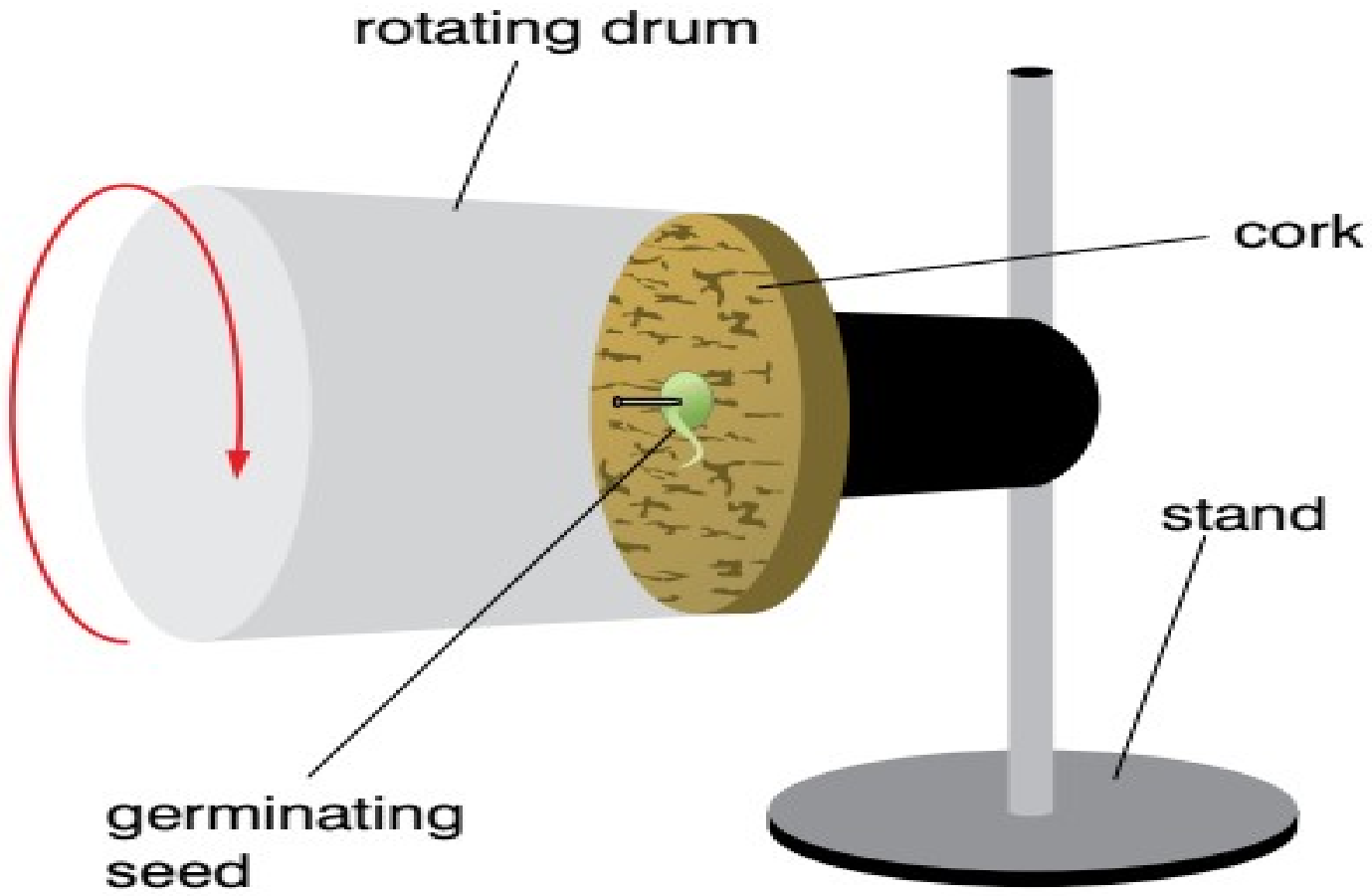
❖ **Phototropism :** is the tendency of plants to move or grow towards light

- Shoots are positively phototropic because they grow towards light
- Roots are negatively phototropic because they grow away from light
- The shoot of seedling which were in a light proof box toward the hole because when unilateral light is given to the plant more Auxin will be on the dark side than on the light side as a result the shoot bends towards light.


seedlings
light from window
cotton wool
dish

Geotropism (Gravitropism):

- ✓ is the response to the stimulus of gravity.
- ✓ When a seedling put horizontally or vertically the root grow downward & the shoot grow upwards. This indicates the effect of force of gravity on plants.
- ✓ Root is positively geotropic and shoot is negatively geotropic
- ✓ The response of seedling to gravity can also be investigated using a piece of apparatus known as clinostat
- ✓ It can effectively stop gravity from being a unilateral force on the plant



A klinostat can effectively stop gravity from being a unilateral force on your plant.

- **Hydrotropism :**

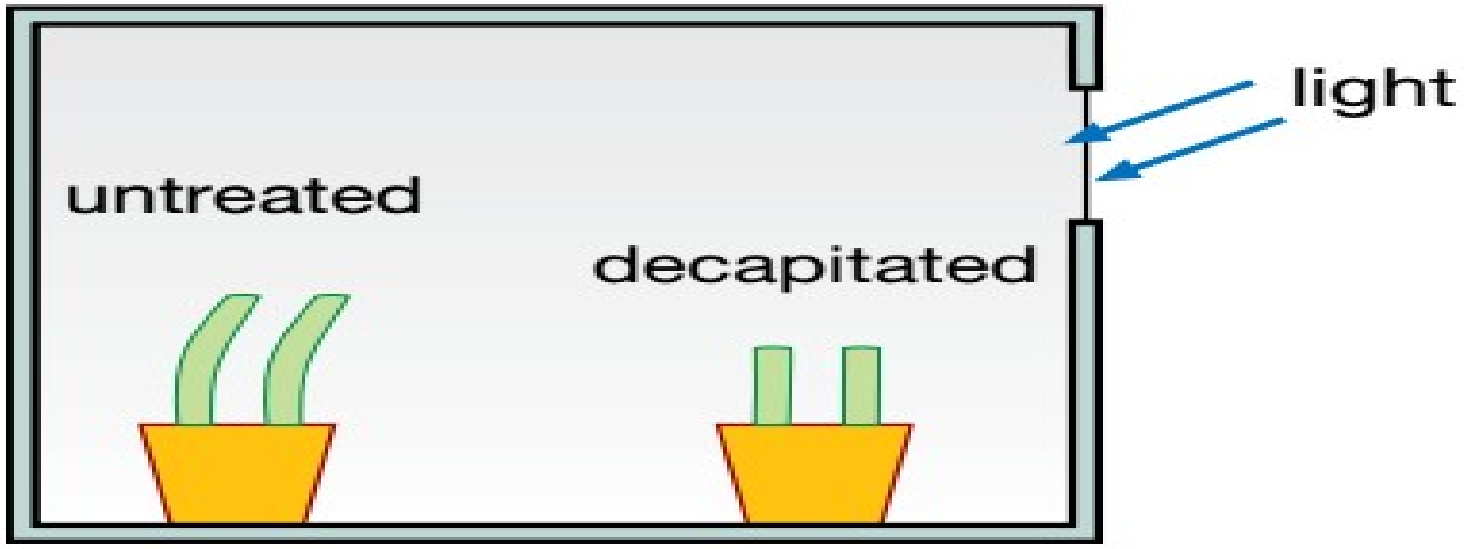
✓ is growth response to water stimulus

✓ shoot is negatively hydrotropic and root is positively hydrotropic.

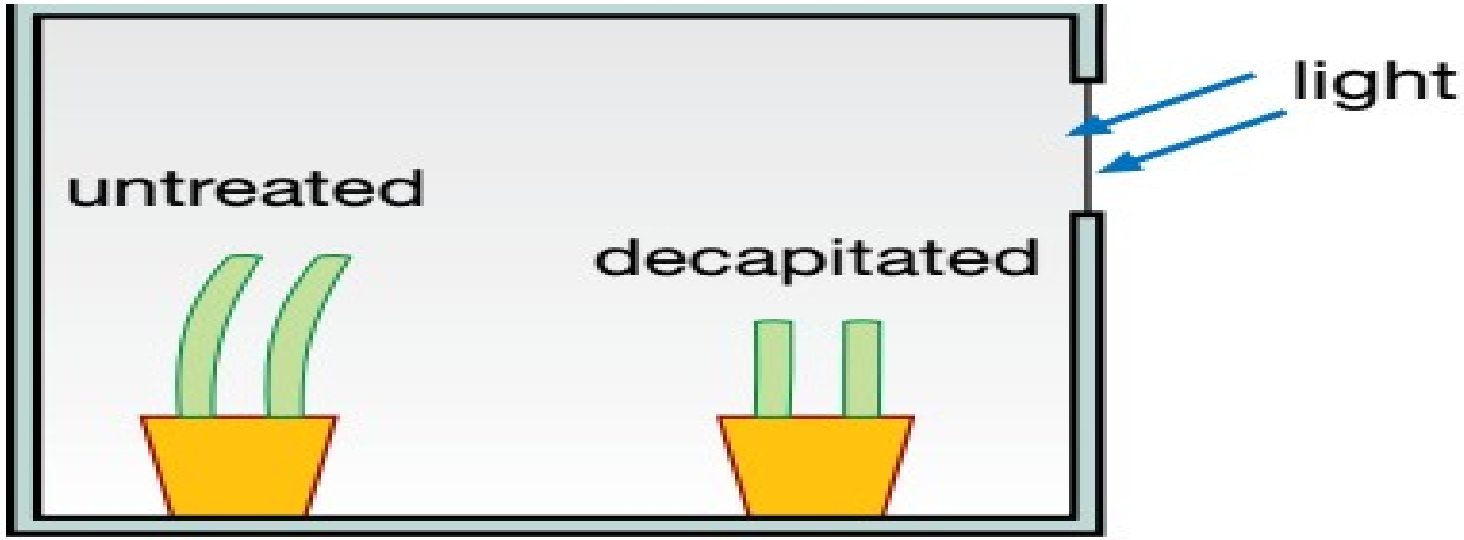
How are tropic responses brought about?

Plants respond to unilateral stimulus for e.g. Maize grains germinate to produce a straight shoot called coleoptiles (widely used in experiments to investigate the role of hormone in shoot growth.

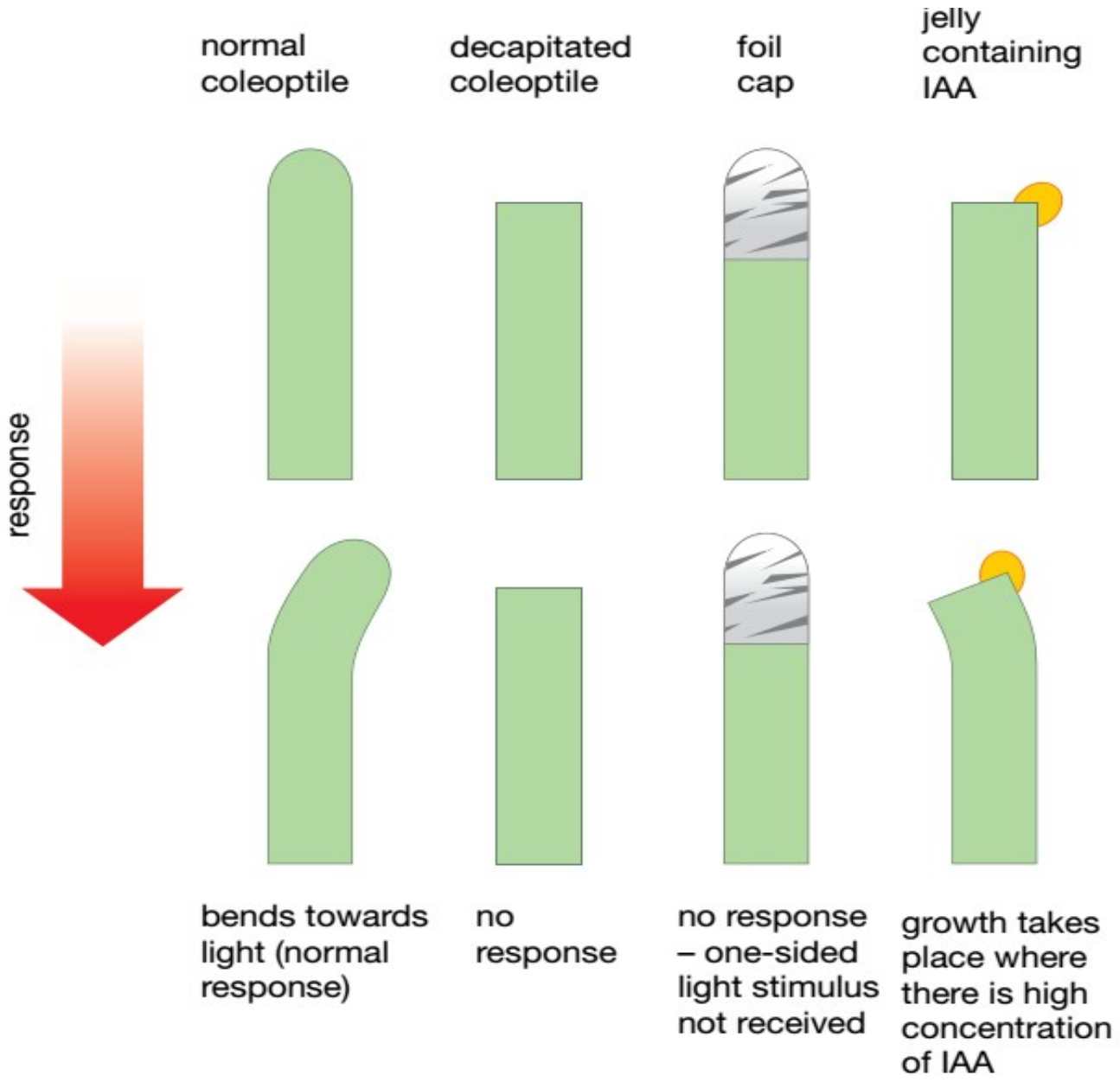
The growth region of the shoot is some distance below the tip, when the tips of coleoptiles are removed , they do not grow because the IAA promotes growth in shoot



At start



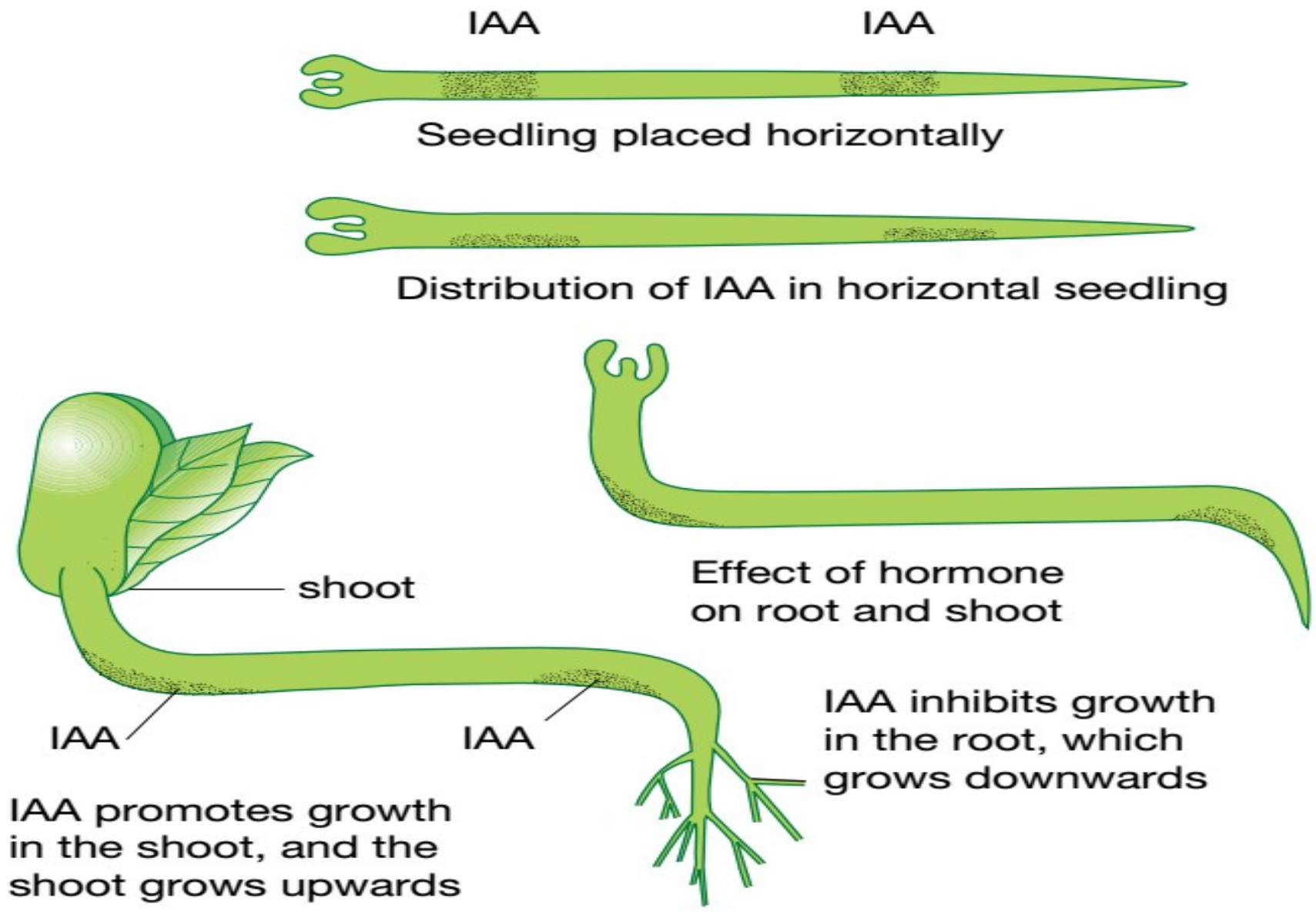
After 2–3 days


normal coleoptile
decapitated coleoptile
foil cap
jelly containing IAA
response
bends towards light (normal response)
no response
no response – one-sided light stimulus not received
growth takes place where there is high concentration of IAA

- IAA production was removed; the seedling grew for a while and then stopped.
- IAA is also involved in the response of the shoots to light and gravity.
- The upward growth of the shoot and the downward growth of the root when the seedling placed horizontally on straight ground.

- There is high concentration of Auxin in the lower side of shoot and root as a result the growth at lower side of the shoot is stimulated and the upper side of the shoot is inhibited ; thus shoot grows up ward

- Low concentration of Auxin on the upper side of the root stimulates its growth, high concentration of Auxin in the lower side, inhibits the root growth, as a result the root bends downward.


IAA
IAA
Seedling placed horizontally
Distribution of IAA in horizontal seedling
shoot
Effect of hormone
on root and shoot
IAA
IAA
IAA inhibits growth
in the root, which
grows downwards
IAA promotes growth
in the shoot, and the
shoot grows upwards

Nastic response

- Is a response of plant that causes movement independent of the direction of the stimulus.
- It is not growth response, is reversible and can be repeated many times.

E.g. movement of some plants leaflet when they are touched

- The opening and closing of stomata
- Rate of cell division
- Rate of photosynthesis.