Unit 1

Sub-fields of Biology

Set by
Ahmedauf A.

1.1 Sub-fields of Biology

- Based on the type of organism it studies, biology is subdivided into three:
- Zoology,
- Botany, and
- Microbiology

- Many have been around for hundreds of years whilst others are far newer and are often developing very rapidly

◆ Zoology

- Zoology, is the study of animals and includes disciplines such as
  - ✓ herpetology (reptiles),
  - ✓ ichthyology (fish),
  - ✓ mammalogy (mammals),
  - ✓ ornithology (birds), and
  - ✓ entomology (insects).

☆ **Zoology** is concerned with all aspects of animal life, such as

- embryonic development to mature adulthood;
- behaviour, such as interactions with other animals or
- food finding; and
- genetics.

◆ Botany

- Botany is a field of biology that studies about plants.
- It deals with plants' structure, properties, and biochemical processes.

- It also studies about classification and diseases of plants and their interactions with the environment.
- The principles and findings of botany have provided the base for such applied sciences as agriculture, horticulture, and forestry.
- Plants used as:-

✓ a source of food,

✓ shelter,

✓ clothing,

✓ medicine,

✓ ornament, and

✓ tools.

- Green plants are essential to all life on earth.
- plants convert energy from the Sun into the chemical energy of food, which allows all life to exist.

- The formation and release of oxygen as a byproduct of photosynthesis
- Ruta chalepensis L. ('Tena Adam' in Amharic), a known traditional herbal medicine of Ethiopia.

◆ Microbiology

- Microbiology is the study of microscopic organisms or microbes that cannot be seen by unaided eye.
- It includes :-

✓ bacteria,

✓ archaea,

✓ protists,

✓ viruses,

✓ microscopic algae and

✓ fungi.

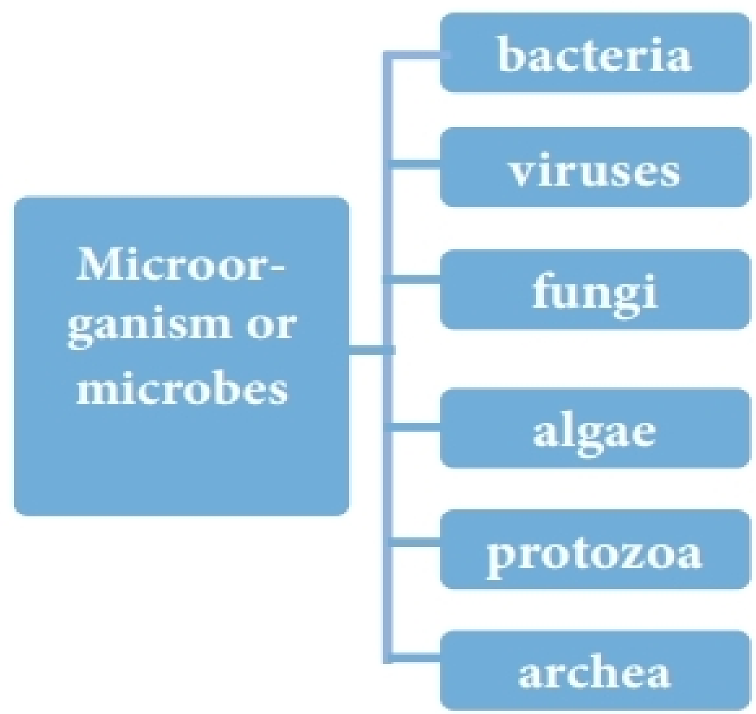


Figure 1.3. The microorganisms

- **Bacteriology** is the study of bacteria,
- **Mycology** is the study of fungi.
- **Anatomy** is a branch of biology that studies the physical structures and parts of organisms,
- **Morphology** is a branch of biology that studies the form and structure (internal and external) of organisms and their specific structural features.

Table1.1 Different fields of biology based on the structure studied

Sub-branch of biology	Definition	Example of the structures studied
Morphology	Study of external form and structure	Shape, the texture of leaves, stem, etc
Anatomy	Study of the bodily structure of humans, animals, and other living organisms, especially as revealed by dissection and the separation of parts	Stomach, liver, heart, etc
Histology	Study of the details of tissue structure	Parenchyma, connective tissue
Cytology	Study of cells	A plant cell, a nerve cell
Cell biology	Study of the structure, function, and various aspects of cell and its components	Mitochondrion, ribosome, nucleus, etc
Molecular Biology	Study of structure and function of informational molecules	DNA, RNA

- biology are concerned with the various life processes, such as how an organism multiplies or forms identical copies of itself,
- its evolution over millions of years, and its relationship with the environment.

Table 1.2 Subjects studied in various branches of Biology

Branch of biology	Subject studies	Examples
Physiology	The normal functions of living organisms and their parts	Photosynthesis, digestion, etc
Embryology	The embryo, from a single-celled zygote (fertilized ovum) to the formation of form and shape	Structure and development of ova, sperm, blastula (an embryo at early stage of development consisting of a hollow ball of cells), gastrula(the stage in embryonic development after blastula during which the embryo develops two layers), etc
Ecology	Interaction of organisms with the environment	Food chain, biomass, biosphere, etc
Taxonomy	Identification, nomenclature, and classification of organisms	The biological name of a human is Homo sapiens and it was placed in the animal kingdom
Paleontology	Origin, growth, and structure of organisms of the past	Fossils of organisms
Evolution	The change in the characteristics of a species over several generations that relies on the process of natural selection	The beaks of Darwin's finches
Genetics	Heredity and variation	Gene concept, Mendel's laws
Exobiology	The origin, evolution, distribution, and future of life in the Universe	Life on Moon, life on Mars

- Biology is related to other sciences that study life
  - ✓ as an energy state of all living things,
  - ✓ their interrelationships, and
  - ✓ links to their surroundings.

Table1.3 Knowledge taken from other subjects that help to explain biological phenomenon

Structure/ mechanism studied	Example	Related Science	Knowledge of other sciences is required because
Cell membrane	Structure of lipids and proteins	Chemistry	Living organisms are made of inorganic and organic compounds
Transportation of Oxygen (O2) in the body	Formation of Oxyhaemoglobin (haemoglobin with oxygen)	Chemistry	All metabolic pathways involve chemical change
Excretory system	Absorption and elimination of salts	Chemistry	Homeostasis involves acid-base equilibrium to maintain the pH of living organisms
Absorption of food/ water	Absorption of sugars, amino acids, fatty acids, water, or salts	Chemistry	During diffusion and osmosis molecules move into and out of the cell
Transportation of water in plants	Conduction of water from root to leaves	Physics	Liquids have certain properties like cohesion and adhesion to result in surface tension and capillary action which helps in certain processes
Release of energy during respiration	Electron transport chain (transfer electrons from electron donors to electron acceptors via redox reactions)	Chemistry	Energy transfer and transport

1.2 Pure and applied fields of biology

☆ **Pure biology** is the study of how life functions in nature (behavior, internal and external structure, reproduction, etc.)

☆ **Applied biology** refers to using what you have learned in biology for (gardening, nursery work, agriculture, plant disease, forestry, poultry, etc.).

- Therefore, applied biology is the use of your knowledge of biology to manage life.
- The relationship is similar to anatomy and surgery.
- Some of the biological importance of the branches of biology in other branches of sciences.

ylviculture
The branch of forestry dealing with the development and care of forests
silviculture The branch of forestry dealing with the development and care of forests

1) Biotechnology: is the use of living organisms or their products for the welfare of humanity.

- It involves the Genetic Engineering.

A genetically modified and improved variety of crops and animals have been produced by biotechnology.

2) Bioinformatics: is concerned with the acquisition, storage, analysis, and dissemination of biological data, most often DNA and amino acid sequences.

- Bioinformatics uses computer programs for a variety of applications, including:

✓ determining gene and protein functions,

✓ establishing evolutionary relationships, and

✓ predicting the three-dimensional shapes of proteins.

3) Genetic Engineering: is a means of extracting selected genes from an organism or synthesizing selected genes and these genes are inserted into another organism; as a result, an organism develops with a new combination of genes.

4) Biomedical Engineering: is the application of the principles and problem-solving techniques of engineering to biology and medicine.

- Biomedical engineering focuses on the advances that improve **human health** and **health care** at all levels.

5) Environment Management: deals with environmental observation and finding out the solution to maintain the balance of nature.

6) Forensic Science: is the application of the knowledge of biological science (DNA fingerprints (unique patterns in DNA molecule), blood typing) to criminal and civil laws.

1.3 Major discoveries that revolutionized biology

- Biology is a fascinating and diverse subject area.
- If you're thinking of studying Biology, here are the twelve famous discoveries to inspire you.

1. Aristotle (384–322 BC) the ancient Greek philosopher

- Aristotle was responsible for a breakthrough classification system for living things.
- Aristotle's classification system was known as the '**Ladder of Life**' until the nineteenth century.
- For the first time, he established species relationships and grouped them correctly.

2. Galen (129–161 AD)

- Galen had a significant impact on the advancement of numerous medical specialties, including :

✓ Anatomy,

✓ Pathology,

✓ Physiology, and

✓ Neurology.

- Among his important findings were the distinctions between **veins** and **arteries**, as well as the recognition that the **larynx** produces voice.

3. Antonie van Leeuwenhoek (1632–1723)

- He is well renowned for his contributions to microscopy and how he applied it to the field of biology.
- He invented a method for making strong lenses that, could magnify up to 500 times.
- among his findings were **bacteria** and the **vacuole of the cell**.

4. Carl Linnaeus (1707–1775)

- He a botanist, physician, and naturalist,
- He devised the method for naming, ordering, and classifying creatures that we still use today.
- He separated items into three categories – **animals**, **plants**, and **minerals**.
- further organized living things into classes, orders, genera, and species.
- ‘**Homo sapiens**,’ for example - ‘**homo**’ is the genus and ‘**sapiens**’ is the species.

5. Charles Darwin (1809–1882)

- Charles Darwin’s contribution to biology and society is immense.
- He established that all species of life descended over time from common ancestors, with species continuing to exist through the process of natural selection.

- Evolution by natural selection combined with Mendelian genetics is now accepted as the modern evolutionary synthesis and forms the foundations of much biological scientific endeavor.

6. Gregor Mendel (1822–1884)

- He used peas to discover and demonstrate the **laws of genetic inheritance**,
- coining the terms ‘**dominant**’ and ‘**recessive**’ genes in the process.

7. Louis Pasteur (1822-1895)

- He is regarded as the father of **medical microbiology**.
- His contributions to science, technology, and medicine are nearly unparalleled in history.
- He demonstrated that bacteria cause fermentation and disease,
- introduced **pasteurization**, rescued France’s beer, wine, and silk industries, and developed **anthrax** and **rabies** vaccines.

8. Robert Koch (1843-1910)

- He was a well-known German physician who pioneered microbiology.
- As the father of **modern bacteriology**,
- he is credited with pinpointing the precise causal agents of tuberculosis, cholera, and anthrax, as well as providing experimental support for the concept of infectious disease.

9. Jane Goodall (1934)

- Our knowledge of wildlife and conservation has been transformed by Jane Goodall, the UK ethologist.
- Best known for her career-long studies of **chimpanzees**,
- She discovered the **animals are omnivores** and tool users.

10) Barbara McClintock (1902–1992)

- Barbara McClintock American geneticist
- She spent her career **analyzing maize**, where she developed a technique for identifying and examining **chromosomes** individually.
- She was awarded the Nobel Peace Prize in 1983 for her discovery of transposition and how genes could turn their physical characteristics on and off.

11. Watson (1928–) and Crick (1916–2004)

- They were shot to fame in 1962 for their discovery of the structure of DNA.
- Their model of DNA (double helix) explains how DNA replicates, and hereditary information is coded and passed on to descendants.
- The discovery of DNA structure has led to a much more developed understanding of function – used in disease diagnosis and treatment, forensics, and more.

12. Wilmut (1944) and Campbell (1954–2012)

- In 1996 Ian Wilmut and Keith Campbell cloned a mammal, famously named **Dolly the Sheep**.
- The pair cloned Dolly using a single adult sheep cell and a process of nuclear transfer.
- Dolly died after six years but cloning continues, although still not perfect, and certainly not ready for human application.

1.4 The contributions of biological discoveries to society and the environment

- The invention of devices such as **microscopes** and curative medications such as penicillin has transformed human life.
- The biological discoveries aided humans in developing abilities required for the use of living systems or influencing natural processes to produce products, systems, or settings that aid in human development.

❖ The Microscope

- The microscope is a device that magnifies objects or organisms that are too small to be seen with the naked eye.
- the microscope has had an enormous influence on the development of modern medical, forensics, and environmental sciences.

☆ Medical field

- The use of microscopes in medicine began in the 1860s when Louis Pasteur reported that the microscopic organisms he saw in the microscope caused **certain diseases**.
- Pasteur's germ theory revolutionized the process of identifying, treating, and preventing infectious diseases.

☆ Ecosystem study

- The microscope is used to study the health of an ecosystem.
- Field biologists utilize microscopes to observe a specific habitat, such as a marine environment,
- by identifying the types and numbers of micro-organisms found in ecosystem samples.

☆ Forensic Science

- Forensics is a field of science used to gather and analyze evidence to establish facts that are used in a legal scenario.

- The microscope is used to examine pieces of evidence collected at a crime scene that may have information not visible to the human eye,
- For example, striations in bullets can be examined under a microscope to see if they match bullets shot from a particular gun.

☆ Atomic Study

- microscope has enabled scientists:-
- to study cells at an atomic level.
- to scrutinize viruses at their atomic level and influence them for the delivery of innovative treatments.

☆ Genetic Study

- A microscope is used by scientists:-
- to examine certain genetic makeup.
- to evaluate genetic abnormalities, regeneration, and tissue death.

☆ Tissue Analysis

- It is common for histologists to study cells and tissues using a microscope.
- For example, if a section of tissue is taken for analysis, histologists can use a microscope in combination with other tools to determine if the sample is cancerous.

☆ Discoveries in Medicine

- Science has never moved at such a rapid rate as it is happening now.
- it stands to reason that our scientific understanding has upgraded with time.
- This is particularly true of medical discoveries, and while we might complain of long hospital waiting lists or the poor bedside manner of some of the nurses,
- we shouldn’t forget that only a few generations ago, how ‘irritating it was’ to amputate a limb without anaesthesia.

☆ Inheritance (Application of Genetics)

- in 1884-1885, four scientists (Hertwig, Kolliker, Weismann (all zoologists), and Strasburger (botanist) derived that heredity matter existed in the nucleus in that material which makes up chromosomes.
- After the discovery of Mendel’s work and his laws, Genetics took a progressive turn and revolutionized.
- Working on this subject is still moving.
- Genetics is providing numerous services to humanity in almost every field of life.

1.5 Ethiopian biologists and their contributions

- Three of the Ethiopian scientists and their discoveries are given below.

1. Professor Yalemtsehay Mekonnen

- Prof. Yalemtsehay is a biologist and an academic member of staff at the Department of Biology, Faculty of Science, Addis Ababa University.
- She received her Ph.D., specializing in human physiology, from the University of Heidelberg in Germany.
- One of her research areas is the assessment of the impact of chemical pesticide hazards on humans.
- This research covers almost all government farms including the Upper Awash agricultural farms and some private horticultural farms in the Rift Valley region.
- The other area of her research is in the use of plants as medicine against human and animal diseases.

- She has published over 100 scientific papers in reputable journals in the areas of plants of medicinal and nutritional value in vivo and in vitro physiological tests of

✓ useful plant extracts,

✓ assessment of health hazards to humans,

✓ animals and the environment,

✓ advocacy and collaborative work for the promotion of safe and sustainable use of natural resources, to name but few.

- She has done notable research on medicinal plants especially on Moringa Stenopetala (shiferaw/Alekko Shekatta).

2. Dr. Aklilu Lemma

- Schistosomiasis is a common parasitic disease.
- It is caused by **parasitic flatworms** which spend part of their lifecycle in freshwater snails and part in humans.
- It affects 200–300 million people in Africa (including Ethiopia), South America, Asia, and parts of the Caribbean.

- Anyone washing, working, or playing in shallow freshwater is at risk.
- Once inside a person, the parasites mature and produce eggs which are passed out in the urine and feces.
- They also infest the blood vessels, liver, kidneys, bladder, and other organs.
- The body sets up an immune reaction and an infected person can become weakened and ill for many years.
- a way of controlling this parasite, was carried out by Dr. Aklilu Lemma, one of Ethiopia's most renowned biologists.
- Dr. Aklilu began his work in 1964 when he was investigating the freshwater snails that carry the Schistosomiasis parasite around Adwa in northern Ethiopia.
- He saw women washing clothes in the water and he noticed that downstream of the washing party there were more dead snails than anywhere else he had collected.

- The women were using the soapberry, ‘**Endod**’ in Amharic (Phytolacca dodecane Dr.a), to make washing suds.
- Dr. Aklilu collected some live snails from above the washing party and asked one of the women to give him some of her Endod suds.
- Not long after the suds were put in the snail container, all the snails died.
- This was the start of years of work for Dr. Aklilu.
- Back in the laboratory, he showed that if the Endod berries were dried, crushed, and diluted in water they would kill snails at very low concentrations.
- Dr. Aklilu’s results were published in journals around the world.

3. Professor Gebissa Ejeta

- When Prof. Gebissa Ejeta was born in a small rural village his mother was determined her son would receive a good education.
- He walked 20 miles to school every sun day evening, returning home on Friday after a week of studying.
- It all paid off as he joined **Jimma Agricultural** and **Technical School and then Haramaya College.**
- He specializes in plant breeding and genetics.
- Prof. Gebissa Ejeta did his research on **sorghum.**
- He got his Ph.D. from Purdue University in the USA where he still holds a professorship.
- He has helped to develop Africa's first commercial hybrid strain of sorghum.
- This sorghum variety not only needs less water and so is resistant to drought, but it also yields more grain than traditional varieties.

- He developed other varieties of sorghum that are also resistant to the parasitic Striga weed, which can destroy a big percentage of a crop.
- In 2009, Prof. Gebissa Ejeta was awarded the World Food Prize, which is the most prestigious agricultural prize in the world.
- He has also been awarded the National Hero award of Ethiopia for his work in science and technology.

UNIT TWO

PLANTS

Set by Ahmedrauf

2.1. Characteristics of plants

- **Plants are living things**. plants grow, reproduce and respond to changes in the environment.
- **Plants are multicellular**.
- They are made up of many eukaryotic cells.
- have well-defined nuclei and membrane-bound organelles.
- have a rigid cell wall made primarily of cellulose.
- **Plants are autotrophic** (self–feeding).
- Plant cells contain the green pigment chlorophyll which enables them to absorb sunlight and produce their own food
- Thus, they are also named Producers.

- **Plants are sessile.**
- They cannot move by themselves.
- They remain fixed at one place, firmly anchored to the soil by their root.
- However, the leaves of plants can turn towards light and some respond to touch.
- The roots of plants can also orient towards water or moist soil.

- **Plants practice asexual and sexual reproduction patterns.**
- In lower plants such as mosses and liverworts, asexual reproduction through spores is the dominant form.
- On the other hand, in higher and seed-bearing plants such as gymnosperms and angiosperms, sexual reproduction which involves the union of gametes or sex cells is the dominant and visible form.

2.2 Flowering and non – flowering plants

- the concept "plant" is widely associated with those that have flowers, root, stem and leaves having transporting vessels (vascular bundles).

❖ **The lower plants (**are **non – vascular plants)**, which do not have transporting system or conducting vessels, essential to transport water, nutrient and food needed for the plant.

- These lower plants are seedless and do not have flowers and fruits.
- They are **Bryophytes** such as mosses and liverworts .
- **The higher plants** (Vascular plants) which have well developed root, stem and leaves.
- **They are non seed bearing** (pteridophytes such as Farns) and **seed bearing plants**(gymnosperms and angiosperms).

❖ **Gymnosperms (Non flowering plants)**

- Are vascular with well-developed root stem and leaves but have no flowers.
- Their reproductive organ is cone, instead of flowers.
- Moreover, the seeds produced in their cone are without cover (naked seeds).

❖ Angiosperms (Flowering plants)

- are also vascular with well-developed root, stem and leaves.

But unlike gymnosperms, they have flowers and produce seeds within a fruit.

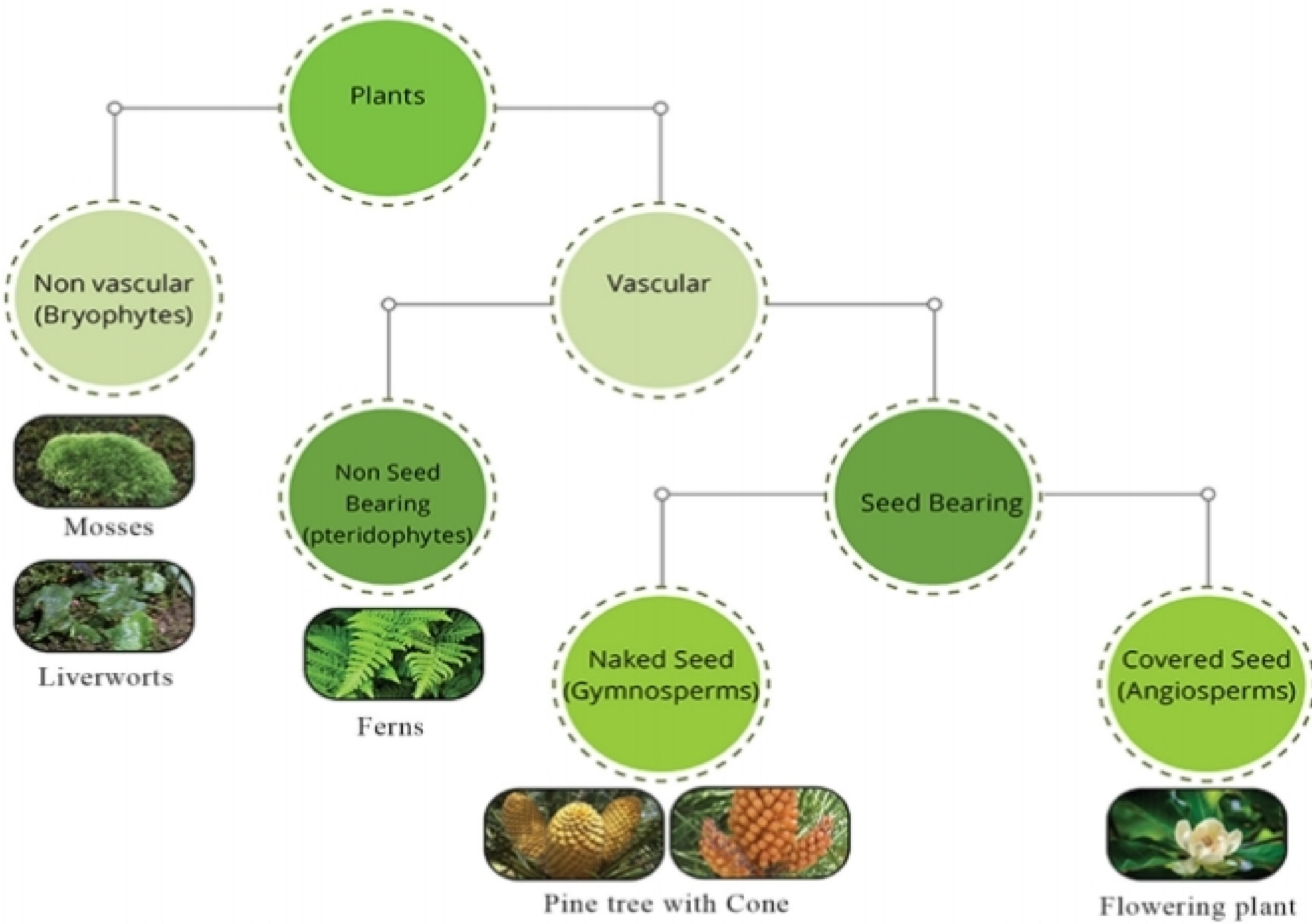


Figure 2.1 Major groups of plants

2.3 Structure and function of plant parts

- plants have different structures which perform a vital function essential for the plant life.
- we will focus on the external & internal structure of a flowering plant (angiosperm).
- the external structure of a typical angiosperm has two major systems.

✓ **The shoot system**: is the usually found above the ground and

- includes the organs such as stem, branches, leaves, buds, flowers and fruits.
- The last two organs may be missing depending on the reproductive stage of the plant.

✓ **The root system**: is usually grows downward into the ground.

- It includes the primary or tap root, lateral or branch roots, root hairs and root cap.
- Roots are distinguished from an underground stem in that, it does not bear either leaves or buds.

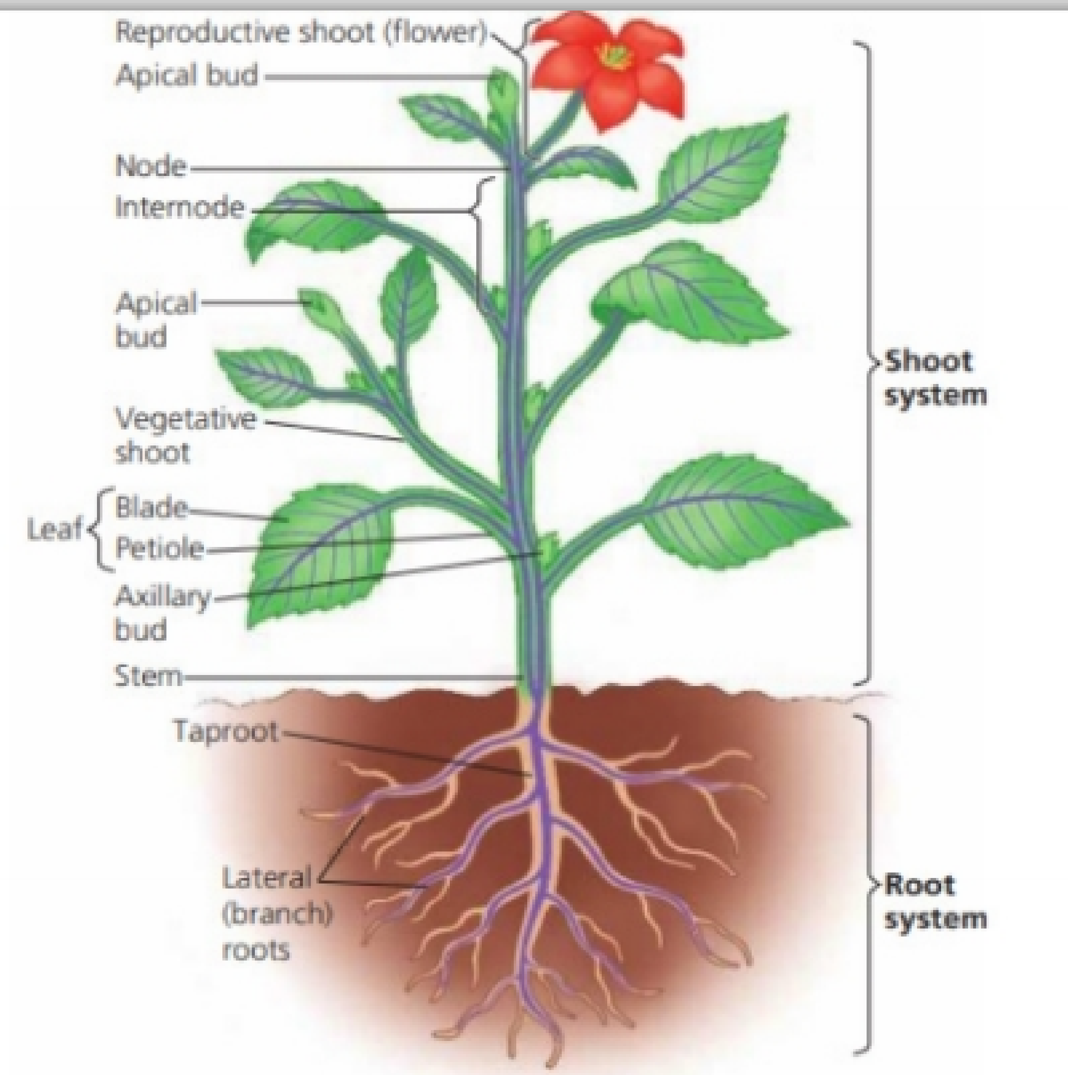


Figure 2.2 External structure of a typical angiosperm (flowering plant)

- ❖ The external structure of a typical leaf consists of the
- ✓petiole (leaf stalk),
- ✓ lamina (blade – broadest part),
- ✓ midrib,
- ✓ margin,
- ✓ base and
- ✓ tips
- **The lamina** is the broadest part, which is flat, wide and commonly thin.
- It provides large surface area, which enables leaf to collect light.
- Its thinness creates short distance for gas exchange through the stomata (tiny pores).
- **The midrib** is harder and contains the vein (transporting vessels) of the leaf as well as supportive tissues with hard cell wall.

❑ Leaves of different plants show difference in absence or presence of

- petiole,
- leaf shape (variation in leaf margin, base and tips) and
- arrangement of veins.

- **there are basically two types of roots , namely**
- ✓ tap-roots and
- ✓ fibrous roots.
- **A tap-root** consists of one large, primary vertical root.
- It has very few lateral roots that develop and grow from this main root.
- By penetrating deep into the soil, tap roots provide stability (anchorage) and absorb water located deep in the ground.
- Tap root system is a feature of dicot plants.
- **A fibrous root** is usually formed by thin, moderately branching roots growing from stems.
- They are more or less similar size and length.
- In grasses they develop as consists of fine hair – like root that.
- Spread out from the base of the stem.

- Fibrous root is very efficient for absorbing water and minerals close to soil surface.
- It creates a thick network of roots that are good at holding soil together and protect soil from erosion.
- Fibrous roots are features of monocot plants .

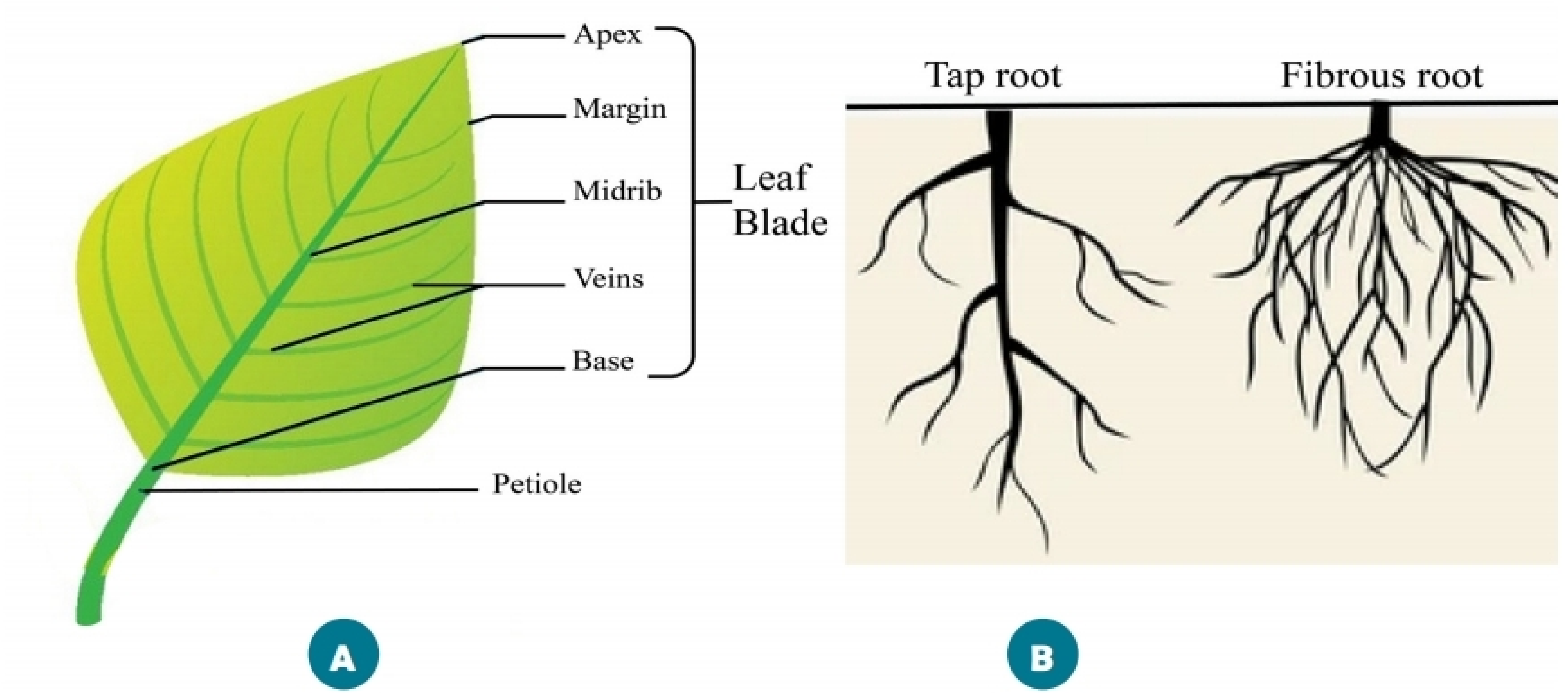


Figure 2.3 External structure of a typical leaf (A) and Types of roots (B)

2.3.1 The internal structure of a leaf

- the two internal layers of a leaf, namely; Outer layer and middle (inner) layer.

A) Outer layer

- This is also known as the epidermis, a single layer of tightly packed cells that covers the upper and lower surface of the leaf.
- **The upper epidermis** is usually covered by a waxy cuticle, which transmits sunlight for photosynthesis but restricts water loss by evaporation from the leaf tissue.
- **The lower epidermis** usually contains bean shaped guard cells that leave open spaces known as stomata (singular stoma).
- Stomata are “little mouths” or “ little noses”, which regulate O2 release, CO2 intake and water loss.
- In most leaves, stomata are more abundant in the lower epidermis, reducing water loss due to direct sunlight.

B) Middle layer

- This is known as the mesophyll (“middle leaf”) layer.
- It lies between the upper and lower epidermis.
- It includes tissues that are directly or indirectly involved in photosynthesis.

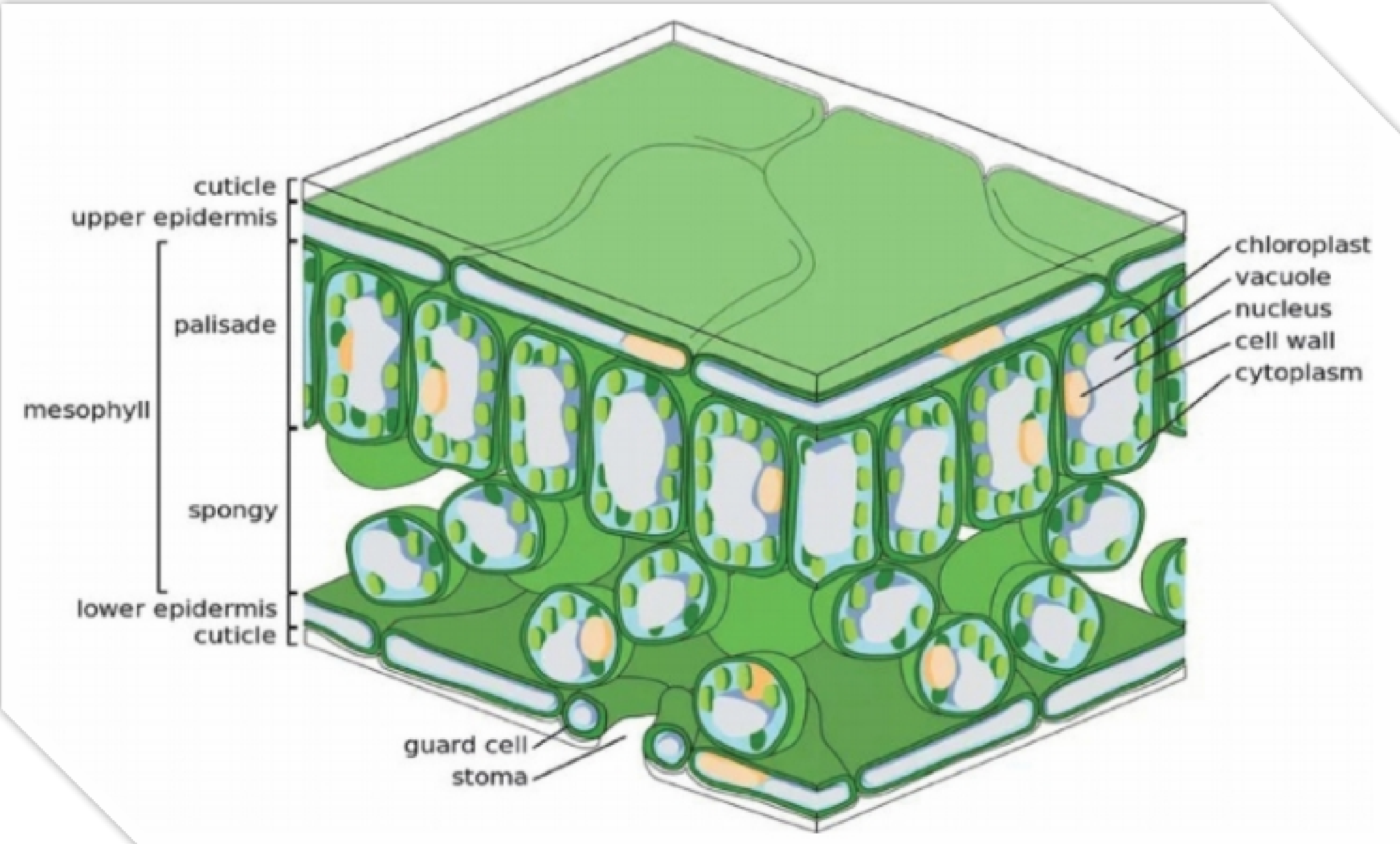
- There are two regions in the mesophyll layer

1. **The palisade layer** is composed of regularly arranged and closely packed columnar (vertically elongated) cells.

- The cells contain the largest number of chloroplasts per cell.
- As the layer is immediately beneath the upper epidermis, it is in the best position to capture most of the sunlight and this enables it to carry out most of the photosynthesis.
- The slight but precise separation of the columnar cells maximizes the diffusion of CO_2 and capillary movement of H_2O.
- The spongy layer – lies below the palisade cells.

2. **Spongy cells** are irregularly shaped with fewer chloroplasts.

- They are very loosely arranged with numerous airspaces.
- These air spaces, which are very close to the stomata allow the diffusion of O_2, water vapour and CO_2.


cuticle
upper epidermis
palisade
mesophyll
spongy
lower epidermis
cuticle
guard cell
stoma
chloroplast
vacuole
nucleus
cell wall
cytoplasm

2.3.2 The internal structure of a stem

- The internal structure of a typical dicot stem of a flowering plant.
- Accordingly, the detailed internal structure includes the following fundamental tissue systems.

1. **The epidermis** is the outermost layer of the stem.

- The outer walls are greatly thickened with cuticles, which minimizes the rate of transpiration.
- Moreover, the cells are compactly arranged, which in turn protect the underlying tissues from mechanical injury and prevent the entry of harmful organisms.

2. **Hypodermis** lies below the epidermis.

- It is mainly composed of collencyma cells that are specially thickened at the corners due to the deposition of thick cellulose.
- This enables the layer to give mechanical strength to the stem.

3. **Cortex** consists of few layers of thin-walled, large, round, or oval cells, having intercellular space and serving for storage of food.

3. **Endodermis** is the innermost layer of the cortex that separates the cortex from the vascular bundles.

- The cells are compactly arranged and usually contain starch grains.
- Thus, the endodermis serves as a food reserve and may be termed as a starch sheath.

5. **Vascular bundles** are longitudinal strands of conducting tissues or transporting vessels,

- consisting essentially of **xylem** and **phloem** arranged in a ring around the central pith.
- **Xylem** transports water and dissolved minerals to the photosynthetic tissues, mainly to the leaf while
- **phloem** transports synthesized food to different tissues, either for utilization or storage.

6. **Pith** – occupies the central portion of the stem,

- composed of thin walled cells, which are rounded or polygonal, with or without intercellular space.
- It stores food and helps in the internal translocation of water.

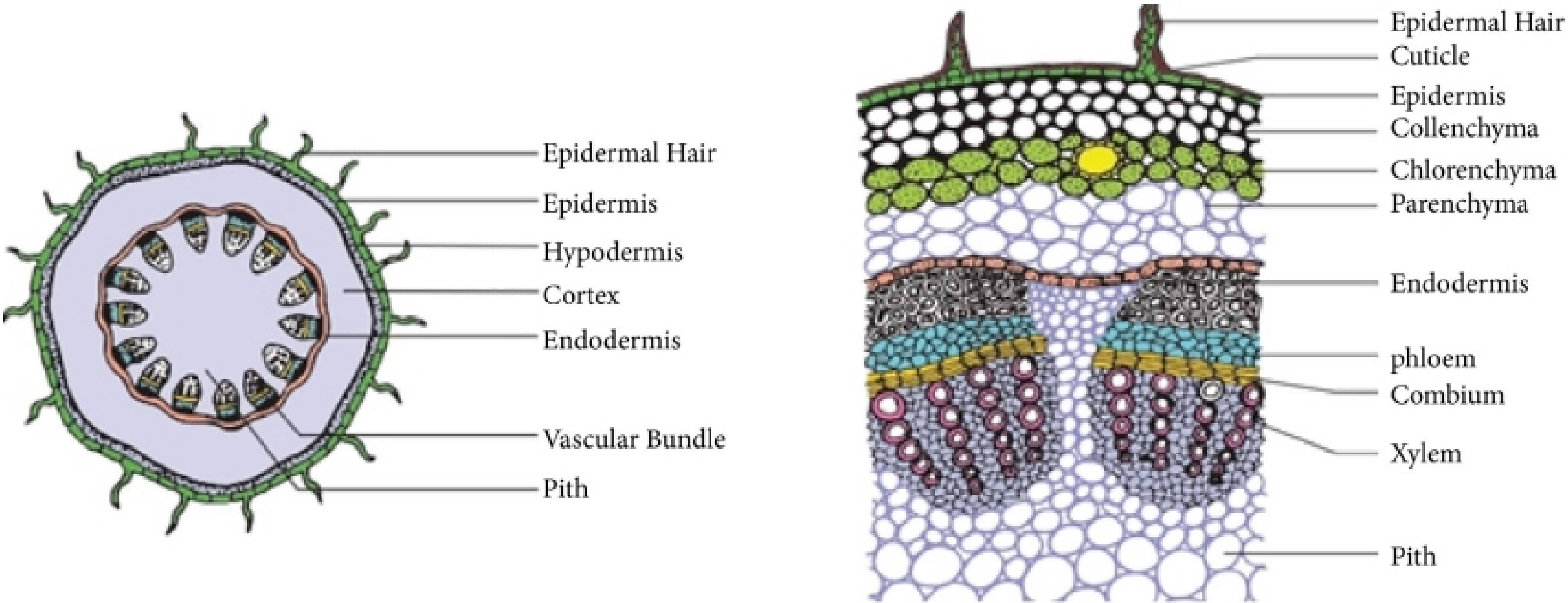


Figure 2.5 Internal structure of a typical dicot stem (A = Ground plan; B = Transverse section)

2.3.3 The internal structure of a root

- the transverse section of the dicot root shows the following plan of arrangement of tissues from the periphery to the centre.

❖ **Peliferous layer** is the outermost layer made up of single-layer cells.

- The cuticle is absent. .
- It consists the single-celled root hairs.

❖ **Cortex** is a multi-layered large zone made of thin-walled oval or rounded loosely arranged cells with intercellular spaces.

- It stores food and water.

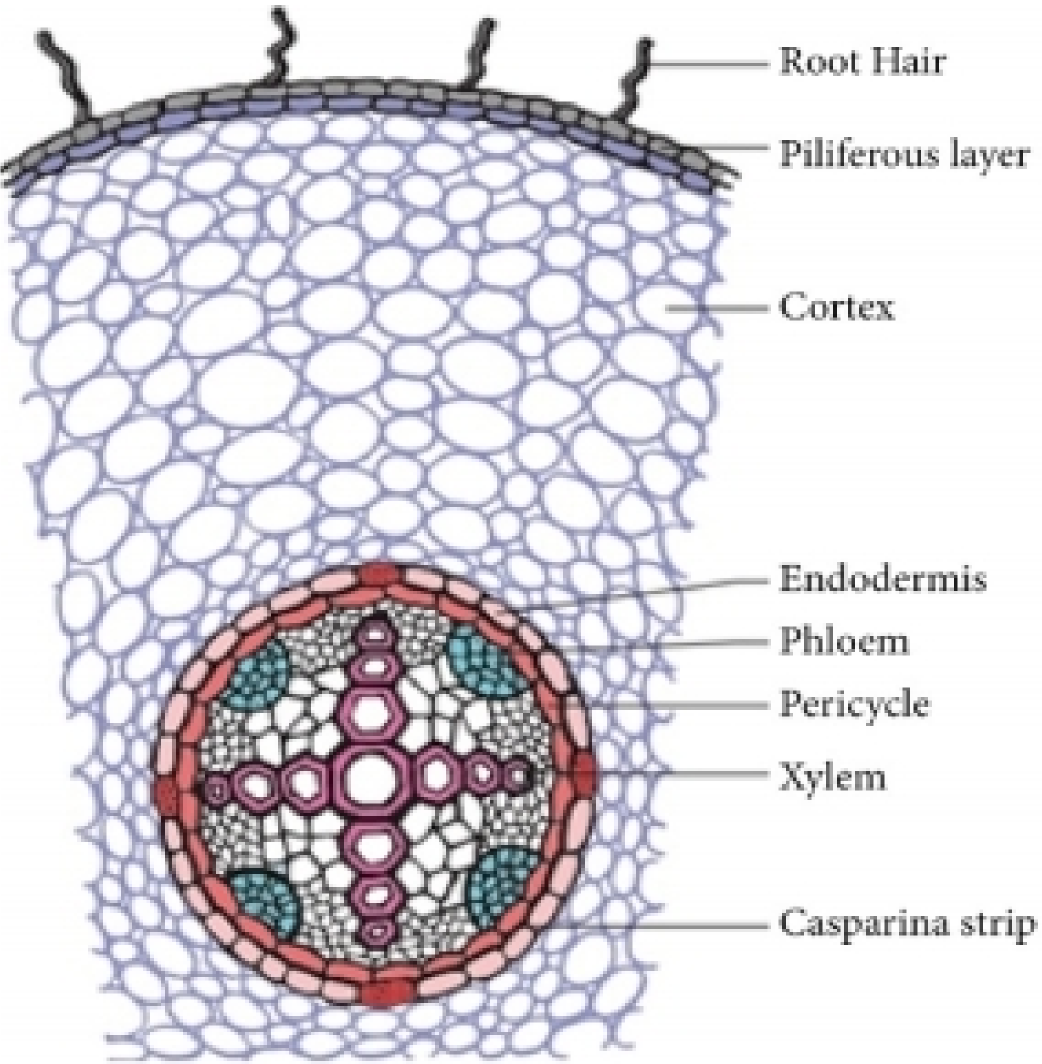
❖ **Endodermis** is the innermost layer of the cortex, made of barrelshaped closely packed cells.

- The layer helps the movement of water and dissolved nutrients from the cortex into the xylem.

❖ **Pericycle** is a single layer inner to endodermis.

- It is the site of origin of lateral roots.

- **Vascular bundles** consist of xylem and phloem with meristematic (cambium) or actively dividing cells between them
- **Pith** is present in young roots while absent in old roots.



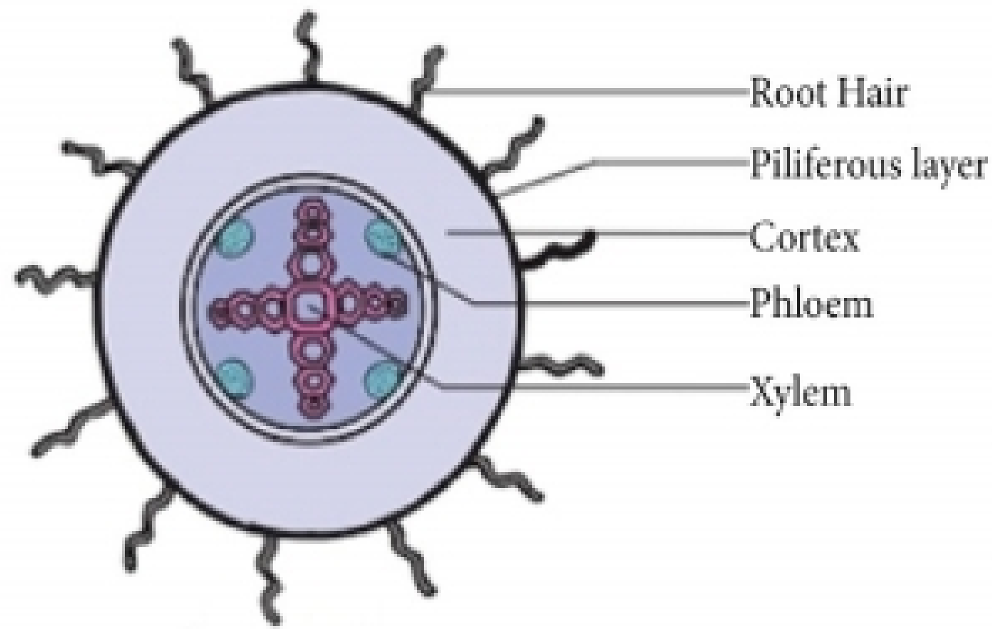


Figure 2.6 Internal structure of a typical dicot root

2.4 Reproduction in plants

2.4.1 Reproductive structure and life cycle of non-flowering plants

- common gymnosperm trees in Ethiopia and reproductive structure, male and female cones, of pine tree.
- These higher plants belong to a group of gymnosperms known as **conifers**.

Figure 2.7 Common gymnosperms and reproductive cones

- Most **conifers** have narrow, needle shaped leaves with thick cuticle, which enable them to live in extremely cold and hot environments.
- They are evergreen and do not shade their leaves both in winter and summer, a feature which makes them to be ornamental plants decorating parks, recreational areas and streets in town and big cities.
- The pine tree has male and female cones on one plant.
- Initially, pollen is transferred from the male cone to the female cone.
- The process is called **pollination** and occurs with the help of wind.
- Following pollination, the pollen completes its germination and produces the male gamete inside the female cone.
- The female gamete is also produced in the female cone.
- Here, the male and female gametes fuse (unite) and form a **zygote**. This process is known as **fertilization**.

- **A zygote** develops into a seed embryo inside the female cone.
- After the seed is matured, it is liberated upon drying and opening of the female cone.
- Then the seed will be dispersed or scattered away from the parent plant and germinates into a seedling (young pine plant) upon getting favorable conditions.
- Finally, the young plant grows and develops in to mature plant with female and male cones and the reproductive cycle of the pine tree is complete.

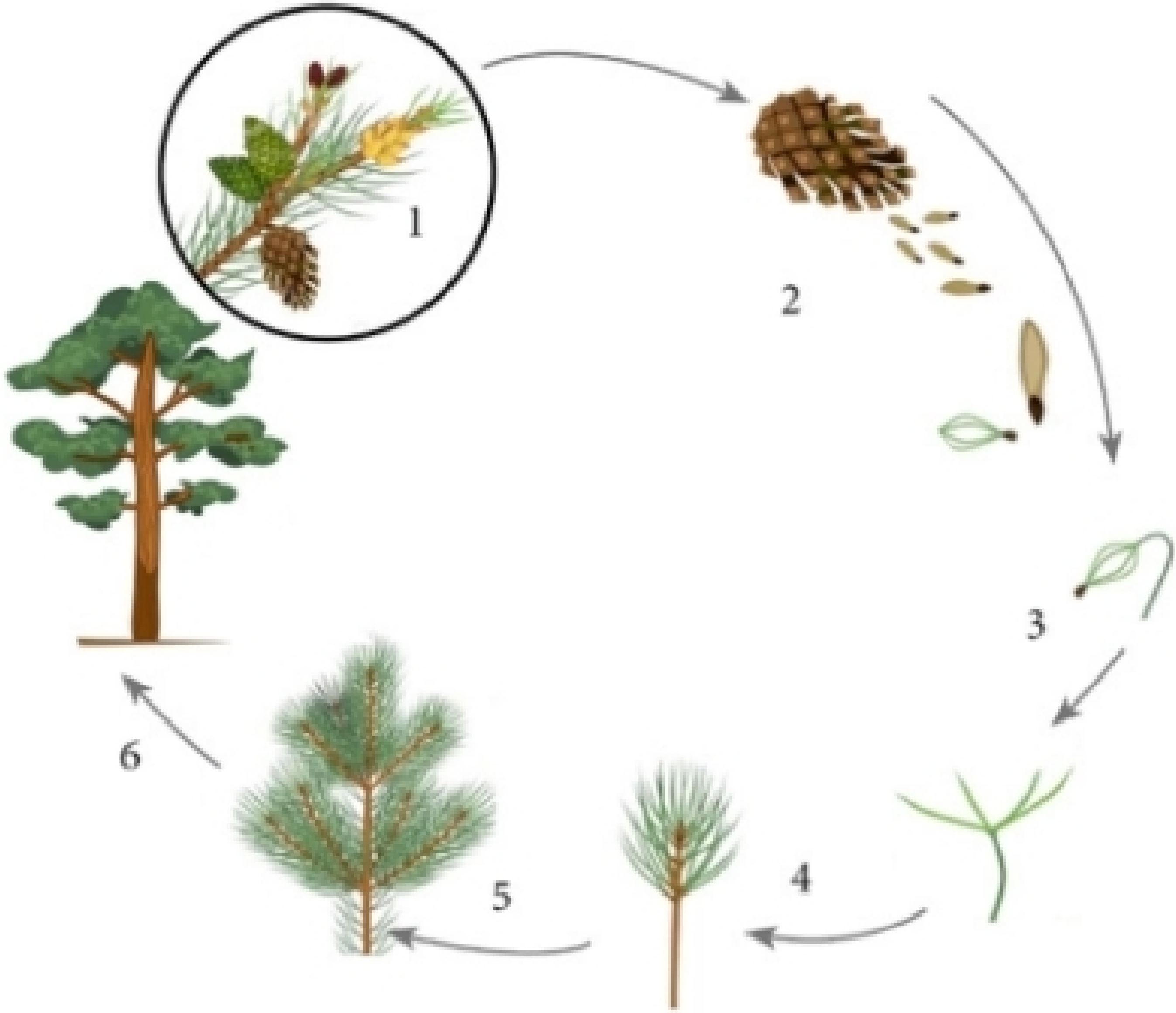


Figure 2.8 Life cycle of a pine tree representing gymnosperms

2.4.2 Reproductive structure and life cycle of flowering plants

- **A flower** is the reproductive organ of angiosperms, plants with seeds covered by or contained in a fruit.
- A typical flower has four floral parts, namely Sepals, Petals, Stamen, and Pisti.

1. **Sepals (calyx)** – usually green leaf-like structure protecting the lower part of female and male parts
2. **Petals (corolla)** – mostly brightly coloured and attract pollinating agents like insects
3. **Stamen (Androecium)** – is the male part, consisting of the filament and bilobed anther
4. **Pistil (Gynoecium or carpel)** – is the female part, consisting of the ovary with ovules, style and stigma.

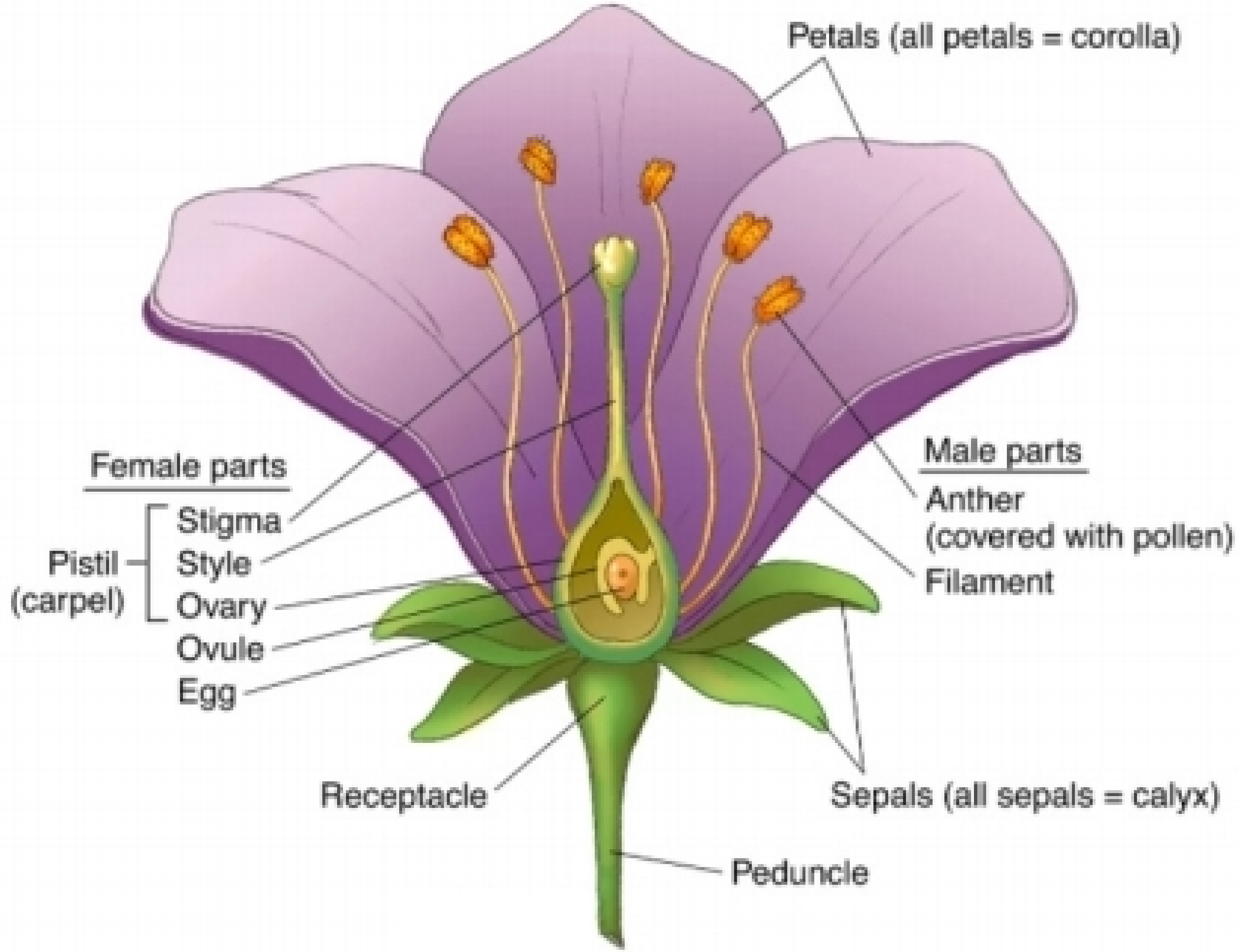


Figure 2.9: Structure of typical flower

- A complete flower has the four floral parts.
- It is called incomplete flower if it does not have any one of the floral parts.
- A perfect flower has both stamen and pistil.
- If a flower does not have either stamen or pistil, it is known as imperfect flower.
- It is either pistilated (has pisitil and no stamen), or staminated (has stamen but no pistil) flower.

2.4.3 Pollination

- **Pollination** is the transfer of pollen grains from the anther of a stamen to the stigma of the pistil.
- The transfer can be between stamen and pistil on one flower or between flowers on one plant (**Self Pollination**)
- The transfer can be between two flowers on different plants (**cross-pollination**).
- Pollination requires pollinating agents such as **insects** or **wind**.
- There is a strong relationship between the nature of the flower and the pollinating agents.

- flowering plant passes through distinct stages.

✓ **Pollen tube formation**

- Pollen grains landing on the stigma will form pollen tubes that grow down in the style and form the male gamete as it approaches the ovule.

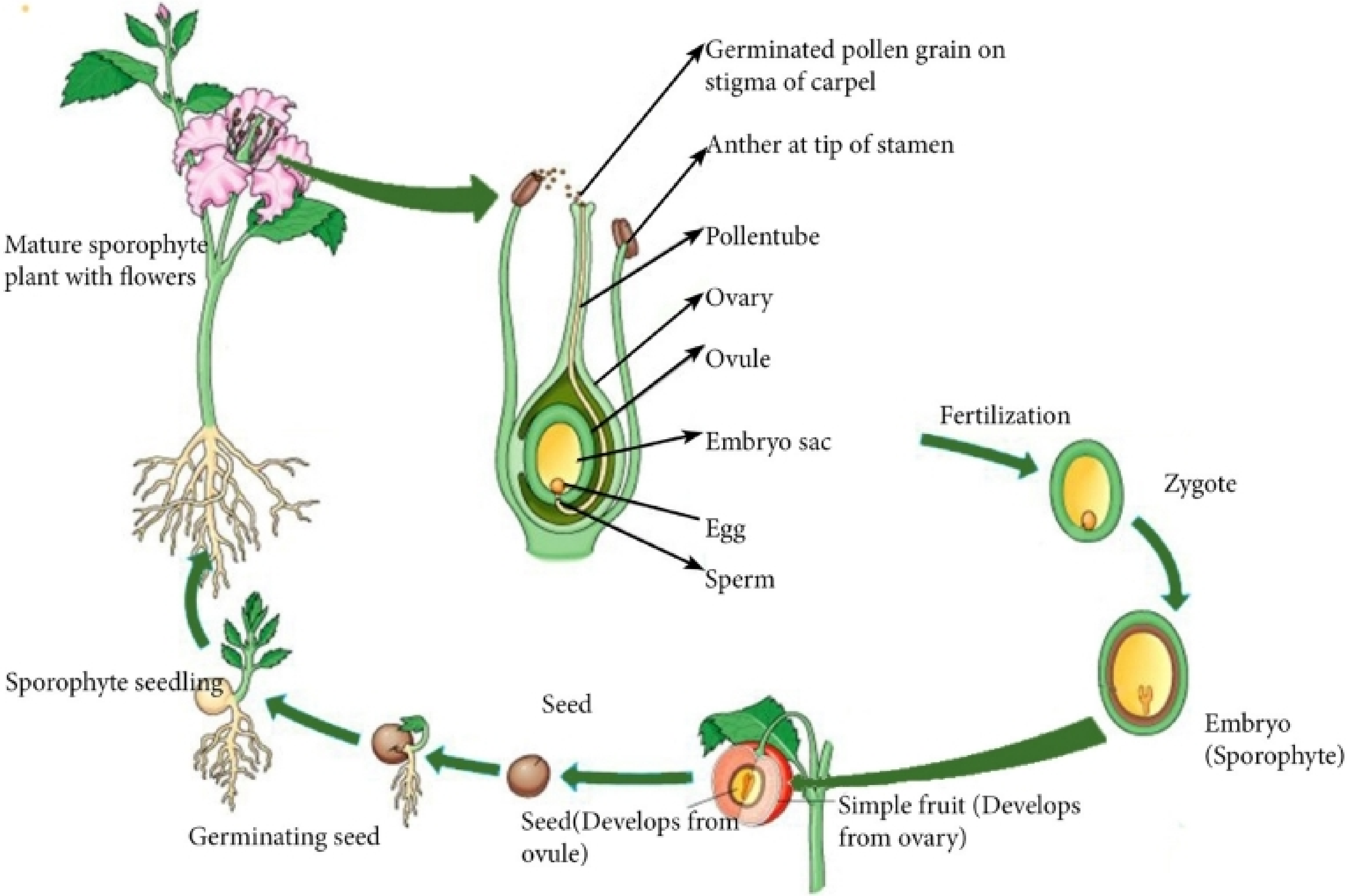
✓ **Fertilization**

- This is the union of the male gamete and the female gamete, occurring in the ovule within the ovary.
- As a result, a zygote that develops into a seed embryo will be formed.

✓ **Seed and fruit formation**

- Following fertilization and formation of seed embryo, the ovule matures into seed while the ovary matures into a fruit.
- Thus seed is a matured ovule while the fruit is a matured ovary.

- ✓ **Seed dispersal**
- This is a mechanism of scattering seeds around or away from the parent plant.
- Seed dispersal like pollination requires agents such as animals or wind.
- ✓ **Seed dormancy /Seed germination**
- The fate of a seed landing at a certain place will be either dormancy or germination.
- A dormant seed is inactive and waiting for the favourable condition to start germination.
- If there is enough water and nutrients the seed will break dormancy and the seed embryo starts to develop into a seedling (Young and new plant).
- This process is called **seed germination**.



- **Figure 2.10** Life cycle of typical flowering plant (angiosperm)

2.5 Seeds

- The seed (fertilized ovule) contains three parts:
  - ✓ the seed embryo,
  - ✓ cotyledon/endosperm (reserve food) and
  - ✓ seed coat.
- In Angiosperms, the seed is additionally covered by the fruit.
- Thus it is called covered seed as opposed to the naked seed of gymnosperm.
- A naked seed has nothing on except its own seed coat.
- The seed embryo, consists of the radicle (future root), epicotyl, hypocotyl and the plumule (future shoot).

- Cotyledon and endosperm are food storing tissues, essential for the seed embryo (future plant) until it forms leaf and starts manufacturing its own food.
- A seed of angiosperm may have

✓ one cotyledon (monocot) or

✓ two cotyledons (dicot).

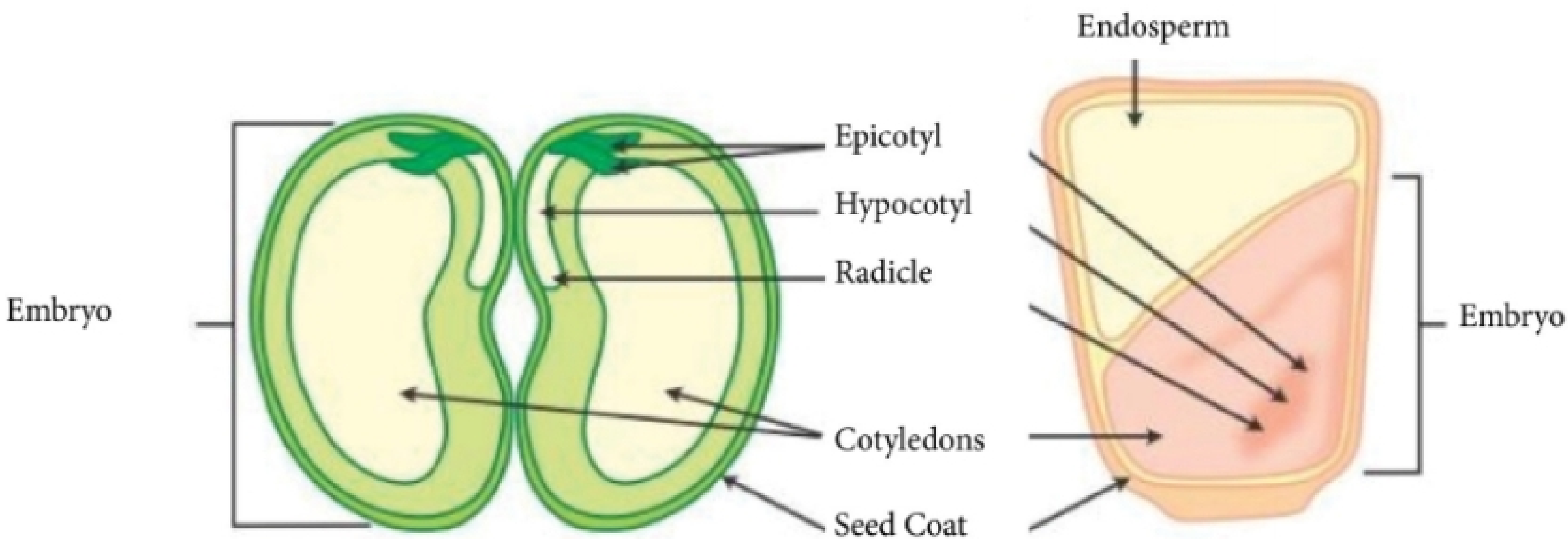


Figure 2.11 Section of a dicot (Bean) and monocot (Corn/Maize) seed and the associated structures.

Table 2.1 Differences between dicot and monocot seeds

Dicot seed	Monocot seed
Two cotyledons are present in the embryo	Only one cotyledon present
Cotyledons are fleshy and store food materials	Cotyledon is very thin and lacks food materials
Endosperm is absent	Endosperm is large and well developed
Primary root produced from the radicle bears many lateral roots.	Primary root formed from radicle is replaced by adventitious fibrous roots

2.6 Seed dispersal and germination

2.6.1 Seed dispersal

- Seed dispersal is seed will be separated from the parent plants distributed over a large area to safeguard the germination and survival of the seeds to adult plants, thereby minimizing overcrowding at one place.
- Seeds can be dispersed by **animals**, **wind** or **water**.
- For instance, fleshy fruits that have seeds in them can be ingested by birds and due to hard seed coats, the seeds escape digestion and are dropped at a distance upon defecation.
- Seeds that have additional hairy or winged structures can be dispersed by wind or float in water and taken away to a new habitat.

2.6.2 Gemination of seed

- The life of a flowering plant starts with a tiny seed embryo that stays dormant until the essential conditions for active growth are fulfilled.
- There are three essential conditions for seed germination.

✓ **Water (moisture)**

- Water is important for the germinating seed because the hydration of the seed coat increases its permeability to O2.
- Water is essential for the enzymatic hydrolysis of organic food and acts as an agent of transport in the translocation of soluble substances.

✓ **Oxygen (Aeration)**

- Oxygen is necessary for aerobic respiration by which the seeds get energy for the growth of the embryo.

✓ **Temperature (warmth)**

- Seeds require optimum temperature for germination.

- Optimum moisture, air and warmth activate the embryo to start growth.
- With more and more nourishment from the food stored in cotyledon and endosperm, the tiny embryo grows more.
- The outward sign of growth is a radicle that develops from the hypocotyl.
- It is the first to come out of the seed and grow down to the soil as the primary root.
- The root is essential for anchorage and access to water and nutrients from the soil.
- The shoot that develops from the plumule grows upward towards sunlight.

(a)

	Hypocotyl	Epicotyl
1.	The portion of the embryonal axis which lies below the cotyledon in a dicot embryo is known as the hypocotyl.	The portion of the embryonal axis which lies above the cotyledon in a dicot embryo is known as the epicotyl.
2.	It terminates with the radicle.	It terminates with the plumule.

b)

Coleoptile	Coleorrhiza
It is a conical protective sheath that encloses the plumule in a monocot seed.	It is an undifferentiated sheath that encloses the radicle and the root cap in a monocot seed.

c)

Integument	Testa
It is the outermost covering of an ovule. It provides protection to it.	It is the outermost covering of a seed. It provides protection to the young embryo.

d)

Perisperm	Pericarp
It is the residual nucellus which persists. It is present in some seeds such as beet and black pepper.	It is the ripened wall of a fruit, which develops from the wall of an ovary.

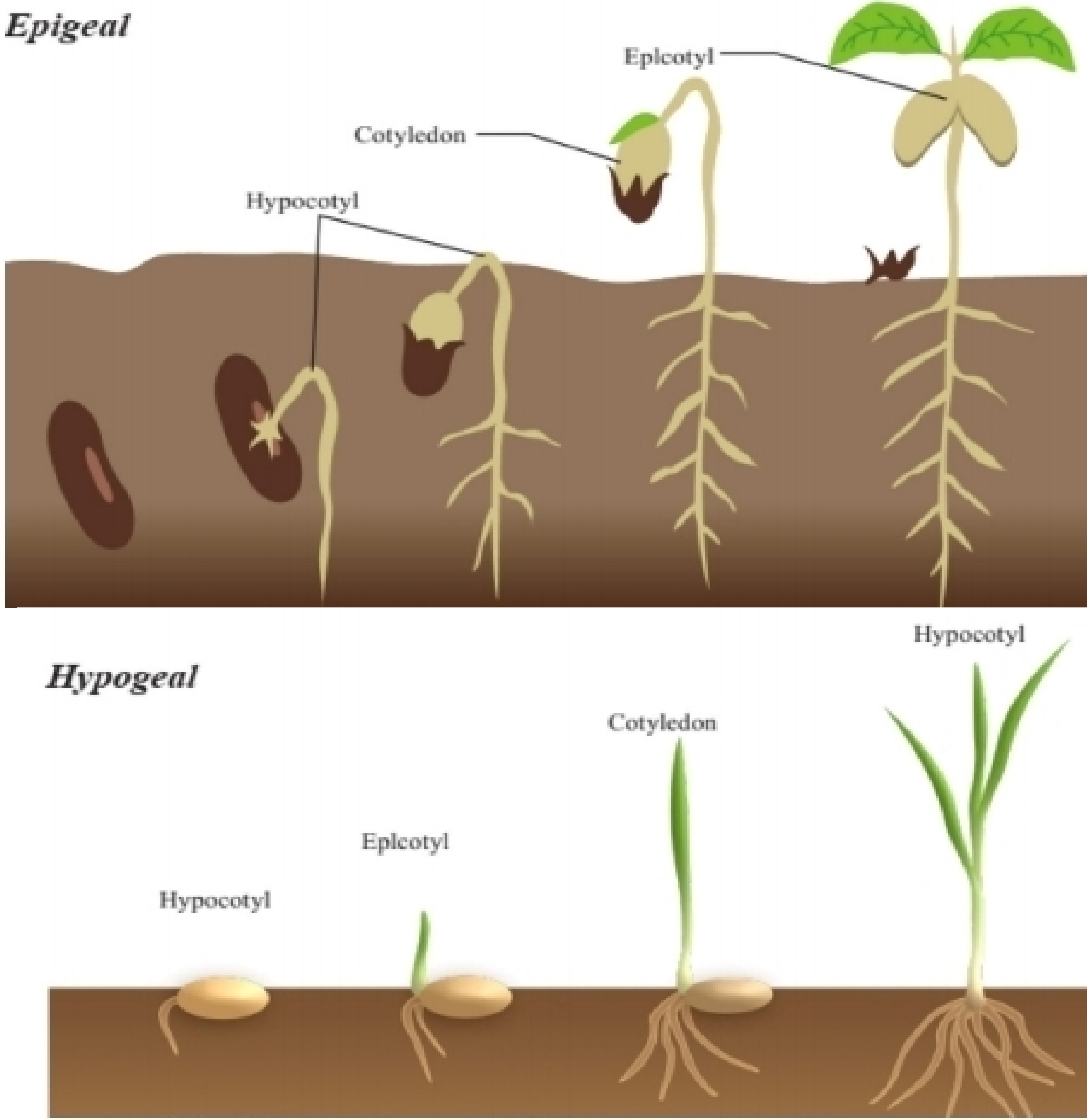


Figure 2.12. Epigeal and Hypogeal germination

- It is the position and fate of cotyledon which differentiate hypogeal germination from epigeal germination
- ✓ **In epigeal germination**, the cotyledon is pushed up to become the photosynthetic surface of the seedling by the elongation of a region of the embryo.
- ✓ **In hypogeal germination**, the cotyledon remains under the soil

2.7 Photosynthesis

2.7.1 The photosynthetic apparatus

- The mesophyll layer of the leaf contains the largest number of chloroplasts and is in the best position to trap the maximum amount of solar energy.
- There are two distinct parts in chloroplasts: Granum and Stroma.

i) Granum: consists of stacks of flattened sacks, each of which is called **thylakoid**.

- The granum contains the chlorophyll, enzymes and cofactors that participate in the light trapping phase of photosynthesis.
- It is here that the light reaction takes place.

ii) Stroma: is a gel-like colourless matrix, which is a site for sugar (carbohydrate) synthesis through carbon fixation.

- It is from the sugar produced in the stroma that is directly or indirectly converted to all organic compounds (including amino acids, proteins and lipids) virtually found in all organisms.

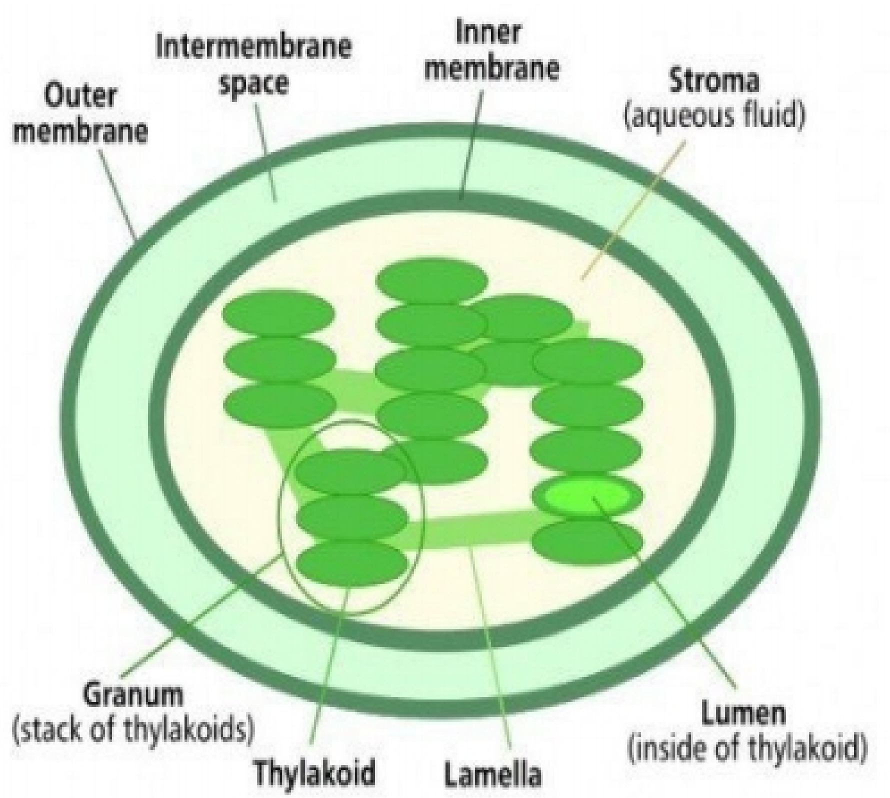


Figure 2.13: Chloroplast – the photosynthetic apparatus

2.7.2 The light absorbing system in chloroplast

- The chloroplast contains chlorophyll (particularly chlorophyll a and b) and other light absorbing accessory pigments capable of absorbing light at different wavelengths.
- The light absorbing pigments of chloroplasts absorb most of the visible light, ranging from 400 – 700 nm.
- Maximum light absorption occurs at wavelengths from 400 – 500 nm and 600 – 700 nm, blue and red light respectively.
- Light ranging from 500 to 600nm that includes green light is not absorbed, it is rather reflected.
- This is the reason why leaves look green.

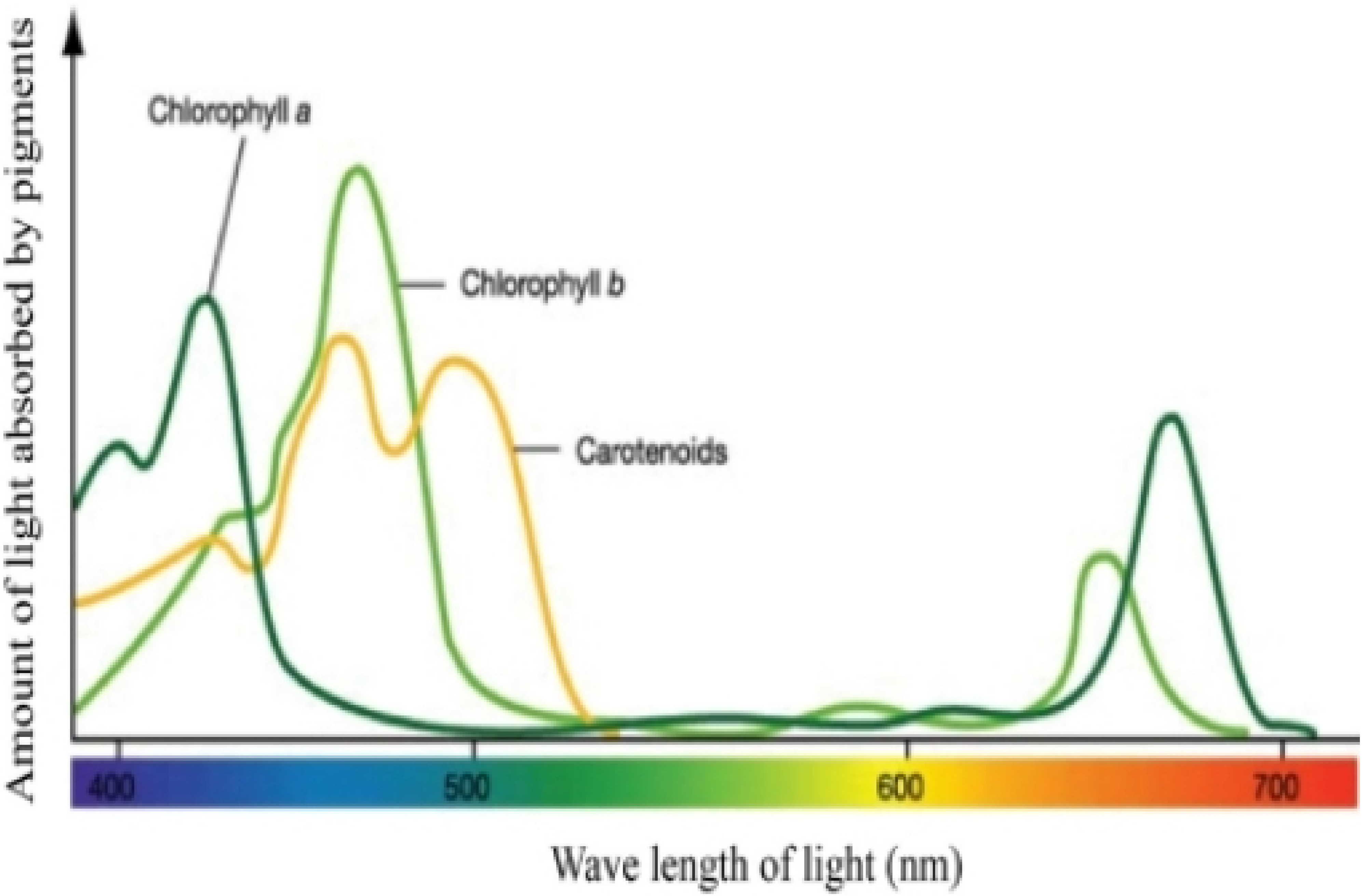


Figure 2.14 The action spectrum for different wavelengths

2.7.3. Mechanism of photosynthesis

- Photosynthesis consists of a number of photochemical and enzymatic reaction.
- It is the sum total of the following two sub reaction.

1. Light reaction (light dependent stage),

- It takes place in the granum, where the light absorbing system – mainly chlorophyll occurs.
- Here, the granum is organized as Photosystems and Electron Transporting System.
- The photosystem consists of chlorophyll that absorbs sunlight maximally at blue and red range of light spectrum.

☆ The light absorbed by the chlorophyll will

✓ split of water molecules (H_2O) into H^+ and O_2.

- This is known as photolysis.
- The O_2 is released to the atmosphere through leaf stomata.

✓ excite some electrons in the chlorophyll molecule to higher energy level which pass down the ETS and generate high energy ATP molecule.

- The ATP and H^+ harvested during light reaction will be used as an input in the Stroma where conversion of CO_2 to carbohydrate takes place.

2. Dark reaction (light – independent stage),

- because it can occur in the absence of light as long as there is sufficient amount of H+ and ATP supplied from the light reaction.
- The dark reaction and enzymatic reaction H+ indirectly combines with CO2, in the stroma of chloroplast.
- The process is known as carbon fixation.
- Glucose (carbohydrate) is the immediate result of the dark reaction.

The chemical equation for the same process is:

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

2.7.4. Testing a leaf for starch

» To know the presence of starch

✓ Remove a leaf from the plant

✓ plunge it into boiling water (about 30 seconds).

- to kill the leaf
- Because leaf has waxy cuticle that prevent iodine to penetrate.

✓ Place the leaf in a boiling tube half filled with ethanol,

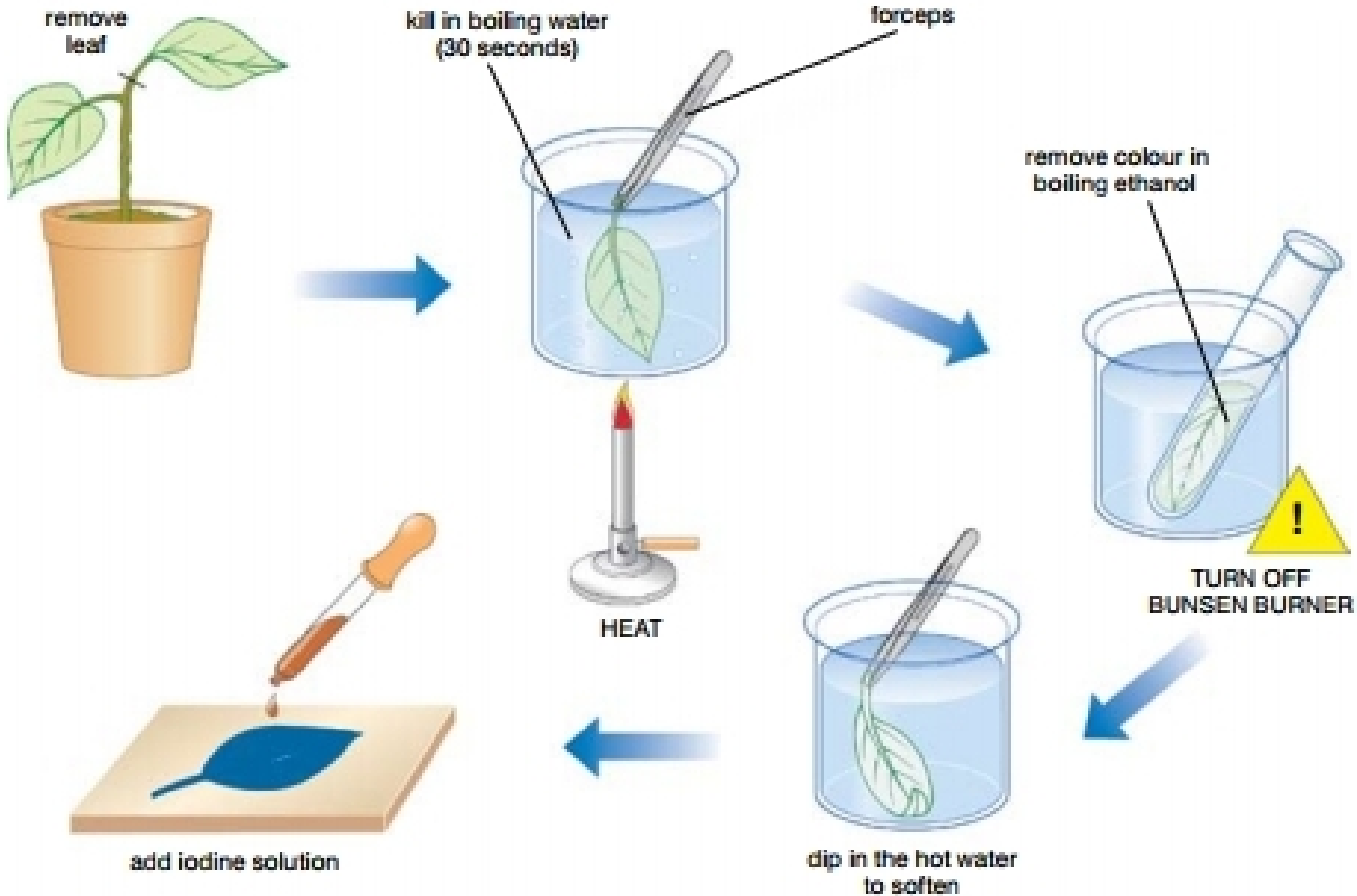
- to remove green colour.

✓ Dip the leaf in the hot water.

- to soften

✓ Add iodine solution on the leaf.

- The leaf colour is turn into blue black.


remove leaf
kill in boiling water (30 seconds)
forceps
remove colour in boiling ethanol
HEAT
TURN OFF BUNSEN BURNER
add iodine solution
dip in the hot water to soften

2.8 Transport in plant

2.8.1 Transporting systems in plants

- the transporting vessels of higher plants commonly called vascular bundles.
- The two transporting vessels, **xylem** and **phloem** in the root.
- They are collectively known as **vascular bundles**.
- **Xylem** consists of elongated dead cells, joined end to end to form continuous vessels.
- are transport water and minerals from the root to the leaf via the stem.
- **phloem** consists of living cells arranged end to end.
- It allows transport of food (sucrose and amino acids) up and down the plant.

- Sugars synthesized in the leaf is converted to starch and accumulated in the storage organs of plants, such as:

✓ root and stem tubers,

✓ leaves,

✓ seeds and fruits of a plant.

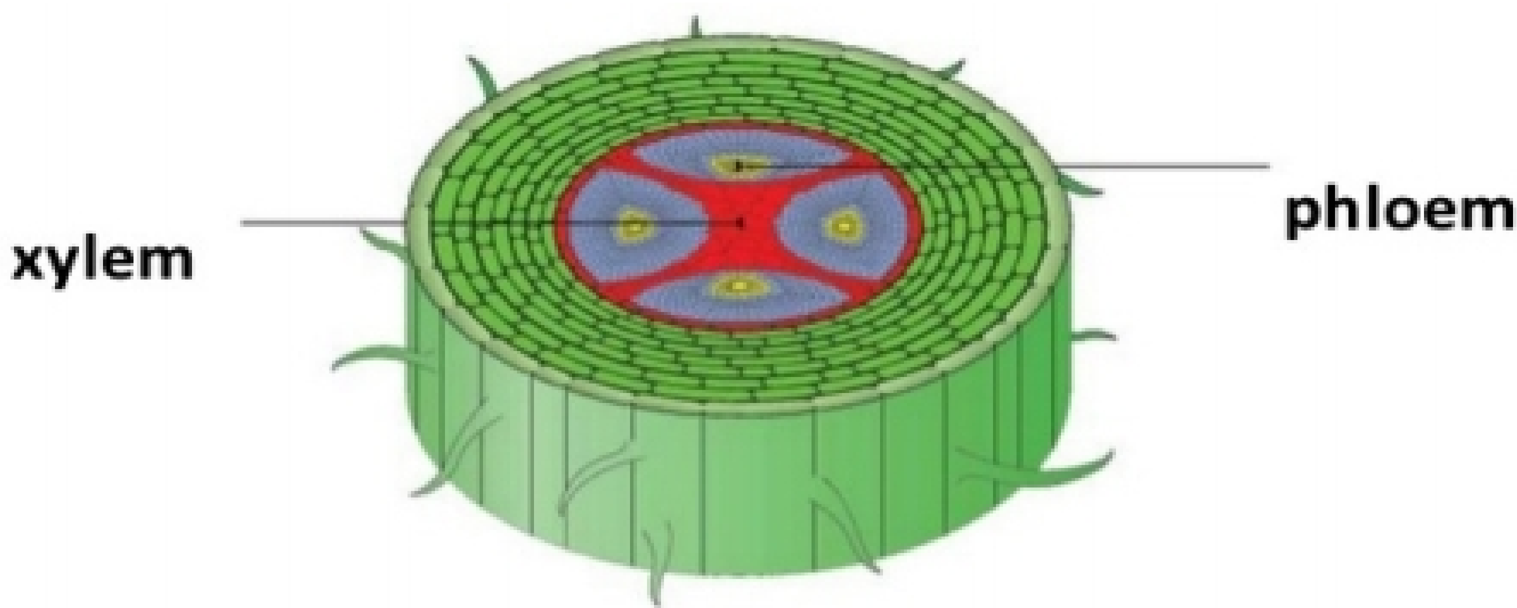


Figure 2.15 Root vascular bundles

2.8.2 Mechanism of transport in plant

i. Uptake of water and minerals

- Water from the soil first enters the root through **root hairs**.
- These are elongated single cells that provide a large surface area allowing more water to enter into the root.
- Minerals also enter the root together with the water.
- This process is known as **absorption**.

☆ **Water** entering the root passes from cell to cell either by **osmosis** or freely flow by **diffusion** along the porous cell wall.

- water passes **passively** (without spending additional energy from the cell) across the root cells and reaches the root xylem.

- Water in the root xylem is pulled upward **passively** by transpiration pull.
- During transpiration water that evaporates from the leaves serve as a mechanism to pull or drag water from the root.

☆ Minerals enter the root in the ionic (charged) form either passively or actively.

- They are taken **actively** (cell spends energy) when concentration is higher in plant cell than outside the cell and, therefore accumulation of salts or their ions occur as a result of active transport against a concentration gradient.

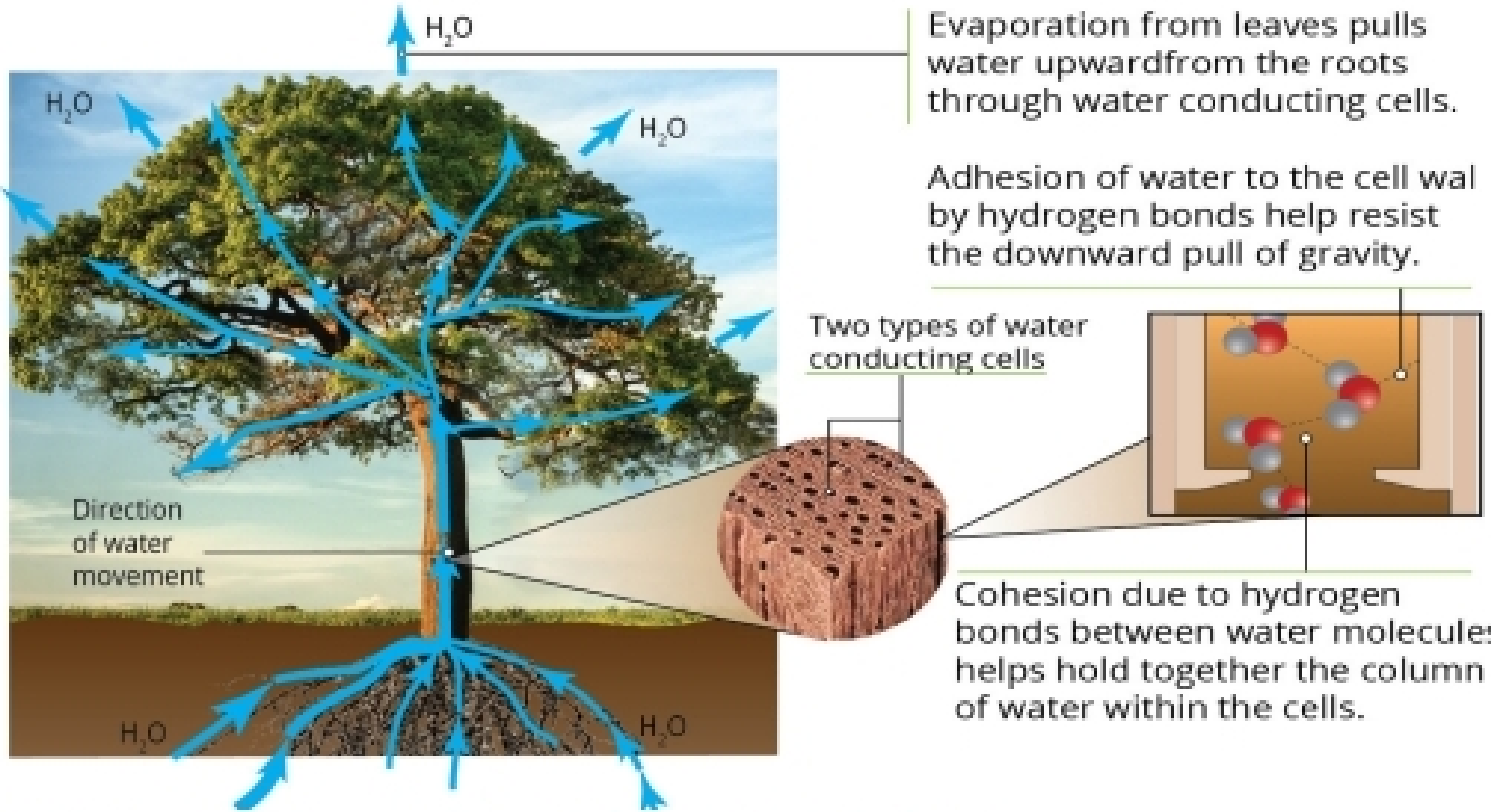


Figure 2.16 Transport of water and minerals from root to the leaf via the stem

ii. Translocation of organic matter (food)

- Translocation in plants is a shift or transport of food from the site of synthesis (source), to the site of utilization or storage (sink).
- Translocation occurs through the phloem, which is made up of living cells.
- It is an **active transport**, where the living phloem cells use energy obtained by metabolic process.

▪ **Removing the ring of bark** with the phloem and After few days, a **swelling** will be observed in the upper girdle.

• Xylem will be the only vessel in the girdled area, which connects the upper and lower part of the plant.

- The sugar can be sucked with syringe or using aphids and can be confirmed with food test.

- Aphids are soft – bodied insects that use piercing and sucking mouth parts to feed on phloem sap.
- Ringing will ultimately kill the plant, because of disruption of food transport through the phloem.
- The root dies first, As the root dies, the upper part and finally the whole plant, will die.

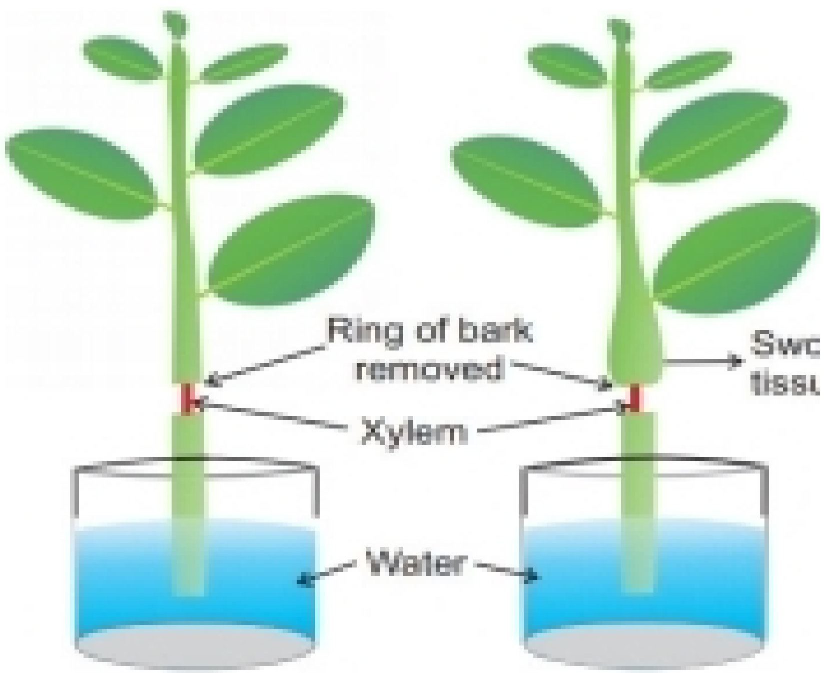


Figure 2.17 Ringing /Girdling experiment

2.9 Response in plants

2.9.1 Tropism as growth response

- All living organisms need to be able to respond to their surroundings.
- This may be to find food, move towards the light or avoid danger.
- how plants respond to light (phototropism), water (hydrotropism) and gravity (geotropism).
- Tropism is bending towards (positive response) or opposite (negative response) to the direction of the stimulus.
- The cause of the response is a unilateral stimulus (coming from one side only), which causes unequal production or distribution of growth hormone resulting in unequal growth.
- Tropism is exhibited by the shoot and root of a plant due to unequal concentration of **growth hormone**, commonly auxin, resulting in unequal growth.

- **Plant hormones** (phytohormones) have several effects on plants.
- **For example**,
  - ✓ they co-ordinate flowering,
  - ✓ cell division and
  - ✓ cell elongation.
  - ✓ Fruit ripening
- **Examples of plant hormones are**
- auxins (including indole-acetic acid, **IAA**),
- gibberellic acid,
- cytokinin,
- ethylene and
- abscisic acid.

1. Auxin (IAA)

- It is produced at the tips of shoot and root.
- It is transported to the region of active growth and affects **cell elongation**,
- Shoot and roots respond differently to different auxin concentration.
- The graph (Figure 2.18) shows that auxin concentration that promotes shoot growth (10 -2 to 101 ppm) inhibits root growth .
- It also shows that root requires minimum auxin concentration, which is about 10 -4 ppm and such concentration has no effect on the shoot growth.

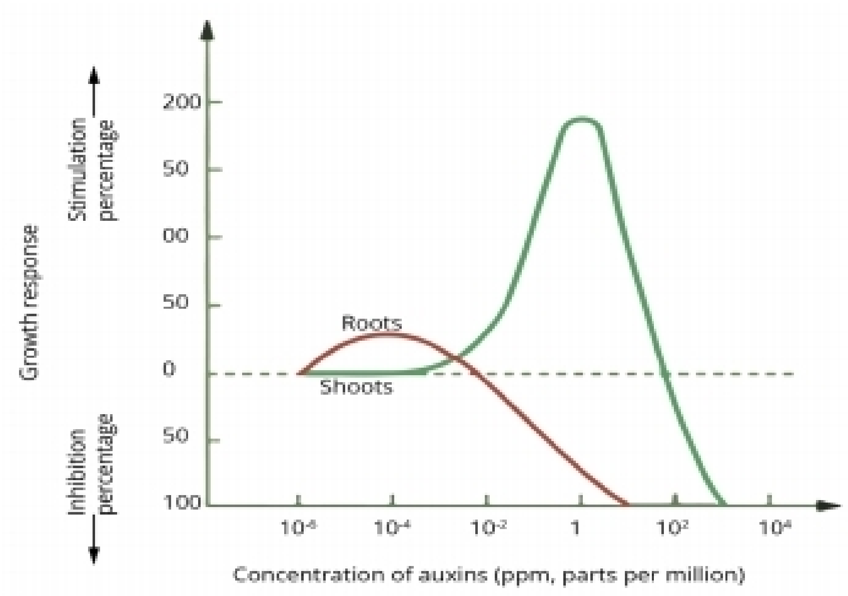


Figure 2.18 Effects of auxin concentrations on the growth of shoots and roots

- it is involved in general plant growth.
- It is also involved in **apical dominance**.
- If you cut off the growing tip of a plant it **will bush out**.
- The **side shoots grow quickly** once you remove the apical dominance from the auxins produced by the main shoot.
- Auxin also stimulates the growth of roots.
- The best-known function of auxins is in the responses of plants towards light and gravity are called **tropisms**.
- shoot and root respond to unilateral light, auxin move from illuminated side to shaded side of shoot and root.
- In shoot higher auxin concentration on the shaded side causes more growth by cell elongation than the illuminated side.
- As a result, the shoot bends towards light.
- More auxin on the shaded part of the root inhibits cell elongation as compared to the illuminated side.
- Thus, root bends away from light.

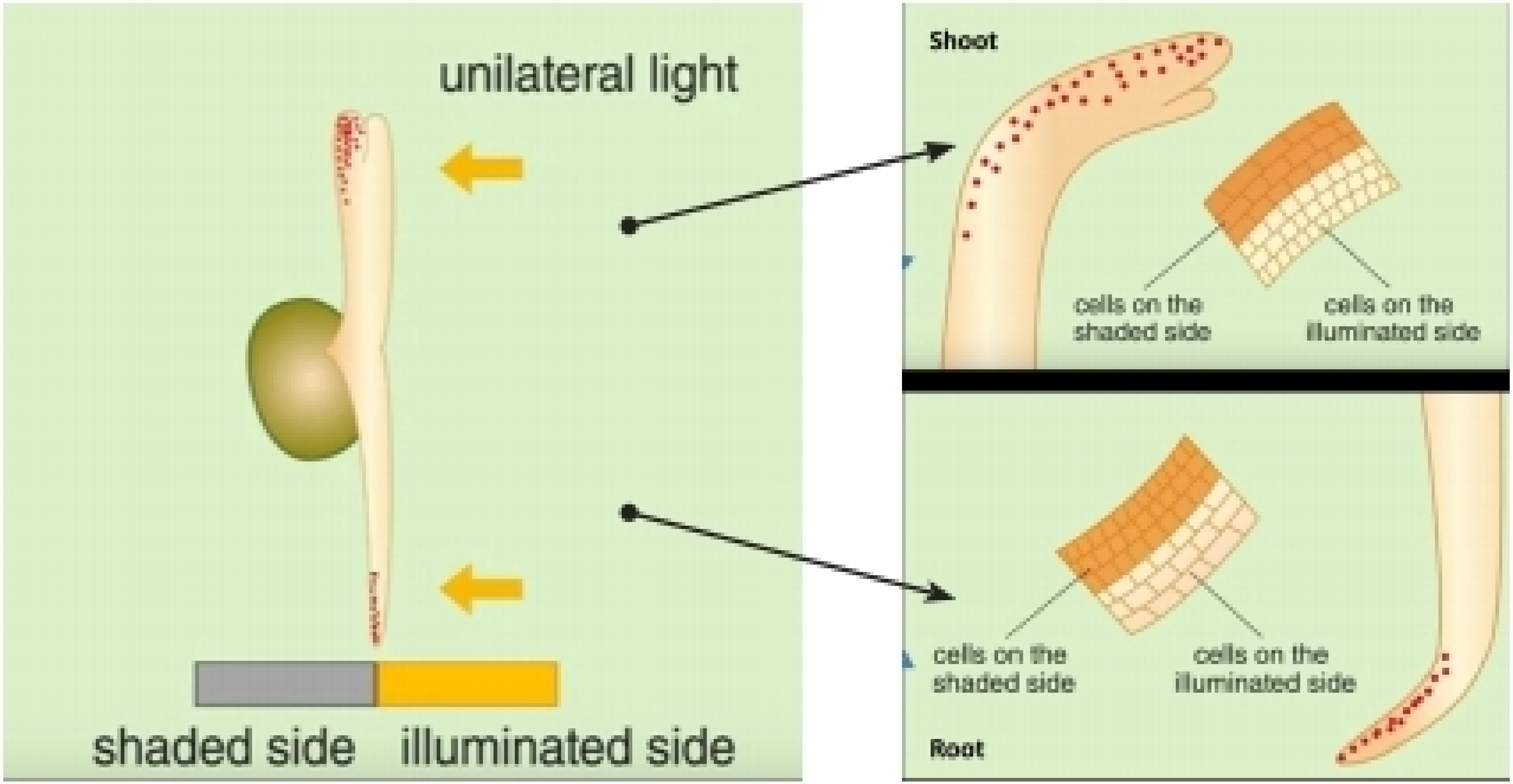


Figure 2.19 How unilateral light affects shoot and root response

2. Gibberellins

- These hormones stimulate the growth of plant stems.
- also help seeds to break their dormant period and start to grow.
- stimulating the production of the enzymes needed to break down the food stores in the seeds.
- It makes dwarf plants grow into normal size.

3. Cytokinins are hormones that stimulate cell division in plants.

- Together with auxin are used to cause differentiation roots, stems leaves and a bud of plants.

4. Ethylene a gas hormone, at room temperature.

- it causes fruit to ripen.
- It prevents falling of fruits and leaves in some plants

- **Abscisic acid (ABA)** is another important plant hormone. It inhibits growth and plays a major role in leaf fall.
- It is also involved in seed dormancy.
- it may be involved in **geotropisms**

☆ Phototropism

- Phototropism is a plant response to light, mainly exhibited by the shoot.
- The tips of the plant shoot bend towards the side where there is sunlight.
- Thus shoot is **positively phototropic**.
- The earliest experiment on phototropism was conducted by Charles Darwin, “father of evolution”.

☆ Hydrotropism

- Roots search for and grow toward water because it is needed for photosynthesis and to support cell structure (make them turgid and strong).
- Thus, hydrotropism exhibited by root is biologically important and vital for the survival of plants.

☆ Geotropism

- Plants response to gravity,
- The root progressively bends downward while the shoot bends upward until root–shoot system orient itself in an upright (standing position), when there is a uniform effect of gravity.
- A horizontally placed seedling responds to gravity in that its root is **positively geotropic** (grow downward or towards gravity) and shoot is **negatively geotropic** (grow upward or against gravity).
- The effect of gravity in a horizontally placed seedling can be overcome by a **clinostat**, which is a rotating instrument.
- A seedling fixed horizontally in a rotating clinostat grows straight, because the rotation overcome (gravity acts equally for all sides) the effect of gravity.

2.10 Medicinal plants

- Medicinal plants play a vital role in treating diseases and fighting infections.
- Globally, more than 60 % of the total world population depends on traditional or locally available plant medicines for their health care.
- According to World Health Organization (WHO), nearly 3.5 billion people in developing countries including Ethiopia believe in the efficiency of plant medicines and widely use them to overcome their health problems.

Table 2.2 List of medicinal plants and disease treated

No.	Scientific name	Local name (Amharic)	Habit	Plant part used	Route of administration	Disease treated
1.	*Ruta chalepensis*	Teenadem	Herb	Leaf	Oral	Abdominal pain
2.	*Zingiber officinalis*	Jinjibil	Herb	Rhizome (underground stem)	Oral	Tonsilitis , abdominal pain, cough
3.	*Hagenia abysinica*	Ye-kosso Zaf	Tree	Female flower (Seed)	Oral	Tapeworm
4.	*Artemesia absinthium*	Aritii	Herb	Leaf	Oral	Unexplained stomach ache (Megagna)
5.	*Niglella sativa*	Tikur Azmud	Herb	Seed	Oral	Intestinal parasites
6.	*Ocimum lamifolium*	Damakesse	Shrub	Leaf	Nasal	Headache, General body illness (Mich)
7.	*Rosmarinus officinalis*	Rosmery	Herb	Leaf	Oral	Bronchial asthma. Prostate disorder inflammatory diseases
8.	*Cymbopogen ciratus*	Tejsar	Herb/ Grass	Leaf	Oral	Used for stomach complaint
9.	*Alium sativum*	Nechshinkurt	Herb	bulb	Oral	Abdominal pain, toothache, tonsillitis, common cold
10.	*Eucalyptus golbulus*	Nech-Bahir-zaf	Tree	Leaf	Nasal	Common cold, fever with headache
11.	*Curcurbita pepo*	Dubba	Herb	Seed	Oral	Tapeworm
12.	*Trigonella foenumgraecum*	Abish	Herb	Seed	Oral	Mixed with garlic to treat asthma , used to treat gastritis
13.	*Ocimum basilicum*	Besobilla	Herb	Leaf	Oral	Abdominal pain
14.	*Lepidium sativum*	Feto	Herb	Seed	Oral	Treatment of diarrhea

2.11 Renowned Ethiopian Botanist

- Sebsebe Demissew is a professor of Plant systematics and Biodiversity at Addis Ababa University and Executive Director of the Gullele Botanic Garden in Addis Ababa.
- He was awarded the Kew international medal in 2016.
- In 2021, Professor Sebsebe was awarded the "Cuatrcases Medal" for Excellence in Tropical Botany by the Smitheonian National Museum of Natural History ",