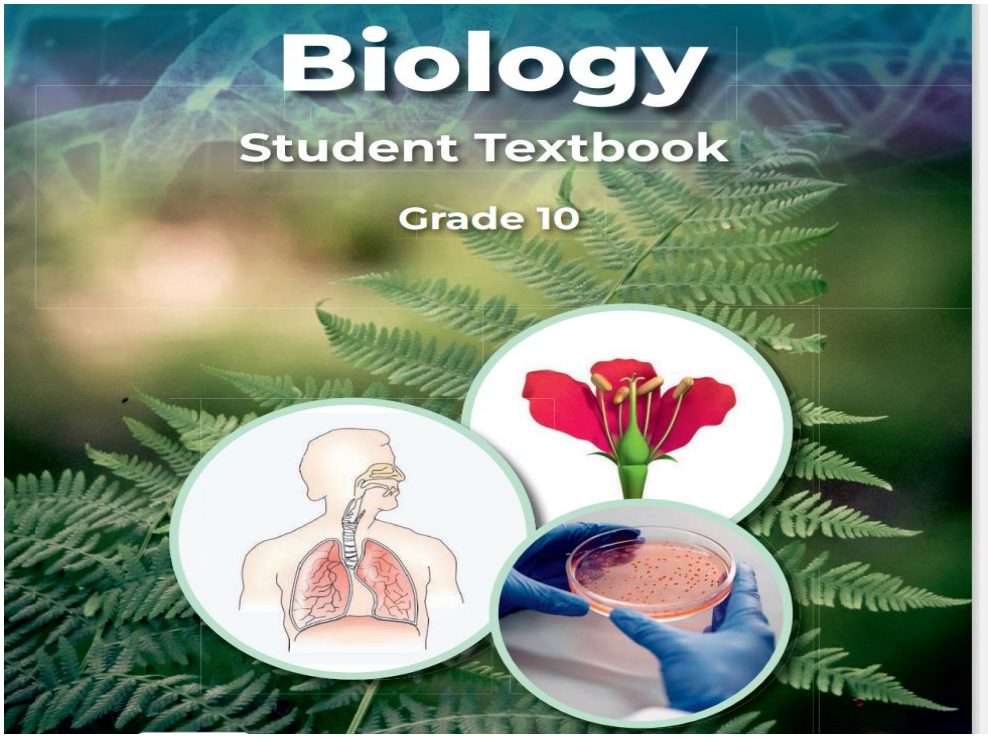
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2016/2023

BIOLOGY GRADE 10

NOTE PP

Ambo Ifa Boru
Secondary Special
Boarding School



October, 2016 E.C

Oromia, Ambo

Biology Grade 10

Unit 1: Sub-fields of Biology

1.1 Sub-fields of Biology

You will study the different sub-field of biology.

Q. List the sub-fields of biology do you know?

Biology Grade 10

1.1 Sub-fields of Biology

❑ **Biology is a broad discipline, it is sub divided into several branches.**

✓ it contains many branches and sub-disciplines.

✓ Based on the type of organism it studies

✓ biology is subdivided into three:

i. Zoology,

ii. Botany, and

iii. Microbiology.

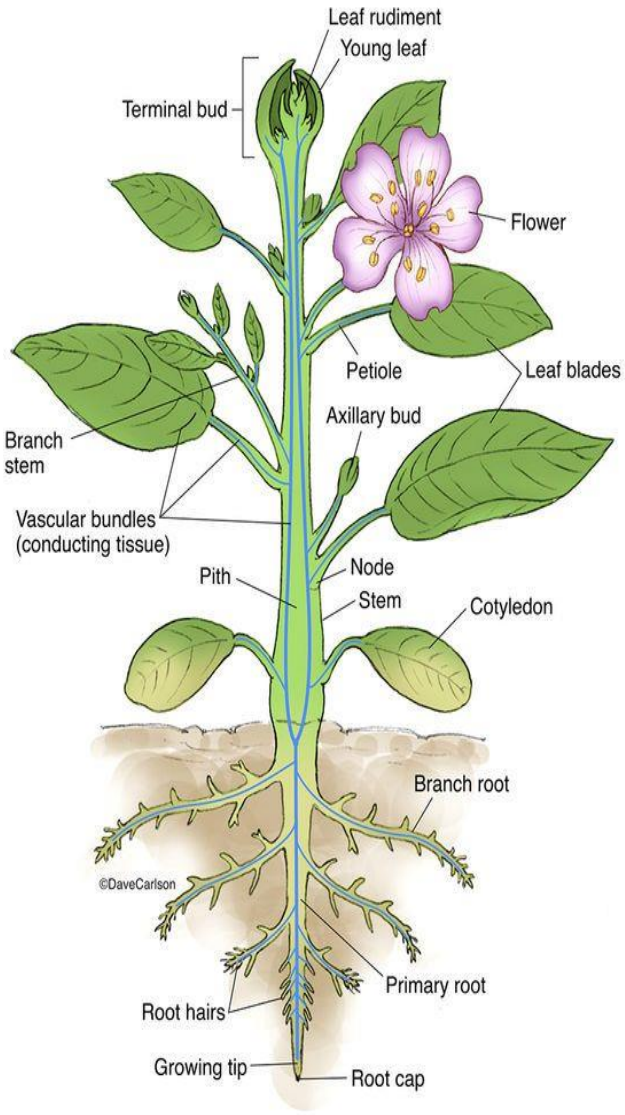
In addition to these three sub-fields, there is a huge array of sub-disciplines or fields of biology.

i. Zoology



- Animal biology
- is the **study of animals**
- includes disciplines such as:
  - ✓ herpetology - the study of reptiles
  - ✓ ichthyology - the study of fish
  - ✓ mammalogy - the study of mammals
  - ✓ ornithology - the study of birds
  - ✓ entomology (insects)
  - ✓ Ethology-behaviour of animal
- Zoology is concerned with all aspects of animal life, such as embryonic development to mature adulthood; behavior

Eg. Waliya ibex (in Simien Mountains of Ethiopia) endemic wild animals of Ethiopia.



ii. Botany

- studies about **plants**.
  - ✓ their physiology, morphology, ecology, evolution, taxonomy and economic importance
- Includes many subdisciplines
  - ✓ Phycology - the study of algae
- 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 have long been used as a source of food, shelter, clothing, medicine, ornament, and tools.
- Green plants are now known to be essential to all life on earth.
- In addition to their practical and economic values, through the process of photosynthesis, 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 by product of photosynthesis is the second unique and important capability of green plants.

Eg. Ruta chalepensis L. (‘Tena Adam’ in Amharic), a known traditional herbal medicine of Ethiopia.

iii. Microbiology

- Microbiology is the study of **microscopic organisms or microbes**
- It includes bacteria, archaea, protists, viruses, microscopic algae and fungi.
- Has many sub-disciplines such as
  - ✓ Bacteriology is the study of bacteria
  - ✓ mycology is the study of fungi
  - ✓ Variology-virus



- Is an important with many practical applications-in medicine, agricultural, biotechnology.
- are importance in food industry, fermentation and pollution control

cont…

- Microbiology is a rapidly expanding field of study.
- new technology and developments in the field are constantly assisting in the identification of new species.

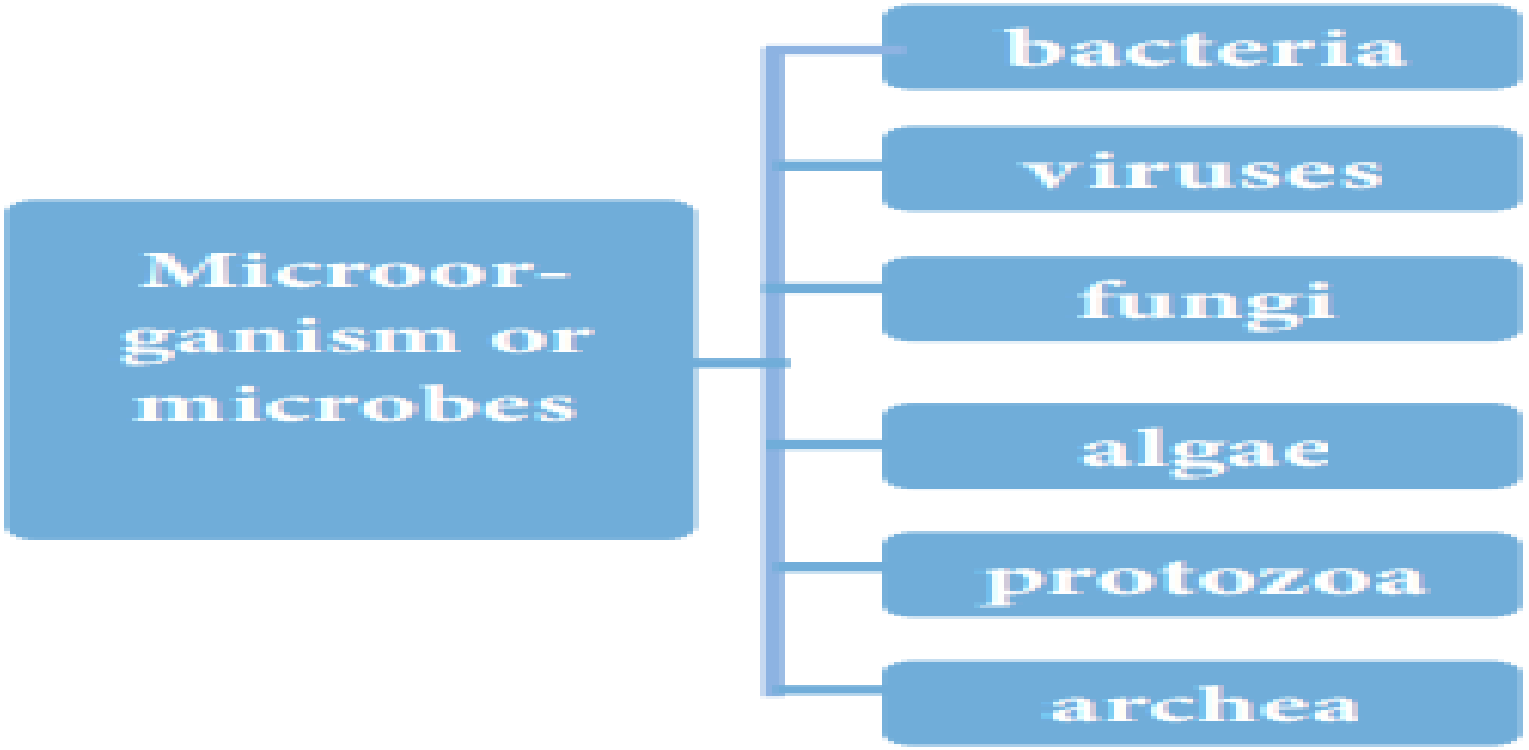


Figure 1.3. The microorganisms

Home Work

1. Define bacteria, viruses, fungi, algae, microscopic protozoa and archaea.

2. Draw typical bacteria, viruses, fungi, algae, microscopic protozoa and archaea.

Table1.1shows how various branches of biology are related to the structure we are studying.

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

Cont…

Many other branches of 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 lists some of these fields 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

Cont..

- Biology is related to other sciences

Table 1.3 shows some of the interrelationships.

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

Class Work

1) Study of plants called:

A) Zoology B) Botany C) Histology D) phycology

2) A branch of biology that study about bird is__

3) A branch of biology that study about classification of living things is_____

4) Ichthyology is the study of fishes. T/F

1.2 Pure and applied fields of biology

• Classify the different sub-fields of Biology into pure and applied

What do we mean by pure and applied fields of biology?

Pure biology /basic

- study of how life functions in nature (behavior, internal and external structure, reproduction, etc.)

Eg. Anatomy, Morphology, cell biology

Applied biology

- refers to using what you have learned in biology for (gardening, agriculture, plant disease, forestry, poultry, etc.).
- is the use of your knowledge of biology to manage life.
- The relationship is similar to anatomy and surgery

Eg. Agricultural biology, biotechnology, medicine, Food, soil, industrial, Aquatic

Group Work

Activity 1.4: Categorizing pure and applied fields of biology

Select pure and applied fields of biology from the list given in the columns on the left side in the table below and categorize them in their appropriate column on the right side (columns A & B).

Table 1.4 Pure and Applied fields of Biology

Fields of Biology		Pure Biology (A)	Applied Biology (B)
Agriculture	Biotechnology		
Morphology	Molecular Biology		
Taxonomy	Evolution		
Horticulture Cytology	Pathology		
Embryology	Physiology		
Histology	Forestry		
Poultry	Pharmacognosy		
Agroforestry	Pisciculture		
Apiculture	Paleontology		
Animal Husbandry	Bacteriology		
	Entomology		
	Sericulture		

Definition of terminologies

- **Apiculture**-Study of keeping of bees
- **Pisciculture** –Study of rearing of fishes
- **Sericulture**- The process of an insect producing silk from silkworm
- **Horticulture**- The science and art using of high grown food and ornamental plants
- **Agroforestry**- deals with crop plants
- **Pharmacognosy**- The study of medicinal drugs obtained from plants, animals and microbes
- **Poultry**-study which deals with the keeping of foul

  -domesticated bird kept by humans for meat, eggs

Fields of biology	Pure biology	Applied biology
	Entomology	Agriculture
	Morphology	Horticulture
	Taxonomy	Poultry
	Cytology	Agroforestry
	Embryology	Apiculture
	Histology	Animal Husbandry
	Molecular Biology	Biotechnology
	Evolution	Forestry
	Pathology	Pharmacognosy
	Physiology	Sericulture
	Bacteriology	Pisciculture
	Paleontology	

Some of the biological importance of the branches of biology in other branches of sciences.

1) **Biotechnology**:

- ✓ It is the use of living organisms or their products for the welfare of humanity.
- ✓ It involves the technical manipulation of a living organism's genetic makeup (Genetic Engineering).
- ✓ A genetically modified and improved variety of crops and animals have been produced by biotechnology.

2) **Bioinformatics**:

- ✓ It is the acquisition, storage, analysis, and dissemination of biological data, most often DNA and amino acid sequences.
- ✓ It 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**:

- It is 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
  - ✓ this process is called genetic engineering.

4) **Biomedical Engineering**:

- ☑ It is the application of the principles and problem-solving techniques of engineering to biology and medicine.
- ☑ Focuses on the advances that improve human health and health care at all levels

Cont…

5) **Environment Management**:

- ☑ deals with environmental observation and finding out the solution to maintain the balance of nature.

6) **Forensic Science:**

- ✓ It is the application of the knowledge of biological science (DNA fingerprints (unique patterns in DNA molecule), blood typing) to criminal and civil laws

Q. Discuss at least five major discoveries that revolutionized biology

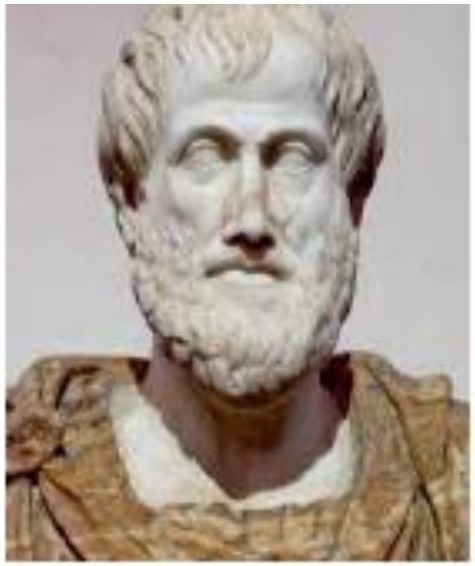


Figure 1.3 Aristotle

1.3 Major discoveries that revolutionized biology

The twelve famous discoveries revolutionized biology.

1. Aristotle (384–322 BC)

- the ancient Greek philosopher
- Aristotle was responsible for a classification system for living things.
- Aristotle's classification system was known as the 'Ladder of Life' until the 19th c.
- For the first time, he established species relationships and grouped them correctly.

2. Galen (129–161 AD)



Figure 1.4 Galen

- ✓ Galen's efforts transformed medical science.
- ✓ 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.
- ✓ Although many of his concepts contained scientific mistakes,
- ✓ But his contribution to medical science is undeniable
- ✓ early medical experimentation

3. Antonie van Leeuwenhoek (1632–1723)



Figure 1.5 Antonie van Leeuwenhoek

- The father of microbiology
- Antonie van Leeuwenhoek 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.
- Leeuwenhoek used microscopes to learn more about the living world;
- his findings were bacteria and the vacuole of the cell.

4. Carl Linnaeus (1707–1775)

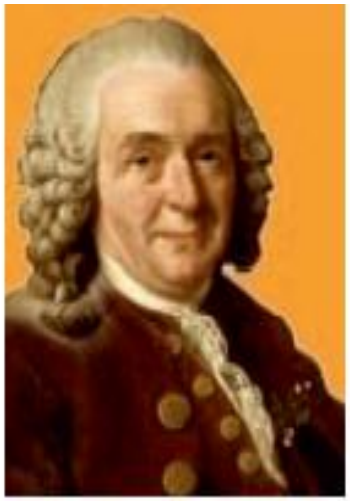


Figure 1.6 Carl Linnaeus

- Modern taxonomy
- a botanist, physician, and naturalist,
- devised the method for naming, ordering, and classifying living organisms that we still use today.
- His extensive collection of plant, animal, and shell specimens inspired him to devise a system for classifying and naming species.
- He separated living things into three categories – animals, plants, and minerals – and
- Further organized living things into classes, orders, genera, and species.

Eg. Take ‘Homo sapiens’- ‘homo’ is the genus and ‘sapiens’ is the species.

5. Charles Darwin (1809–1882)



Figure 1.7 Charles Darwin

- Formulated the theory of evolution
- Probably the most famous naturalist of all time. During 19c
- He established that all species of life descended over time from common ancestors,
- with species continuing to exist through the process of natural selection.
- His theory of evolution was published in On the Origin of Species in 1859
- 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.

Contd..



Figure 1.11 Gregor Mendel

6. Gregor Mendel (1822–1884)

- ✓ the father of genetics
- ✓ He used peas to discover and demonstrate the laws of genetic inheritance, coining the terms ‘dominant’ and ‘recessive’ genes in the process.
- ✓ The laws were rediscovered at the turn of the 20th century and provided the mechanism for Darwin’s theory of natural selection to occur.
- ✓ The two theories combine to form our current understanding of the evolutionary process

Contd..

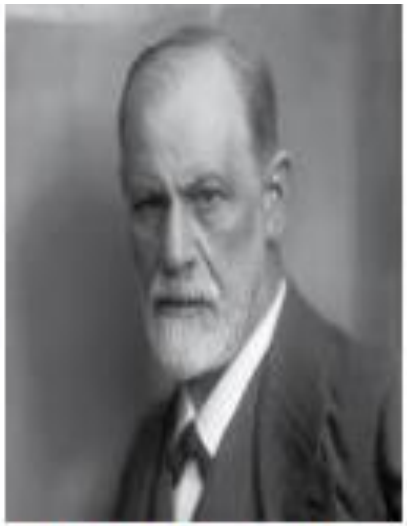


Figure 1.4 Louis Pasteur

7. Louis Pasteur (1822-1895)

- ✓ is the father of medical microbiology.
- ✓ first establish/formulate the germ theory of disease
- ✓ He pioneered molecular asymmetry research
- ✓ demonstrated that bacteria cause fermentation and disease,
- ✓ introduced pasteurization, rescued France's beer, wine, and silk industries, and
- ✓ developed anthrax and rabies vaccines.
- ✓ disproved theory of spontaneous generation
- ✓ Proved that all life comes from pre existing life.

Contd..

8. Robert Koch (1843-1910)



Figure 1.5 Robert Koch

- ✓ 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.
- ✓ identify the microorganisms that cause TB and Cholera.

Contd..



Figure 1.14 Jane Goodall

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.
- ✓ She's a global leader in animal rights and was awarded a Ph.D. degree from the University of Cambridge without holding a bachelor's degree.

Contd..



Figure 1.12 Barbara McClintock

10) Barbara McClintock (1902–1992)

- ✓ American geneticist
- ✓ 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.

Contd..



Figure 1.13 Watson and Crick

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

- ✓ 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

Contd..



Figure 1.15 Wilmut and Campbell

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.

Class Work

Q1. Who discovered DNA structures?

Q2. What did Louis Pasteur Discovery?

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.

Some biological discoveries and their impact on human society and the natural environment are described further in this sub-section.

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.



Contd…

The invention of the microscope has revolutionized the science industry while developing other fields:

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.
- Until that time, people thought diseases came from evil spirits or God.
- Pasteur's germ theory revolutionized the process of identifying, treating, and preventing infectious diseases.
- Today, hospital laboratories use microscopes to identify which microbe is causing an infection.
- They are also used to diagnose cancer and other 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 microscopic organisms found in ecosystem samples.
  - This helps scientists in defining the ecosystem, detecting threats to an ecosystem, and determining the relationship of the organisms with their environments.

Forensic Science

- The microscope has greatly affected the field of 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

- The invention of the powerful atomic force (electron) microscope has enabled scientists to study cells at an atomic level.
- This enables scientists to scrutinize viruses at their atomic level and influence them for the delivery of innovative treatments.
- The electron microscope also enables scientists to study and understand the types of viruses and understand how they infect the body.

Genetic Study

- The microscope has had a significant impact on genetics research.
- A microscope is used by scientists to examine certain genetic makeup.
- This also allows scientists to evaluate genetic abnormalities, regeneration, and tissue death.
- The science of genetics is used to examine infected tissue.
- Histologists will be able to explore future therapies and preventive drugs as a result of this research.

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

- the eleven most important medical discoveries

In table 1.5 outlines the type of discovery and the person who made it.

Table 1.5 Types of discoveries

Type of discovery	Who discovered and year of discovery	Benefits
The Circulatory System	1242 by the physician Ibn al-Nafis, and first brought to prominence in 1628 by William Harvey	
Vaccination	Jenner' France, 1799	
Cell theory	Theodor Schwann and Matthias schleiden, 1838	
Germ Theory	Louis Pasteur, 1861	
X-Ray	Conrad Rontgen, 1895	
Vitamins	Frederick Hopkins, 1900s	
Insulin	Frederick Banting, 1920	
Penicillin	Alexander Fleming, 1928	
DNA	Swiss chemist Friedrich Miescher, 1860/70s	
Anaesthetics	Sigmund Freud and Karl Koller 1st clinical use in 1884; Albert Niemann extracted from leaves of Coca in 1860	
HIV	Robert Gallo and Luc Montagnier, 1980s	

Inheritance (Application of Genetics)

- ✓ Before 1900, the history of genetics was related to cytology.
- ✓ This owes to "Robert Hooke", who elaborated various smaller things in a thinly sliced cork section from a mature tree.
- ✓ In 1831, **Brown** discovered a consistent structure present in a regular way, called "**nucleus**".
- ✓ Then **Schleiden and Schwann** presented "**cell theory**" (1836-1840) to depict various structures present in the cell and their nature.
- ✓ After other contributions, 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.

Class Work

Q1. Pensilin discovered by_____

2. Circulatory system discovered by_____

3. Vaccination discovered by_____

1.5 Ethiopian biologists and their contributions

Objective

- appreciate major discoveries contributed by Ethiopian Scientists
- discuss the importance of discoveries contributed by Ethiopian scientists to human beings

Q. Do you know some of the major discoveries of Ethiopian biologists?

- Mention at least 3 of them and explain their contributions.

1.5 Ethiopian biologists and their contributions

Contd..

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



Figure 1.16 Prof. Yalemtsehay Mekonnen

1. Professor Yalemtsehay Mekonnen

- She is a biologist and an academic member of staff at the Department of Biology, Faculty of Science, Addis Ababa University.
- She has worked in this department for the last 30 years.
- She received her Ph.D., specializing in human physiology

Her Research areas is :

i. 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**.

ii. The use of plants as medicine against human and animal diseases.

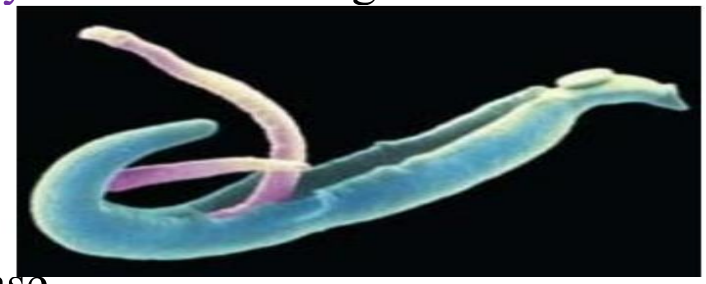
- She has **published over 100 scientific papers in reputable journals** in the areas of plants of medicinal and nutritional value in vivo and in vitro physiological tests of useful plant extracts, assessment of health hazards to humans, animals and the environment, advocacy and collaborative work for 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



Figure 1.17 Dr. Aklilu Lemma

- One of Ethiopia's most renowned biologists.
- discovery of soapberry 'Endod' against bilharzia (Schistosomiasis)



❑ Schistosomiasis:

- is a common parasitic disease.
- It affects 200–300 million people in Africa (including Ethiopia), South America, Asia, and parts of the Caribbean.
- It is caused by parasitic flatworms which spend part of their lifecycle in freshwater snails and part in humans.
- 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 infect the blood vessels, liver, kidneys, bladder, and other organs.
- Some of the most important **work in finding a way of controlling this parasite**, which is effective but does not cost too much, was carried out by Dr. Aklilu Lemma

The work of Dr. Akililu Lemma:

- He began his work in 1964 around Adwa, Northern Ethiopia.
- He saw women washing clothes in the water
- He noticed that were more dead snails
- The women were using **soap berry, Endod (Phytolacca dodecandra).**
- He collected some live snails from above the washing party and
- added the suds of endod into the container.
- The snails all died.

- Endod works well:
  - ✓ it is **cheap**,
  - ✓ it is **well known by the local people** and
  - ✓ it is **environmental friendly**
- Dr. Akililu's results were published in journals around the world.
- He said that '**we found poor man's medicine for poor man's disease**'.

Endod (Phytolacca dodecandra)



3. Professor Gebissa Ejeta



Figure 1.18 Prof. Gebissa Ejeta

- He specializes in plant breeding and genetics.
- He did his research on sorghum
- He got his Ph.D. from Purdue University in the USA where he still holds a professorship.
- He has develop Africa's first commercial hybrid strain of sorghum.

- **This sorghum variety:**
  - ✓ **Needs less water**
  - ✓ **Drought resistant**
  - ✓ **Produce high yield (10x traditional varities)**
  - ✓ **Resist parasitic striga weed**
- For his work awarded
  - World food prize-2009
  - National hero award of Ethiopia

Activity 1.11 Fill in the column with contributions

- In the table below, you are given the names of other known biologists who have contributed to the development of Ethiopian biological science and scientific research. Write the date and type of their contributions in the right hand column of the table below

Ethiopian Biologist	Contribution to the development of biological education and research
Prof. Beyene Petros	
Dr. Brihane Asfaw	
Prof. Ensermu Kelbesa	
Prof . Legesse Negash	
Dr. Melaku Wolde	
Prof. Mogessoe Ashenafi	
Dr. Tewoldebrihan G/Egziabiher	
Prof. Tilahun Yilma	
Dr. Tsehaynesh Asfaw	
Dr. Zeresenay Alemseged	

Dr. Tewolde Berhan Gebre Egziabheran

Worked on :

- *works to **safeguard Biodiversity** and*
- *the Traditional **Rights of farmers** and communities to their **genetic resources**".*

Professor Tilahun Yilma

- *he developed a vaccine to get rid of the terrible **cattle** disease **rinderpest***

Dr. Melaku Worede

He has worked on:

- *to save the genetic diversity of domestic plants of Ethiopia.*
- *He has preserved many different traditional crop varieties*
- *developed ways of farming that produce high yields without commercial fertilizers.*

Professor Beyene Petros

is a biomedical scientist

Dr. Zeresenay Alemseged

- *paleoanthropologist*
- *discovery **Selam**, also referred to as "**Lucy's child**", a 3.3 million-year-old child of the species Australopithecus afarensis.*

Dr Tsehaynesh Mesele

leads research in human health, including HIV/AIDS.

Dr Berhane Asfaw:

- discovered two 160,000 years old human skulls
- *Is an Evolutionist*

Professor Legesse Negash

*He is a pioneer in the propagation of **Ethiopia's indigenous trees***

Professor Mogessie Ashenafi

- *leads international research into food microbiology.*

Professor Ensermu Kelbessa:

- *leading Botanists who has* ***discovered*** *and* ***named many new plant species.***

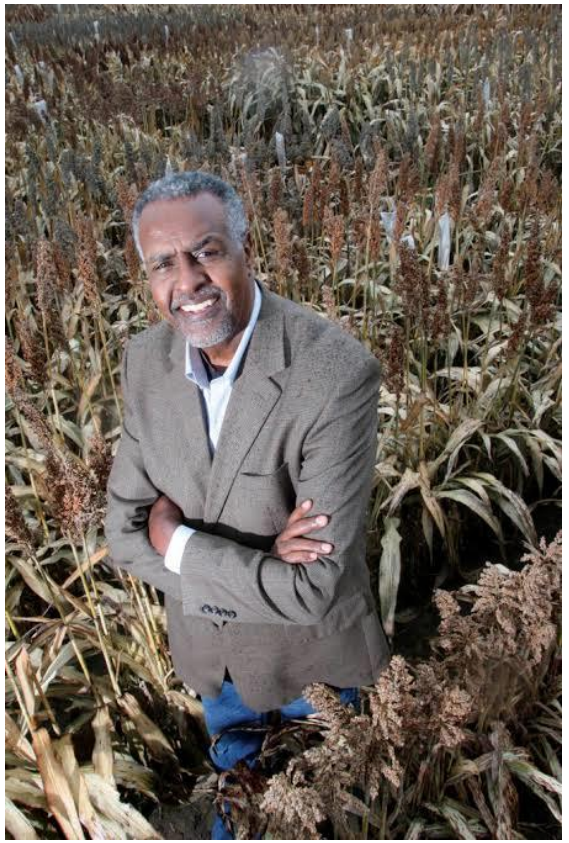
END OF UNIT 1











Review Questions

I. True False Write "True" for correct statements and "False" for the incorrect once on the space provided.

1. X-ray was discovered by Frederick Bating in 1895.

2. Biochemistry deals with the chemical reactions that take place in living organisms.

3. Microscope was discovered by Theodor Schwann in 1838.

4. Genetics is the study of heredity and variation.

5. The scientific contribution of Prof. Gabissa Ejeta is on the application of Endod to control Bilharzia.

II. Matching

Match the description of field of study given under Column A with the field of study given under column B, and write the letter of your answer on the space provided.

Column "A"	Column "B"
1 The study of insects	A. Cytology
2 Embryological development of the fetus	B. Agroforestry
3 The study of tissue	C. Histology
4 The study of mixed agriculture	D. Entomology
5 The study of cells	E. Embryology

III. Multiple Choice

Choose the best answer from the given alternatives (A, B, C & D).

1. The evolutionary history of an organism is known as

   A. Anatomy B. Ancestry C. Palaeontology D. Phylogeny

2. Who discovered the circulation of blood?

   A. Ibn al-Nafis B. McCollum C. Scottish naval D. Edward Mellanby

3. The study of the internal structure of an organism is

   A. Morphology B. Anatomy C. Histology D. Systematic

4. Anatomy is the study of

   A. Life B. Body parts C. Animals D. Ocean

III. Multiple Choice

5. Who is regarded as the father of genetics?

A. Grogor Mendel B. Gabissa Ejeta C. Scottish naval D. Edward Mellanby

6. Who first discovered the germ theory of disease?

A. Louis Pasteur B. Alexander Flaming

C. Frederick Banting D. August Weismann

7. Who discovered vitamins?

A.Anton Van Leeuwenhoek B. Frederick Hopkins

C. James Watt D. All of the above

8. Bilharzia is caused by:

A. Snails B. Bacteria C. Parasitic flatworms D. Viruses

IV. Short answer

1. How biology and chemistry are interrelated in biochemistry?

2. Discuss the role of genetic discoveries in agricultural development.

3. How biological studies help human to keep healthy life?

4. What are the major discoveries of Louis Pasteur?

5. How does biology and physics interrelation form a study termed biophysics?



2.1. Characteristics of plants

Objectives

At the end of this section, the student will be able to:

- list the characteristics of plants
- distinguish unique features of plants

Q1. What are the common characteristics of all living things?

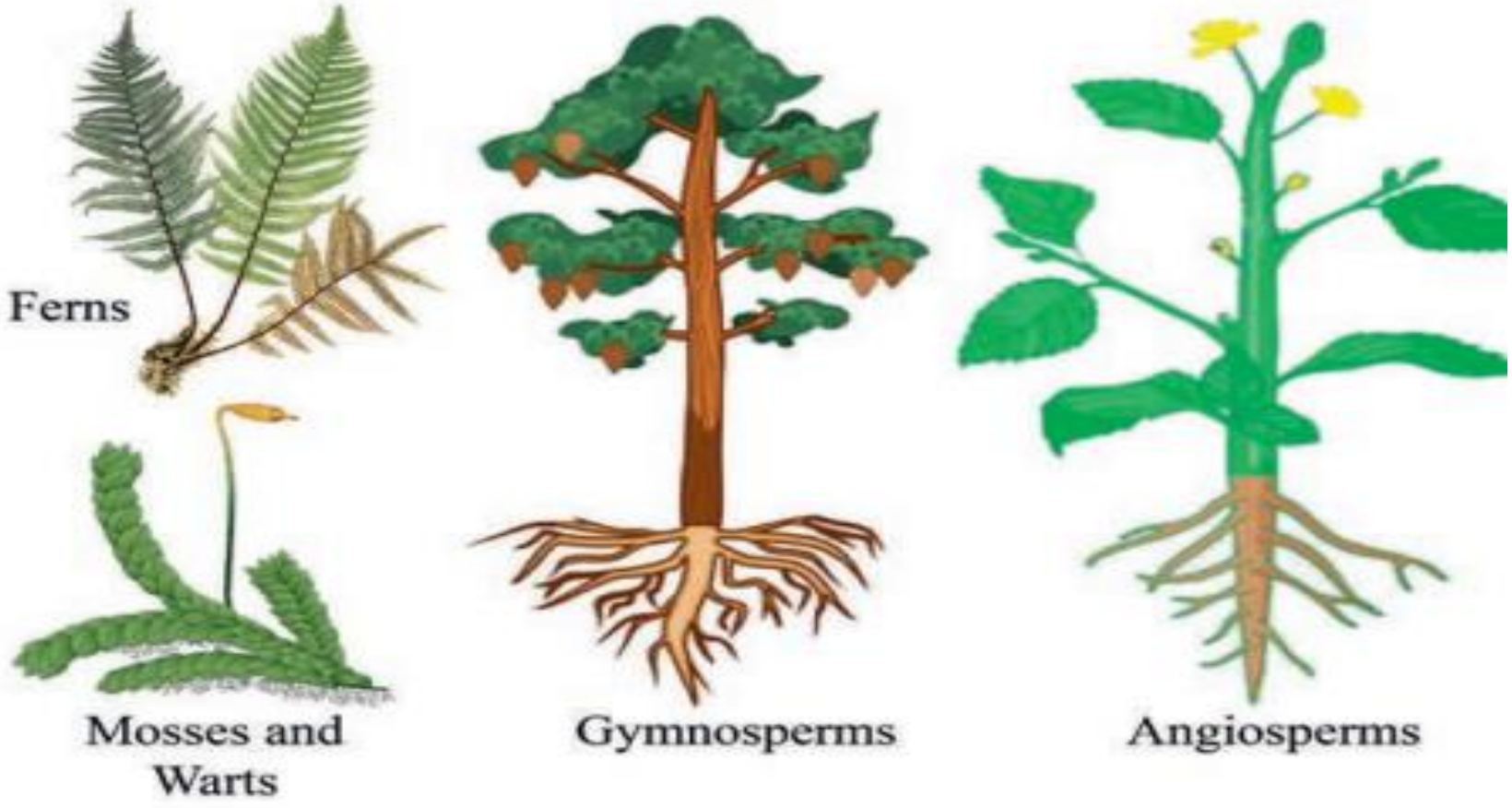
Q2. List the characteristics of plants

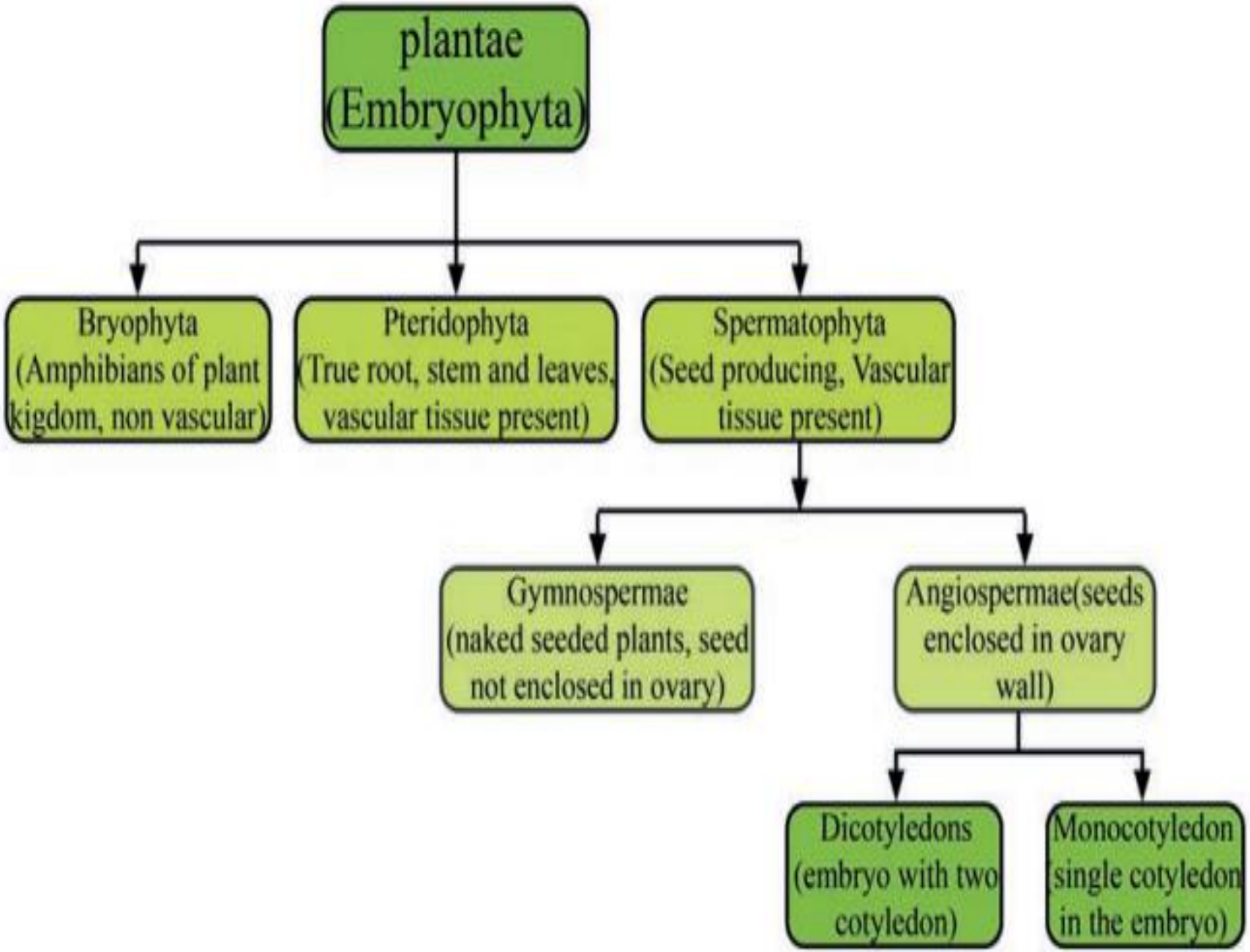
Q2. What are the common characteristics of all living things?

- **Nutrition**
- **Respiration**- require energy
- **Respond to stimuli**:-detect or sense stimuli (change) in the environment and make responses.
- **Growth**-increase in size and mass
- **Reproduction**-produce offspring
- **Excretion**-is the removal of the metabolic wastes
- **Mov't**-change position or place
- display ordered complexity

What are plants?

- There are over 250,000 species of plants.
- These include flowering plants, mosses, ferns, and coniferous plants




plantae
(Embryophyta)
Bryophyta
(Amphibians of plant kigdom, non vascular)
Pteridophyta
(True root, stem and leaves, vascular tissue present)
Spermatophyta
(Seed producing, Vascular tissue present)
Gymnospermae
(naked seeded plants, seed not enclosed in ovary)
Angiospermae(seeds enclosed in ovary wall)
Dicotyledons
(embryo with two cotyledon)
Monocotyledon
(single cotyledon in the embryo)

2.1. Characteristics of plants

Living things from those features which are unique to plants.

- Plants are living things.
  - ✓ Like other living things plants grow, reproduce and respond to changes in the environment.
- Plants are multicellular.
- They are eukaryotic cells.
  - ✓ These cells have well-defined nuclei and membrane-bound organelles.
  - ✓ In addition to the cell membrane, plant cells 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.
  - ✓ 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.

(They reproduce asexually or sexually)

- ✓ In lower plants such as mosses and liverworts, asexual reproduction through spores is the dominant form.
- ✓ In higher and seed-bearing plants such as gymnosperms and angiosperms, sexual reproduction which involves the union of gametes or sex cells

2.2 Flowering and non – flowering plants

Q. Differentiate between flowering and non-flowering plants

Lower plants

- ✓ mosses and
- ✓ liverworts

✍ non – vascular

- – i.e., do not have transporting system or conducting vessels, essential to transport water, nutrient and food needed for the plant.
- – are generally small with limited height and restricted to moist and shaded areas.

✍ seedless and

✍ do not have flowers and fruits.

Higher plants:

- ☞ Gymnosperm(non-flowering plants)
- ☞ Angiosperms (flowering plants)

i. Gymnosperms

- ✓ well-developed root stem and leaves
- ✓ but have no flowers.
- ✓ Vascular
- ✓ Their reproductive organ is cone, instead of flowers.
- ✓ The seeds produced in their cone are without cover (naked seeds).

ii. Flowering plants, commonly known as Angiosperms,

- ✓ are vascular
- ✓ have well-developed root, stem and leaves.
- ✓ But unlike gymnosperms, they have flowers and produce seeds within a fruit
- ✓ Most successful plants

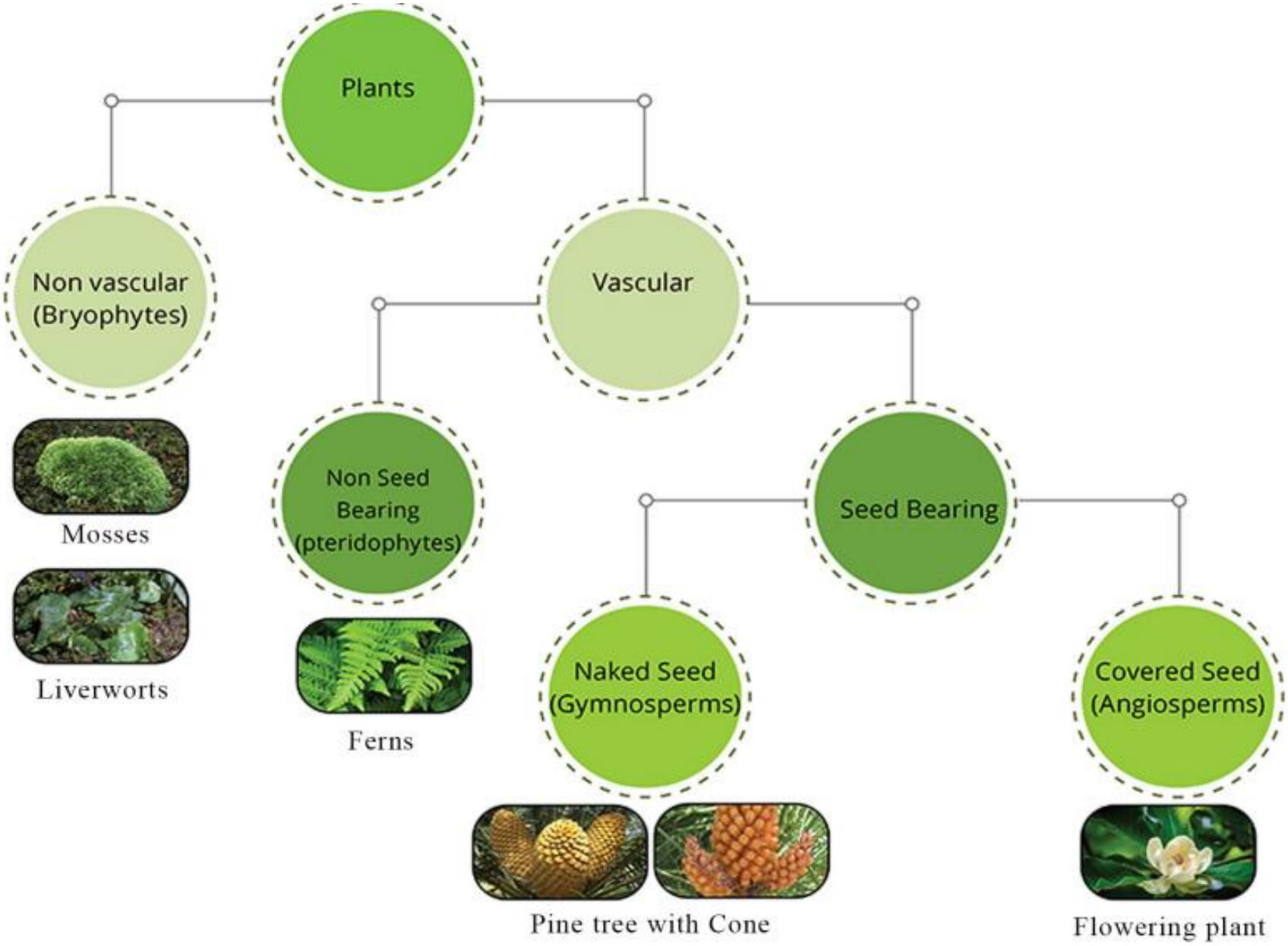


Figure 2.1 Major groups of plants

2.3 Structure and function of plant parts

Objectives

At the end of this section, the student will be able to:

- *draw the external and internal structure of angiosperms,*
- *label the external and internal structure of angiosperms and*
- *relate the structure of plants with the function they perform*

2.3 Structure and function of plant parts

Q. Draw and label the external and internal structure of angiosperms, with the function they perform

Q. List major structures and describe their functions before you learn about structures of a plant in class.

Plants have different structures which perform a vital function essential for the plant life.

The external structure of a typical angiosperm has two major systems.

i. The shoot system:

- the plant part usually **found above the ground**
- includes the organs such as:
  - ✓stem-part w/c provides support and transportation
  - ✓branches
  - ✓leaves-photosynthetic organs
  - ✓buds
  - ✓flowers
  - ✓fruits.
- The last two organs may be missing depending on the reproductive stage of the plant.

ii. The root system:

- the part of the plant that usually **grows downward into the ground**.

Function-attaches the plant to the ground

- involve in absorption of water & mineral

- 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.

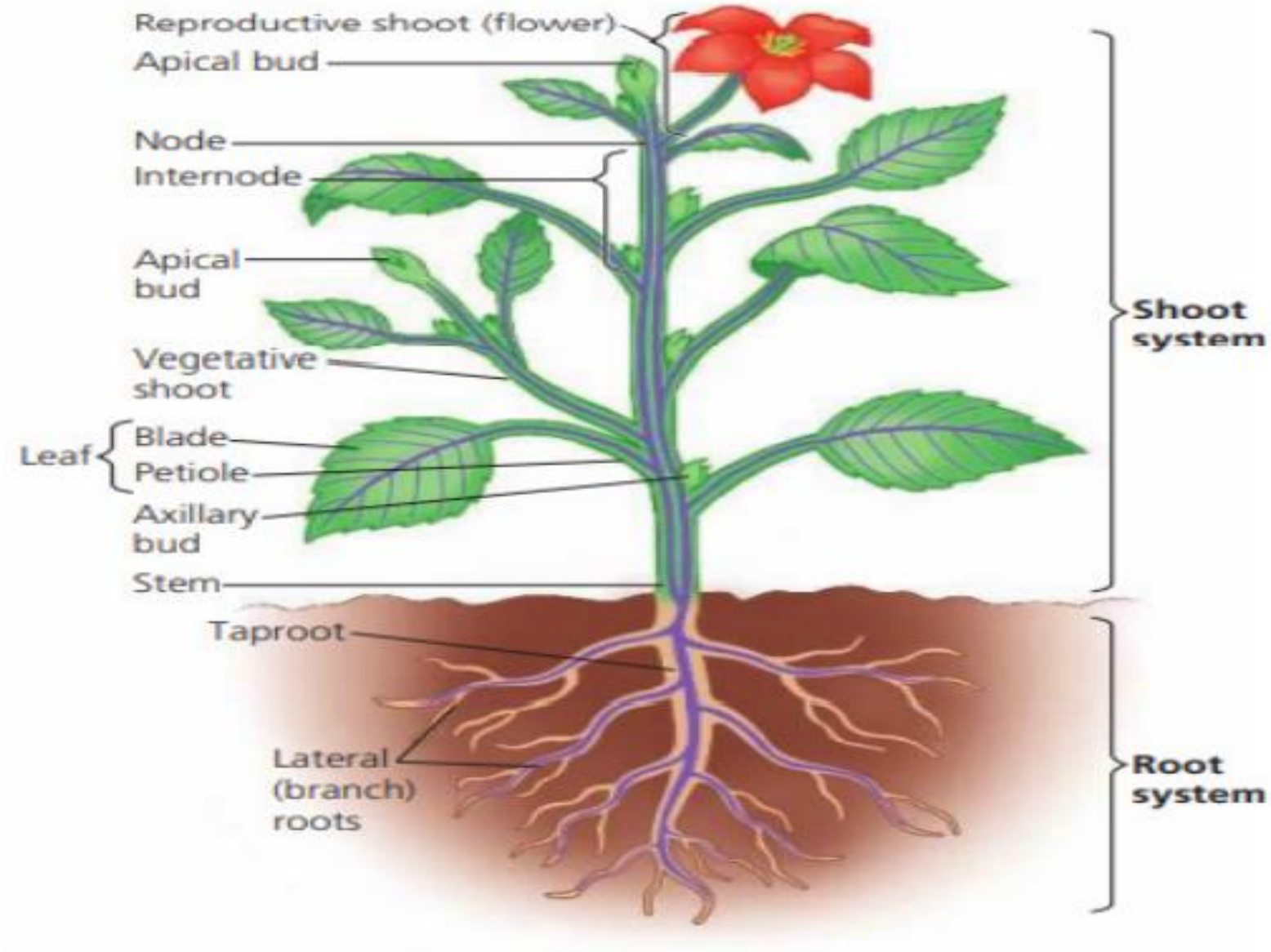
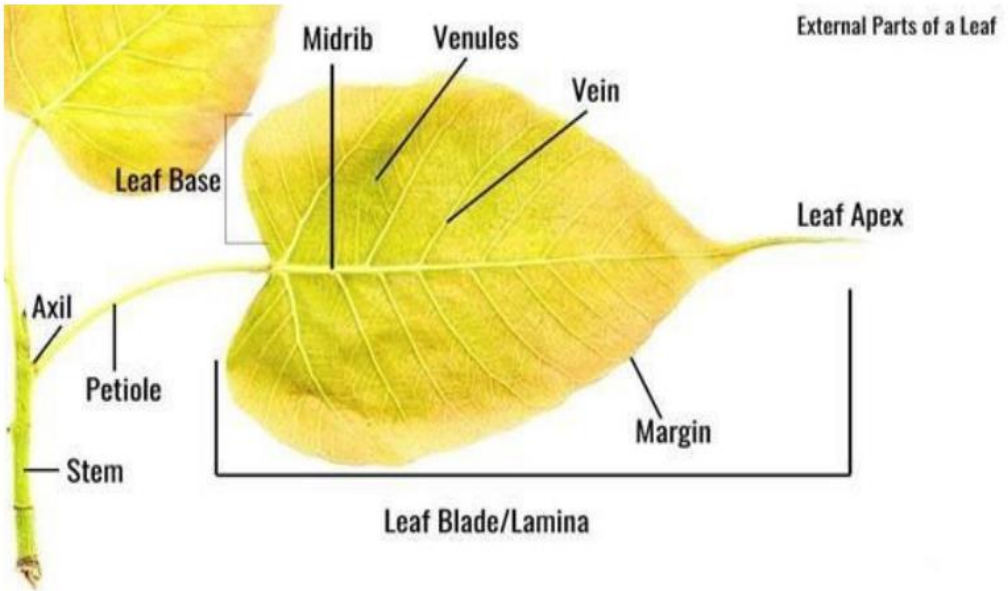


Figure 2.2 External structure of a typical angiosperm (flowering plant)

Leaf

- It is the broad flattened and green part of the plants.
- It is the main food making organ of green plants

- The external structure of a typical leaf consists of:
  - Petiole (leaf stalk)- joins the leaf to the stem
  - Lamina (blade) – broadest part
  - Midrib
  - Margin- leaf border
  - Vein-transport food &I
  - Base
  - Tips -Apex



l external structure of leaf

- **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.
  - ✓ The main vein and consists of vascular tissues

- 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:

- ✓ 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.
- ✓ penetrating deep into the soil
- ✓ 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.
- It 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.

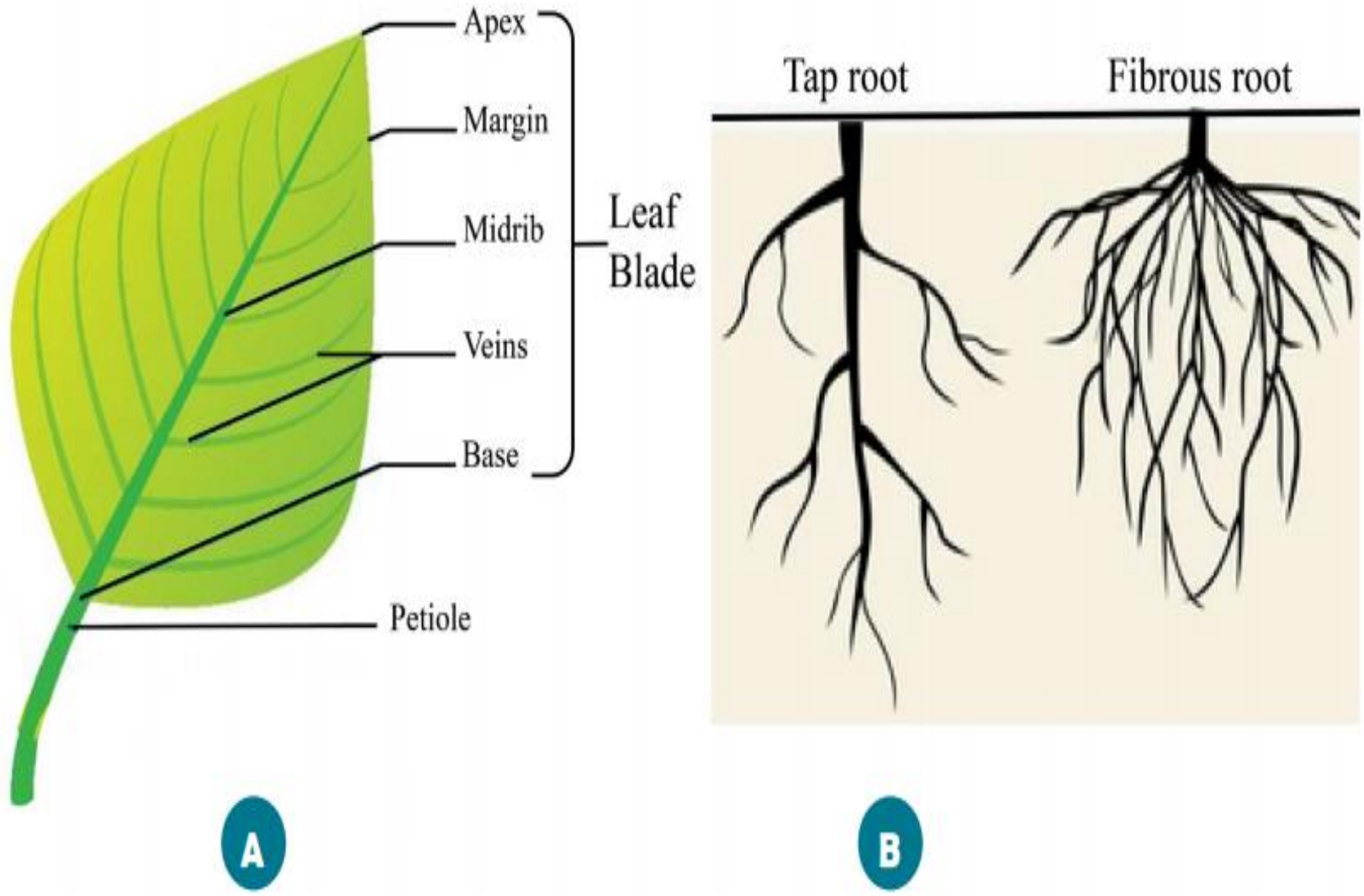


Figure 2.3 External structure of a typical leaf (A) and Types of roots (B)

Class Work

1. What is the difference between
    A. Root system and Shoot system
    B. Tap root and fibrous root

2.3.1 The internal structure of a leaf

Components of 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).
- ✓ The **guard cells** open and close to control the entry of carbon dioxide into the leaf and also to control the loss of water by transpiration

Stomata (singular-stoma)

- ✓ are “little mouths” or “ little noses” present in the epidermis of leaves.
- ✓ regulate O_2 release, CO_2 intake and water loss.
- ✓ (allows exchange of gases &evaporation of water/water loss)
- ✓ Spaces b/n two guard cells
- ✓ In most leaves, stomata are more abundant in the lower epidermis, reducing water loss due to direct sunlight.
- ✓ 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.

B) Middle layer

- This is known as the mesophyll ("middle leaf") layer.
- It found between the upper and lower epidermis of leaf.
- It includes tissues that are directly or indirectly involved in photosynthesis.
- There are two regions in the mesophyll layer

    i. palisade mesophyll and

    ii. spongy mesophyll.

i. The palisade layer

- ☞ cells are near the upper surface of the leaf where they receive more sunlight.
- ☞ is composed of regularly arranged and closely packed columnar (vertically elongated) cells.
- ☞ The cells contain the **largest number of chloroplasts** per cell.
- ☞ the layer is 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 CO2 and capillary movement of H20.
- is the main photosynthetic tissue of the plant.
- There are many cells, closely packed together near the surface of the leaf to get as much light as possible.
- Each cell has many chloroplasts

ii. The spongy layer

- lies below the palisade cells.
- Spongy cells are irregularly shaped with **fewer chloropl**asts.
- (has fewer cells with fewer chloroplasts).
- They are very loosely arranged with numerous airspaces.
- there are lots of air spaces and a big surface area for gas exchange.
- has many large air spaces between the cells.
- These air spaces, which are very close to the stomata allow the diffusion of O_2, water vapour and CO_2.

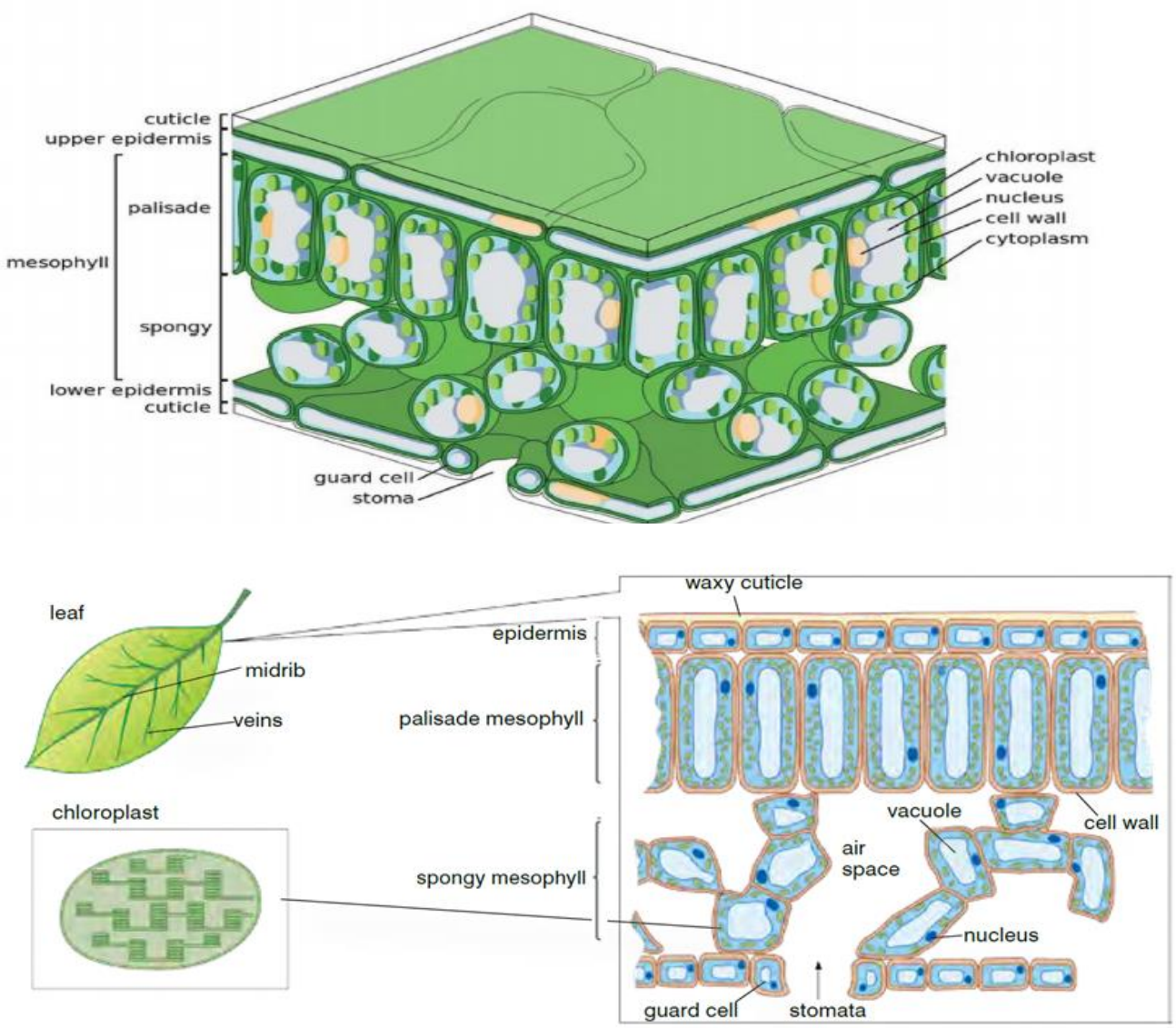


Figure 4.1: This cross section of a leaf shows that leaves of plants are perfectly adapted to make the best possible use of the light that falls on them.

Home Work

1. *Distinguish between the spongy layer and palisade layer.*
2. *What are the stomata?*

   What is their role in the plant?
3. *What leaf structures adjusts the stomata's size?*

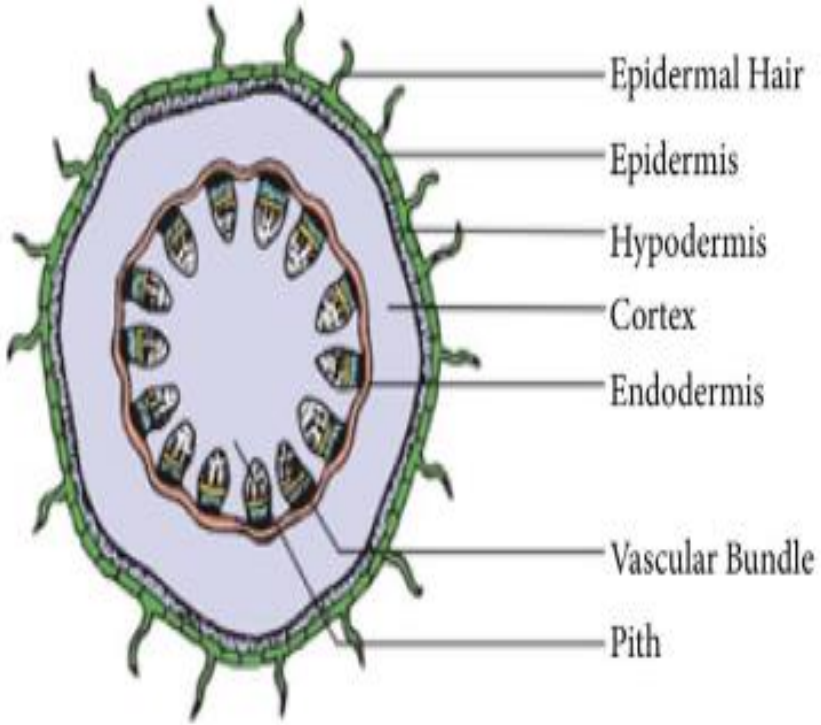
What is the function of a guard cell and cuticle?

2.3.2 The internal structure of a stem

The internal structure of stem includes the following fundamental tissue systems.

The epidermis

- is the outermost layer of the stem.
- The outer walls are greatly thickened with cuticles, which minimizes the rate of transpiration.
- Has the following functions
  - ✓ Protect the underlying tissues from mechanical injury
  - ✓ prevent the entry of harmful organisms.



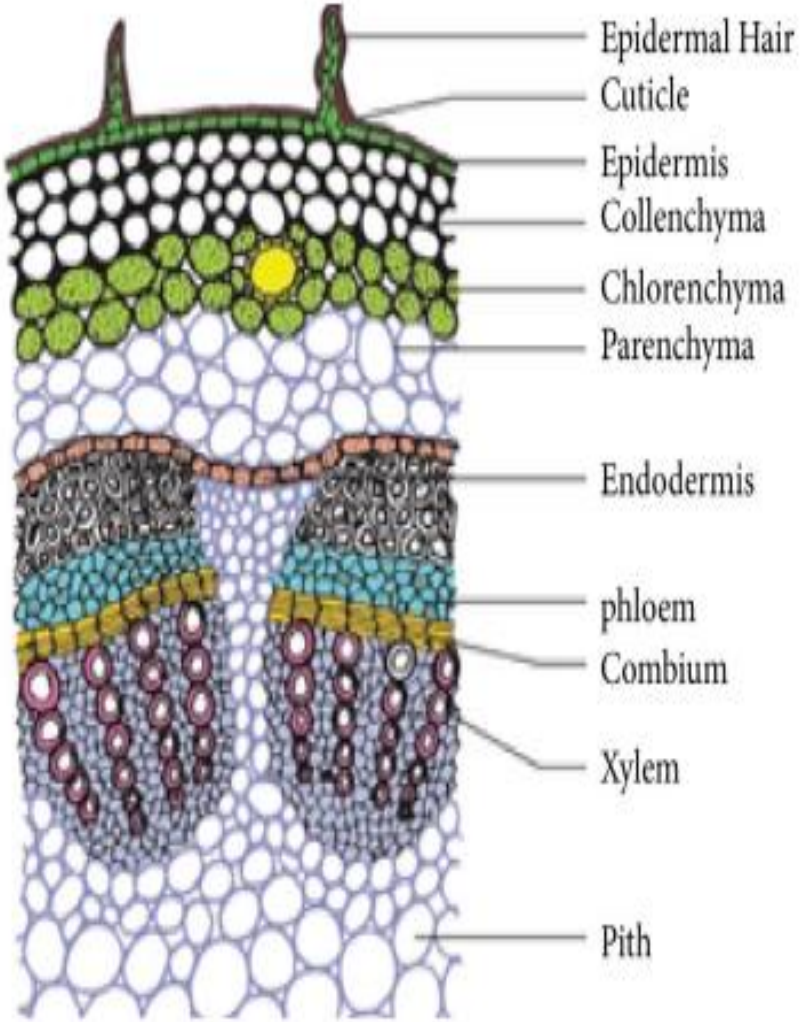


Figure 2.5 Internal structure of a typical dicot stem (A = Ground plan; B = Transverse section)

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.

Cortex

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

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.
- serves as a food reserve and
- may be termed as a starch sheath.

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.

- Each bundle has a patch of xylem towards the pith and a patch of phloem towards the endodermis and a strip of actively dividing young cells (cambium) in between them.
- **Xylem**
  - ✓transports water and dissolved minerals to the photosynthetic tissues, mainly to the leaf
- **phloem**
  - ✓transports synthesized food to different tissues, either for utilization or storage.

Pith

- It occupies the central portion of the stem
- It is composed of thin walled cells
- rounded or polygonal, with or without intercellular space.
- It stores food and helps in the internal translocation of water.

ACTIVITY 2.5 LIBRARY WORK

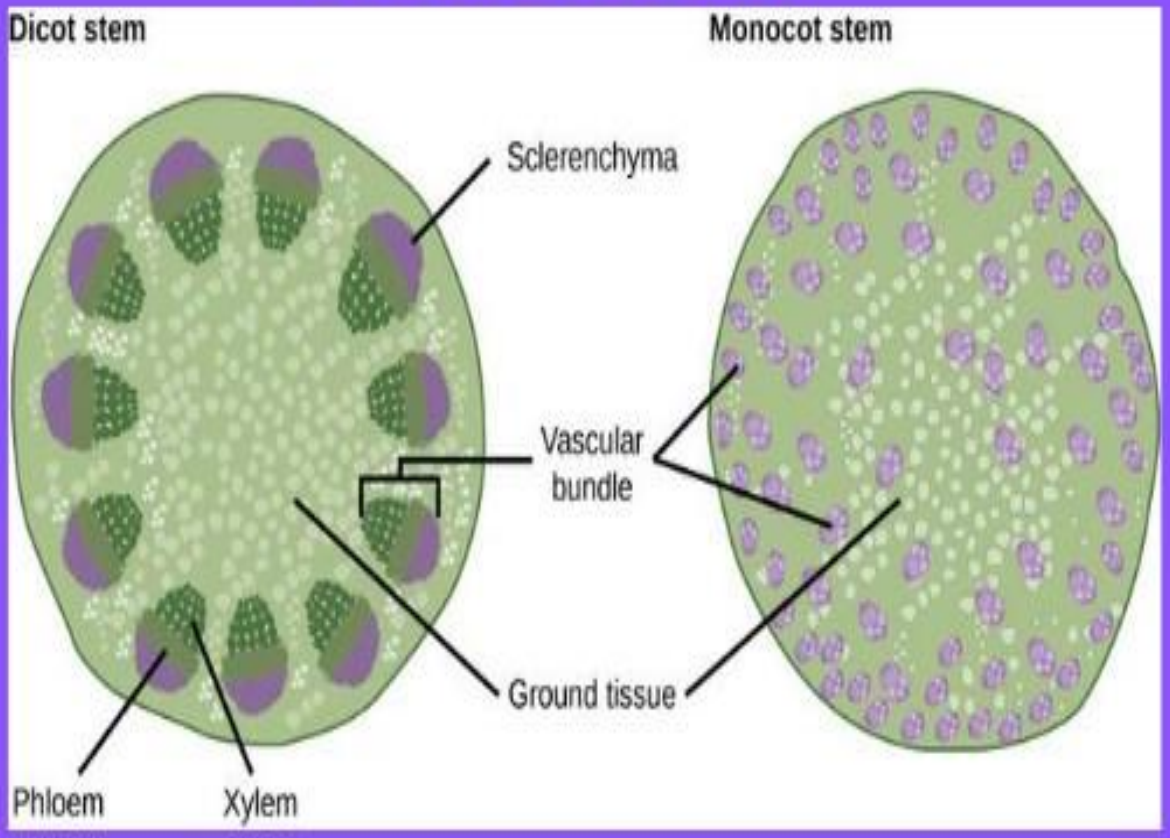
Note: Angiosperms have their seeds enclosed inside fruits. They can be classified as "Monocots" and "Dicots", having one and two cotyledon (s) respectively. Typical examples include maize (a monocot) and bean (a dicot).

Direction:

- Using illustration (Figure 2.5), you can learn the internal structure of a dicot stem. For a contrast, you need to know the internal structure of a monocot stem.
- Refer to biology books available in your library or download pictures showing the internal structure of monocot stem from the internet. Then draw and label the picture in your exercise book.
- Complete the following table of comparison to show the differences between the internal structure of the dicot and monocot stem. The column under dicot is filled to you for references.

Dicot stem	**Monocot stem**
Contains distinct regions known as cortex , vascular bundles and pith (stele)	
Has few number (4 to 8) of set of vascular bundles	
Vascular bundles are arranged regularly in the form of one or two rings	
Pith is present and well developed	

Differences Between Monocot And Dicot Stem



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 /Epidermis

- is the outermost layer made up of single-layer cells.
- The cuticle is absent.
- It consists the single-celled **root hairs**.

Cortex

- Present undeneath the epidermis
- is a multi-layered large zone
- made of thin-walled oval or rounded loosely arranged cells
- has intercellular spaces.
- It stores food and water.

Endodermis

- is the innermost layer of the cortex
- made of barrel shaped 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.

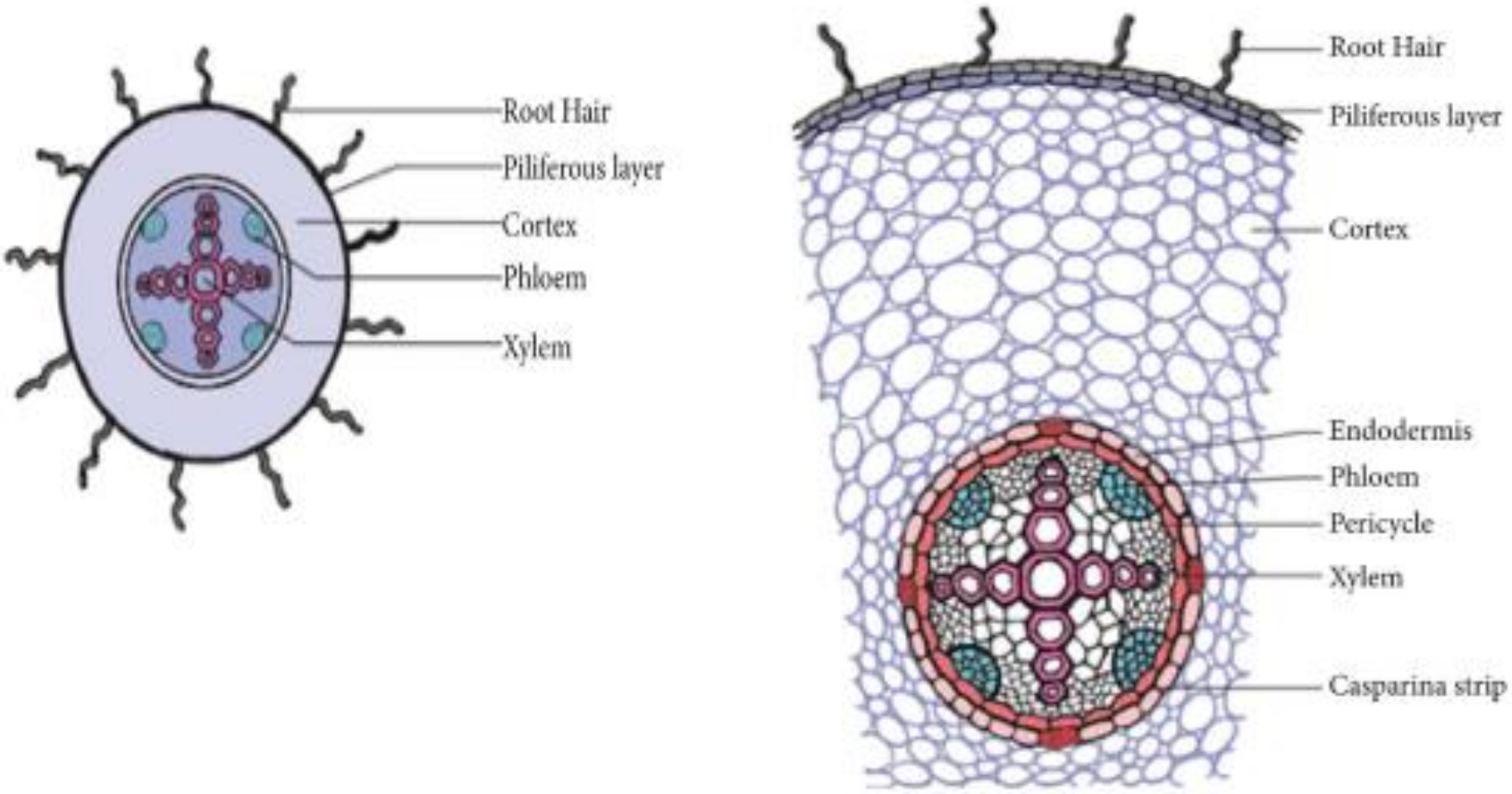


Figure 2.6 Internal structure of a typical dicot root

Class Work

Q1. What are the internal structure of the roots?

Q2. Where is food stored in the root?

3. Root hair originated from_____.

4. The tissue below the cortex in dicot root is____

5. Cortex is lying between _____and_____

ACTIVITY 2.6: COMPARATIVE TABLE

Direction:

- Follow the direction stated in activity 2.6, but this time you will draw and label the internal structure of monocot root in your exercise book.
- Complete the following table of comparison to show the differences between the internal structure of dicot and monocot root. The column under dicot is filled to you for reference

Dicot root	**Monocot root**
The cortex area is narrow	
Vascular bundles limited in number between 2 – 6	
Pith is either extremely small or absent	
Show secondary growth due to the presence of cambium	

2.4 Reproduction in plants

Objectives

At the end of this section, the student will be able to:

- draw and label floral parts,
- outline the reproductive cycle of non – flowering and flowering plants ,
- list different types of pollinating agents and
- appreciate the diversity in floral colour to attract pollinators

2.4.1 Reproductive structure and life cycle of non-flowering plants

Figure 2.7 shows 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

➡ In this lesson, you will learn the life cycle of gymnosperm, using the pine tree as a typical representative of conifers as well as gymnosperms in general.

➡ 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 to show major stages of gymnosperms' life cycle in general.

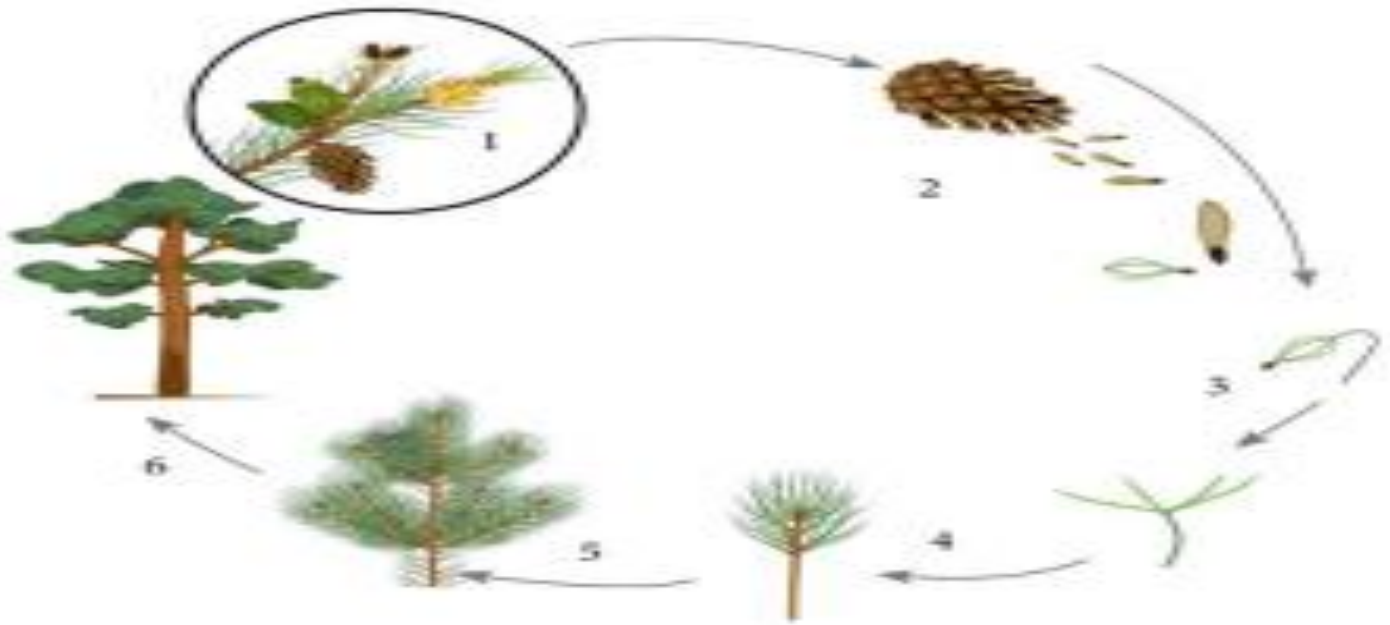


Figure 2.8 Life cycle of a pine tree representing gymnosperms

Class Work

1. What is the reproduction type in gymnosperm?
2. What are the major groups of gymnosperm plants?
3. What is gymnosperm?
4. How do conifers reproduce?

2.4.2 Reproductive structure and life cycle of flowering plants

Group Discussion

Q1. What is flower?

Q2. What are the major floral parts and their role in reproduction ?

2.4.2 Reproductive structure and life cycle of flowering plants

Q. What is flower?

Q2. What are the major floral parts and their role in reproduction ?

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

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

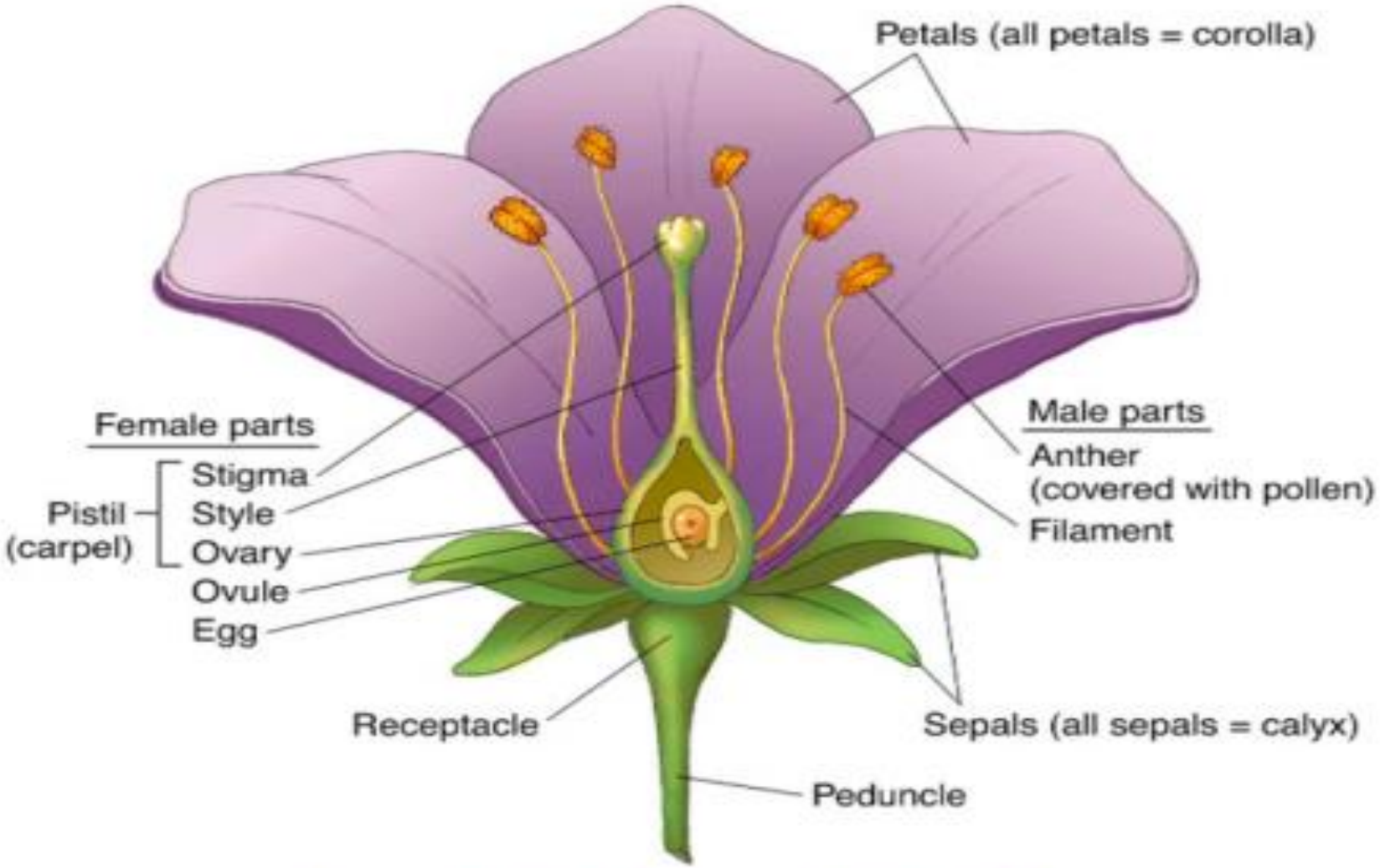


Figure 2.9: Structure of typical flower

A 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 pistil and no stamen), or
- ✓ staminated (has stamen but no pistil) flower

- An imperfect flower is incomplete flower,
- but an incomplete flower may or may not be an imperfect flower. Explain how this is so?

Class Work

1. A flower consists of different parts.

   Name these parts of a flower.

2. What is the male reproductive part of a flower.

3. Mature ovary turns into_____

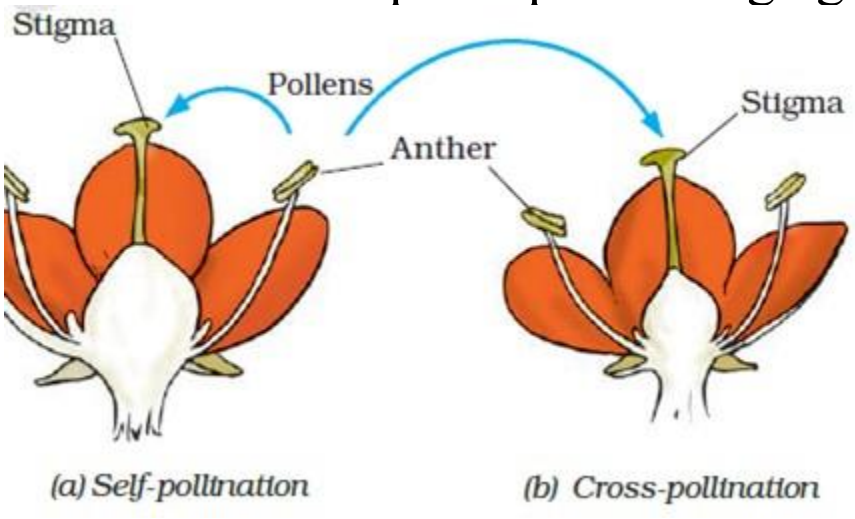
4. Flowers which contain both stamens and pistil are called_____flowers.

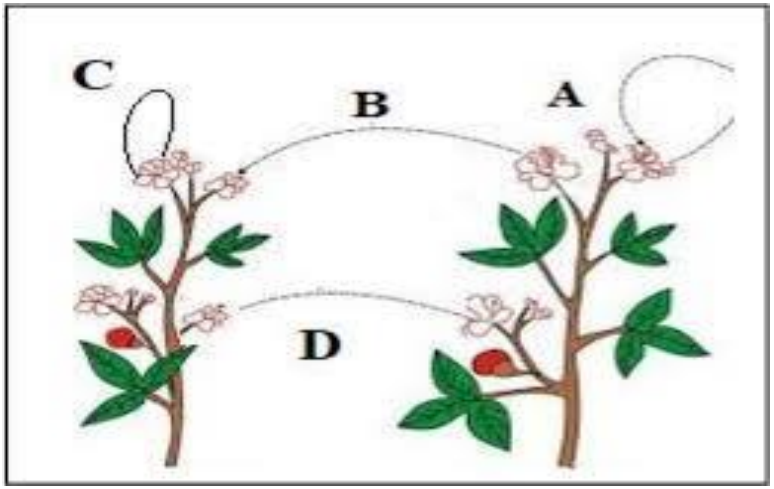
5. Differentiate between complete and incomplete flower.

2.4.3 Pollination

What is pollination?

- It 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) or
  - ✓ between two flowers **on different plants** (cross-pollination).
- Pollination requires pollinating agents such as insects or wind.





Following pollination, a flowering plant passes through distinct stages:

i. Pollen tube formation

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

ii. Fertilization

- 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

ii. Seed and fruit formation

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

iii. 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.

iv. Seed dormancy /Seed germination

- 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.

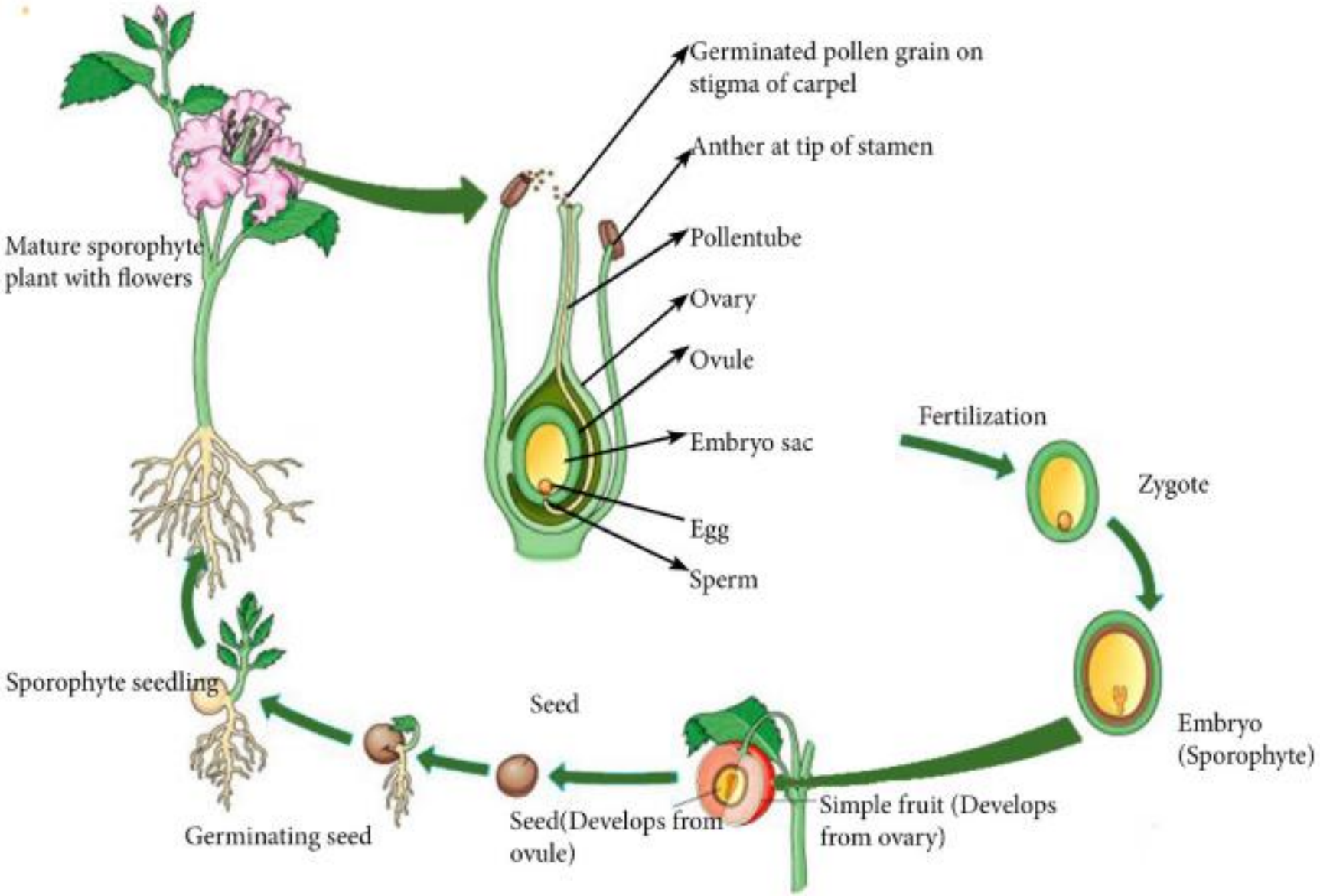


Figure 2.10 Life cycle of typical flowering plant (angiosperm)

Home Work

ACTIVITY 2.10 LIBRARY SEARCH Refer to books or browse on the internet and

prepare a table of summary that shows the difference between insect-pollinated flowers and wind pollinated flowers

The difference between insect-pollinated flowers and wind pollinated flowers

	Insect-pollinated flowers	Wind pollinated flowers
1	Large brightly coloured petals	Small dull coloured petals
2	Have scent	Does not have
3	Large petals	Small or absent petals
4	Contain nectar	Nectaries absent

Class Work

1. What is pollination?

2. What are the two types of pollination?

2. What is fertilization?

3. Transfer of pollen grains from the anther of one plant to the stigma of another plant is called_____

4. Explain the difference between self-pollination and cross pollination?

5. How fruits and seeds are formed?

2.5 Seeds

Objectives

At the end of this section, the student will be able to:

- Describe the structure of seed and embryo
- List down the difference between dicot and monocot seed

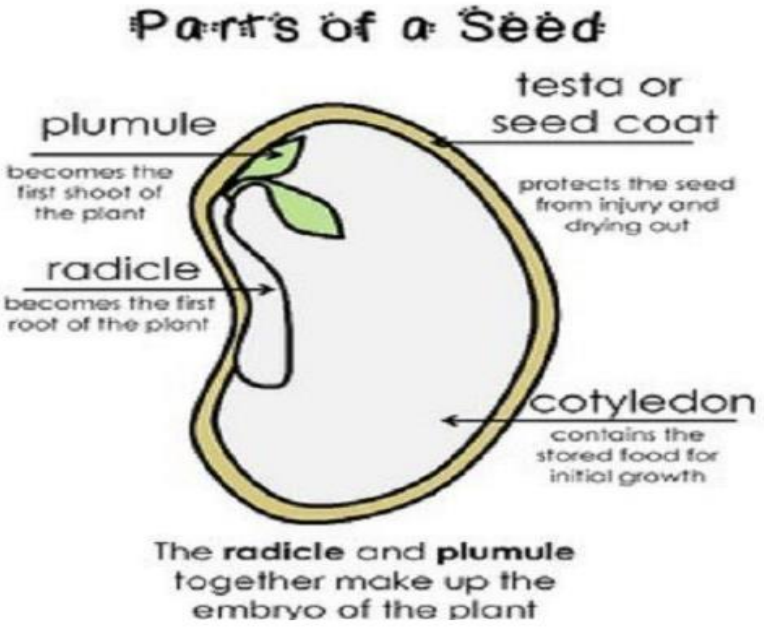
Q. What makes seeds of flowering plants to be different from those of gymnosperms ?

- In Angiosperms, the seed is additionally covered by the fruit.
  - ✓it is called covered seed as opposed to the naked seed of gymnosperm.
  - ✓A naked seed has nothing on except its own seed coat.

2.5 Seeds

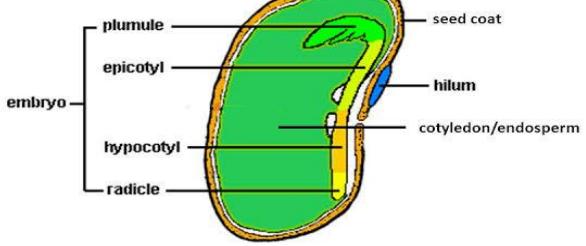
- The seed-fertilized mature ovule
- contains three parts:
  - ✓the seed embryo
  - ✓cotyledon/endosperm-reserve food
  - ✓seed coat





- In Angiosperms, the seed is additionally covered by the fruit.
  - ✓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-embryonic shoot above the cotyledons
  - ✓ Hypocotyl-embryonic axis below the cotyledons
  - ✓ 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).

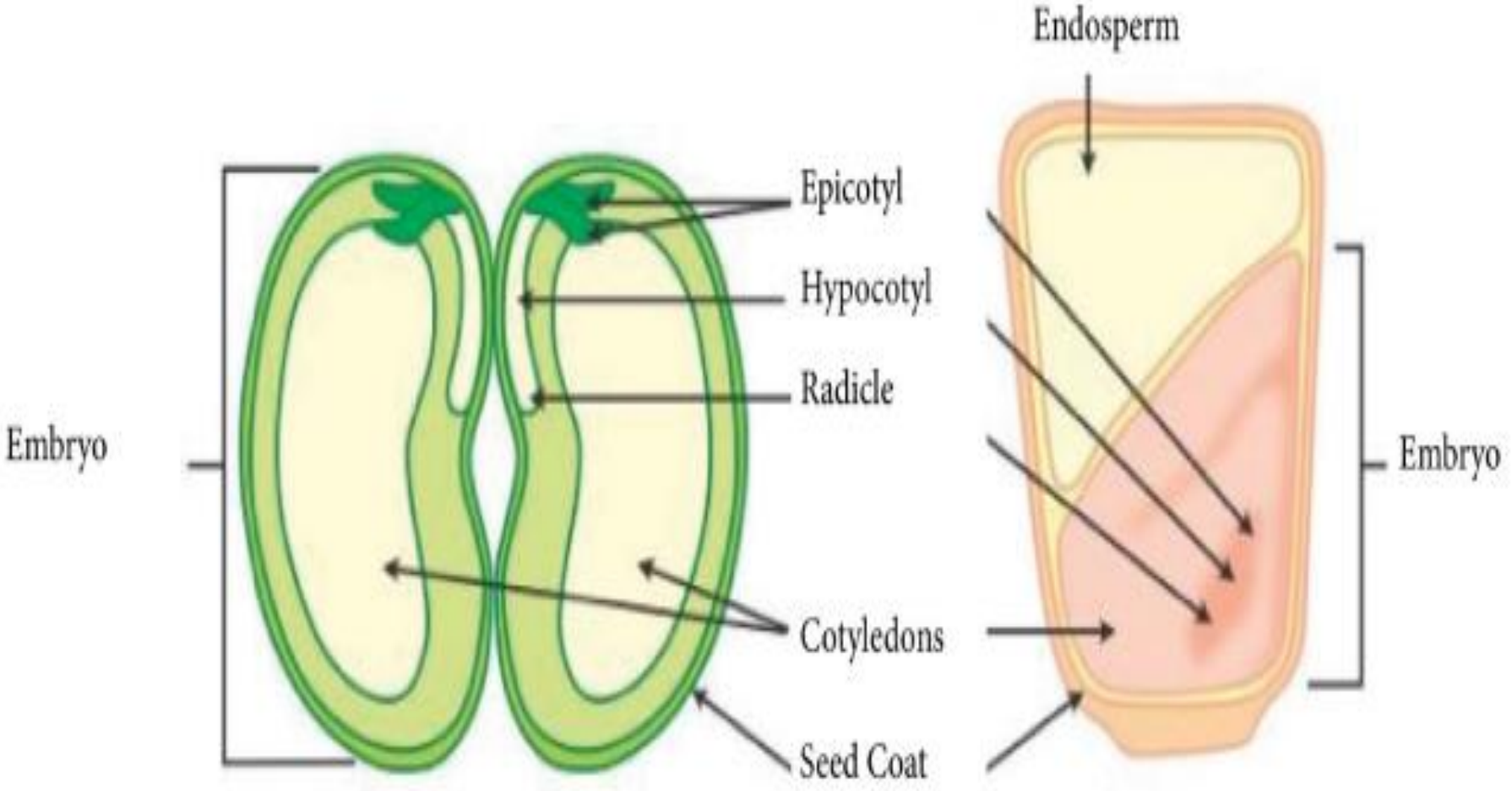


Figure 2.11 Section of a dicot (Bean) and monocot (Corn/Maize) seed and the associated structures.

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

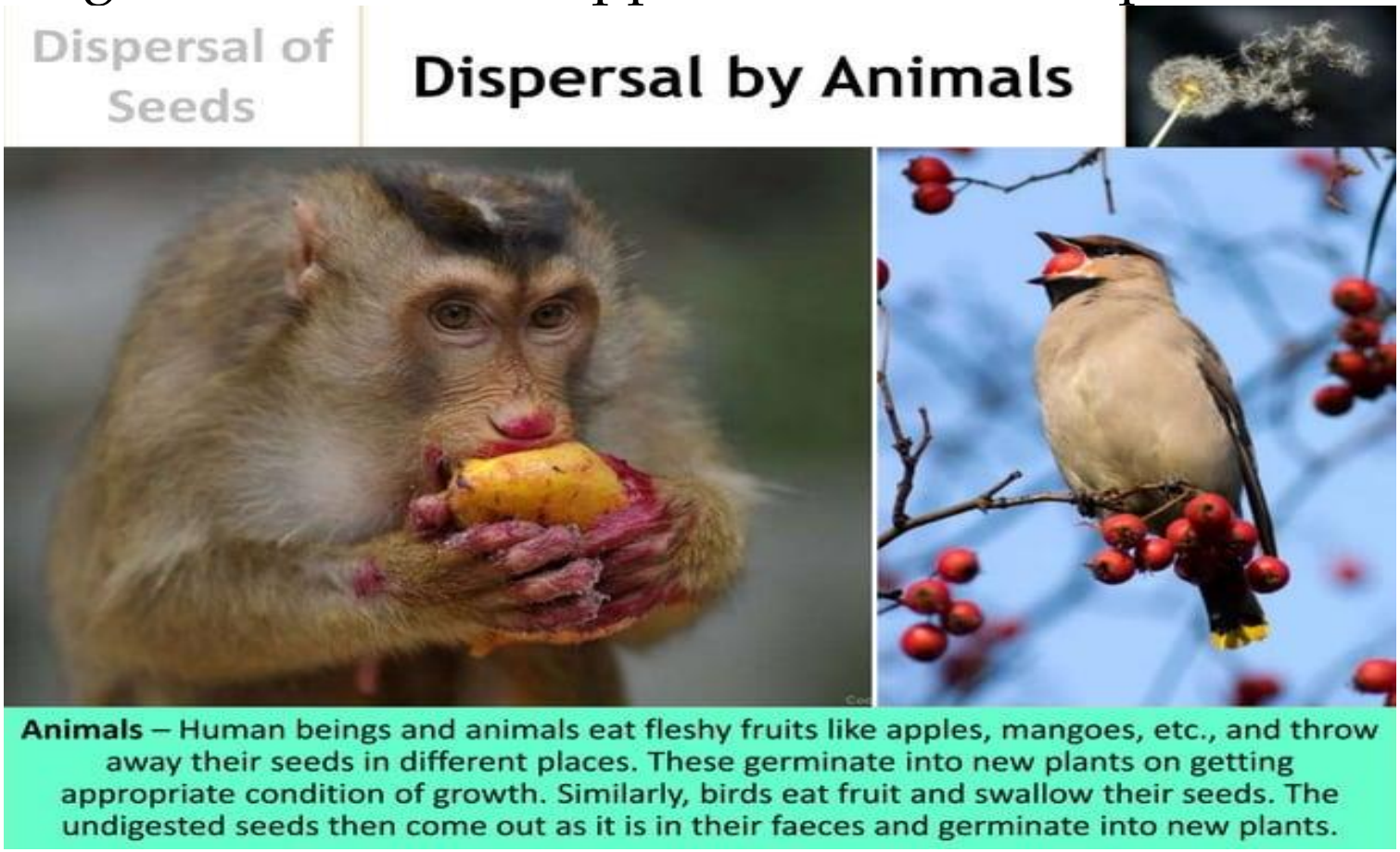
2.6 Seed dispersal and germination

2.6.1 Seed dispersal

What does seed dispersal mean?

- Plants are sessile or fixed at one place.
- However, plants at their seed stage display long-distance mobility and they do so with the help of seed dispersal agents.
- Seed dispersal is an adaptive mechanism of plants that ensures 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,
  - ✓By wind
  - ✓By 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.

1. What is the function of cotyledons?

_____

2. The main food storage in monocot is:

_____

3. Part of plant embryo develop into root is:

_____

4. What is seed dispersal?

_____

5. What is the importance of seed dispersal

_____

6. List mechanism/methods of seed dispersal?

7. List differences between monocots and dicots

1. What is the function of cotyledons? Store food
2. The main food storage in monocot is endosperm
3. Part of plant embryo develop into root is radicle
4. What is seed dispersal?

- Movement/spread of plant's seed a way from the parent plant.

5. What is the importance of seed dispersal ?

- minimizing overcrowding at one place.
- To reduce competition

6. List mechanism/methods of seed dispersal?

- Wind
- Water
- Animals

Home Work

ACTIVITY 2.5 LIBRARY WORK

- Attempt the following activity with a friend sitting next to you.
- Carefully read the description on the nature of the seed or look at the picture of seeds included in the next table and infer the mechanism of dispersal.
- Finally, write the conclusion that you can arrive with regard to the nature of seed and mechanism of dispersal

Nature of seed	Mechanism of dispersal
Seeds that stick or cling to fur or clothes	
	
Seeds within fruits act as kites or propellers	
	

2.6.2 Germination of seed

- Is the process by which a plant grows from a seed.
- Is the emergence of seedling/young plant from the seeds.
- The resumption of active growth of the embryo after a period of dormancy



Q. What are the essential conditions for seed germination?

There are three essential conditions required for seed germination.

i. Water (moisture)

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

ii. Oxygen (Aeration)

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

ii. Temperature (warmth)

- Seeds require optimum temperature for germination.

❖ 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.

❖ Soon, a young plant (seedling) with photosynthetic leaf start manufacturing its own food

Types of seed Germination

- Based on the position and fate of cotyledon
- Two types of seed germination

i. **Epigeal germination**

- the cotyledons are raised above the ground/soil
- the cotyledon is pushed up to become the photosynthetic surface of the seedling by the elongation of a region of the embryo.

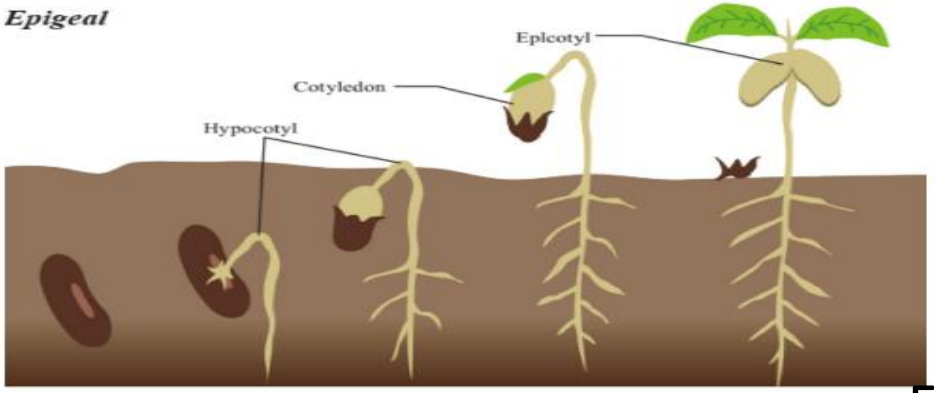


Figure 2.12. Epigeal germination

ii. Hypogeal Germination

- The cotyledon remains under the soil.

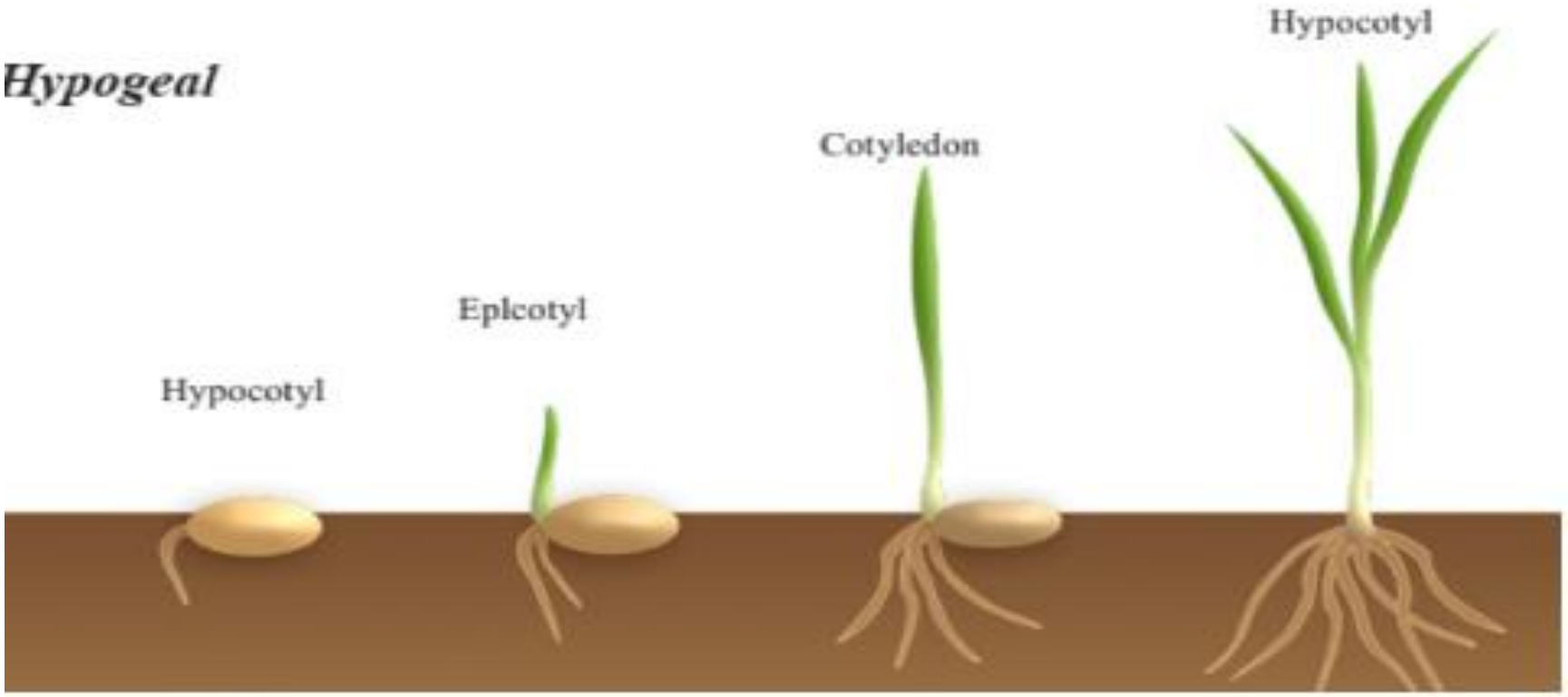


Figure 2.12. Hypogeal germination



Group Work

1. What are the essential conditions required for seed germination?

2. What is the differences between Epigeal germination and Hypogeal Germination of seeds?

4.What is the differences between **Epigeal germination and Hypogeal Germination of seeds?**

Epigeal germination	Hypogeal Germination
Takes place above the ground	Takes place below the ground
Cotyledons emerge out of the soil	Cotyledons remain inside the soil

2.7 PHOTOSYNTHESIS

Objectives

At the end of this section, the student will be able to:

- *identify inputs and outputs of photosynthesis,*
- *outline the process or mechanism by which food is synthesized in green plants,*
- *recognize the importance of photosynthesis to life*
- *appreciate leaves of green plants in their function as food factories*

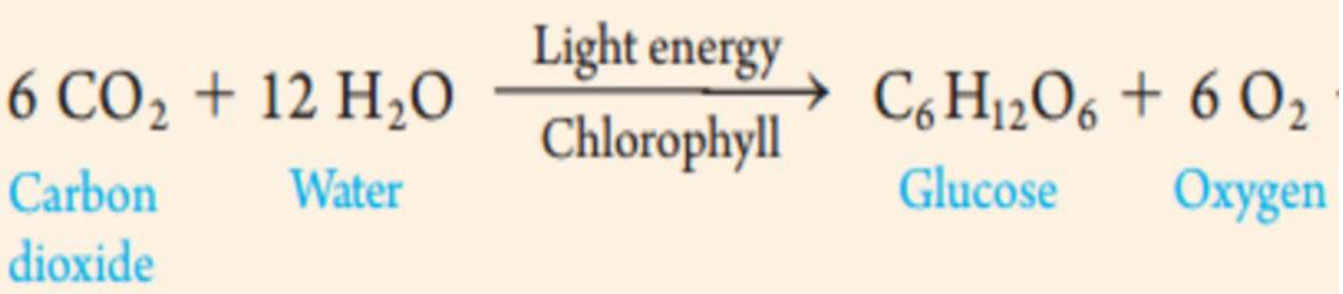
- What is photosynthesis?
- Plants can prepare their own food by photosynthesis.
  - ✓they are called producers or autotrophs (self-feeding).
- plants produce excess food for the vast consumers known as heterotrophs (feeding on plants and on one another).
- The basic source of energy that sustains life begins with sunlight.

- Sunlight is absorbed by a green pigment known as chlorophyll.
- Green algae and plants, which enables them to trap solar energy and transform it into chemical energy.
    - ✓This process is known as photosynthesis.



Photosynthesis

- Photosynthesis is a series of chemical reactions that use light energy to assemble CO_2 into glucose ($C_6H_{12}O_6$) and other carbohydrates.
- The plant uses water (H_2O) in the process and releases oxygen gas (O_2) as a byproduct.
- The overall chemical reaction of photosynthesis



2.7.1 The photosynthetic apparatus

Where does photosynthesis take place?

- Palisade 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.
- The internal structure of the chloroplast, which is termed as photosynthetic apparatus.
- There are two distinct parts in chloroplasts:
  - ✓Granum
  - ✓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

- It is a gel-like colourless matrix
- 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.
- where the light-independent stage of photosynthesis takes place.

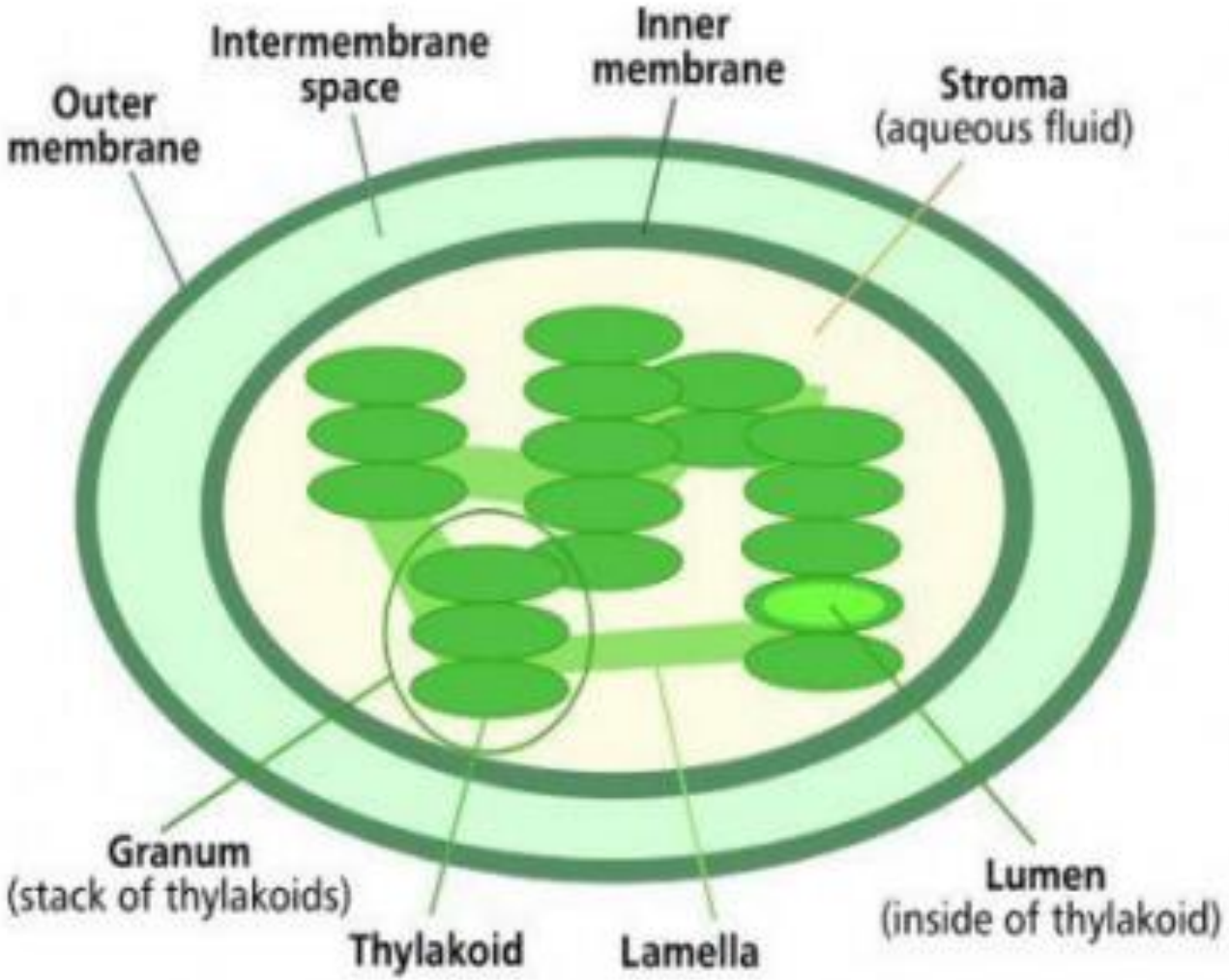


Figure 2.13: Chloroplast – the photosynthetic apparatus

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.
- As shown in Figure 2.14, 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.
- ✪ Only absorbed light **(largely blue and red)** is useful in photosynthesis.

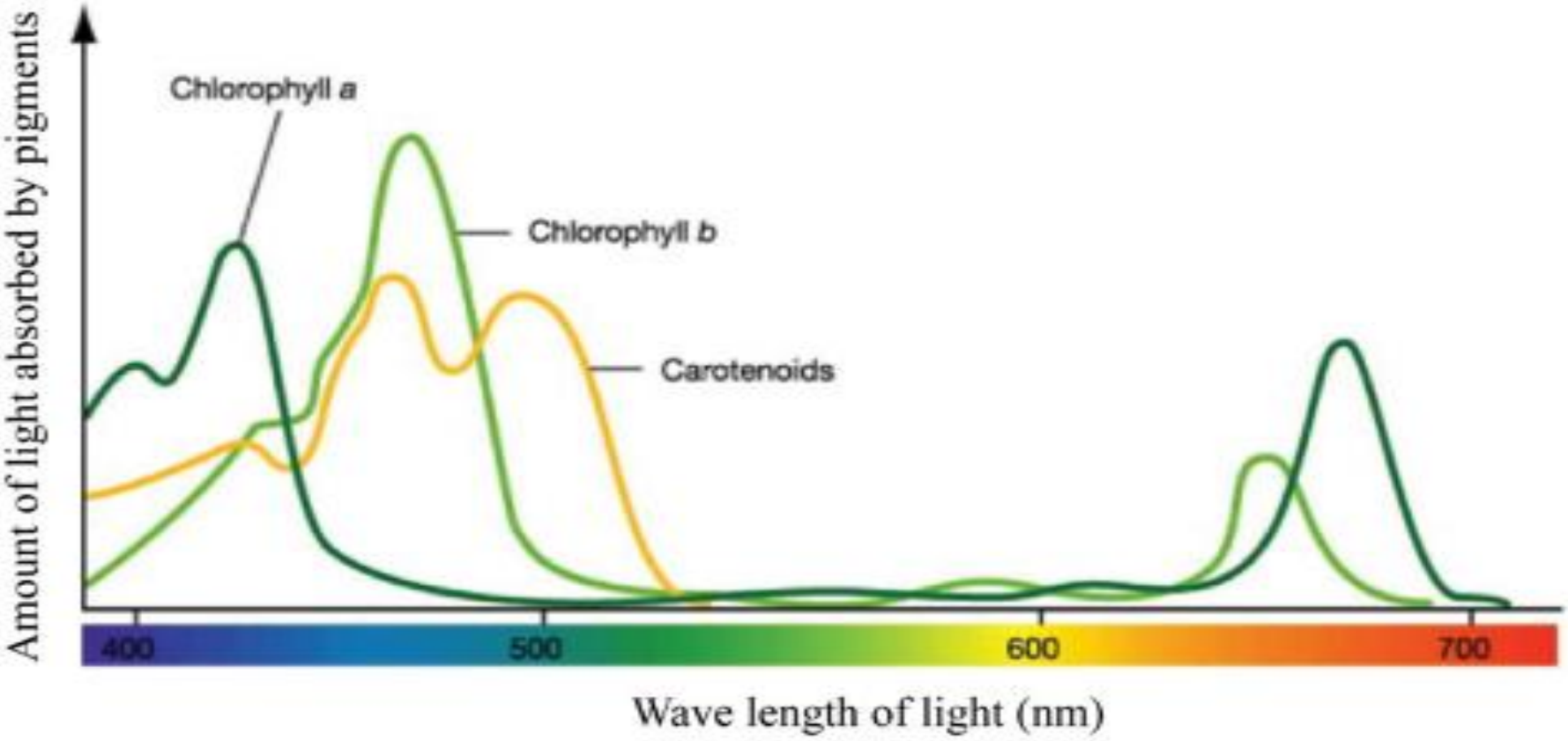


Figure 2.14 The action spectrum for different wavelengths

Group Discussion

- Discuss over all equation of photosynthesis
- What is the source of oxygen?
- What are the inputs (reactants) and outputs (products) of photosynthesis?
- Where do plants get the energy/source of energy for photosynthesis?
- What is photosynthesis?
- Where does photosynthesis take place?
- What does photosynthesis require?
- Light reaction is takes place in_____.
- Which light range is most effective in photosynthesis?

2.7.3. Mechanism of photosynthesis

Objectives

At the end of this lesson, you will be able to:

- *Explain the two stages of photosynthesis & their location*
- *Distinguish between the two stages of photosynthesis*
- *Investigate the presence of starch in a leaf*

1. What are the two stages of photosynthesis?

Where does each reaction take place in chloroplast?

2.What is the importance of sunlight for photosynthesis?

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
- **Inside a chloroplast, photosynthesis occurs in two stages:**

1. Light reaction (the light-dependent reactions) and
2. Dark reaction (the light-independent reactions/Calvin Cycle)

1. Light reaction

- ✓ Also known as the light dependent stage
- ✓ use light energy
- ✓ It takes place in the granum of chloroplast
- ✓ 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 (H2O) into H+ and O2.*

- *This is known as photolysis.*
- *The O2 is released to the atmosphere through leaf stomata.*

✍ *Excite electrons in the chlorophyll molecule to higher energy level which pass down the ETS and generate high energy ATP molecule.*

- *Generates H+ and ATP*
- *The ATP and H+ harvested during light reaction will be used as an input in the Stroma where conversion of CO2 to carbohydrate takes place.*
- *light reactions of photosynthesis produce three chemical products:*
  - ✓ *O2*
  - ✓ *NADPH*
  - ✓ *ATP*

The main events in the light-dependent reactions are summarised in figure 5.32.

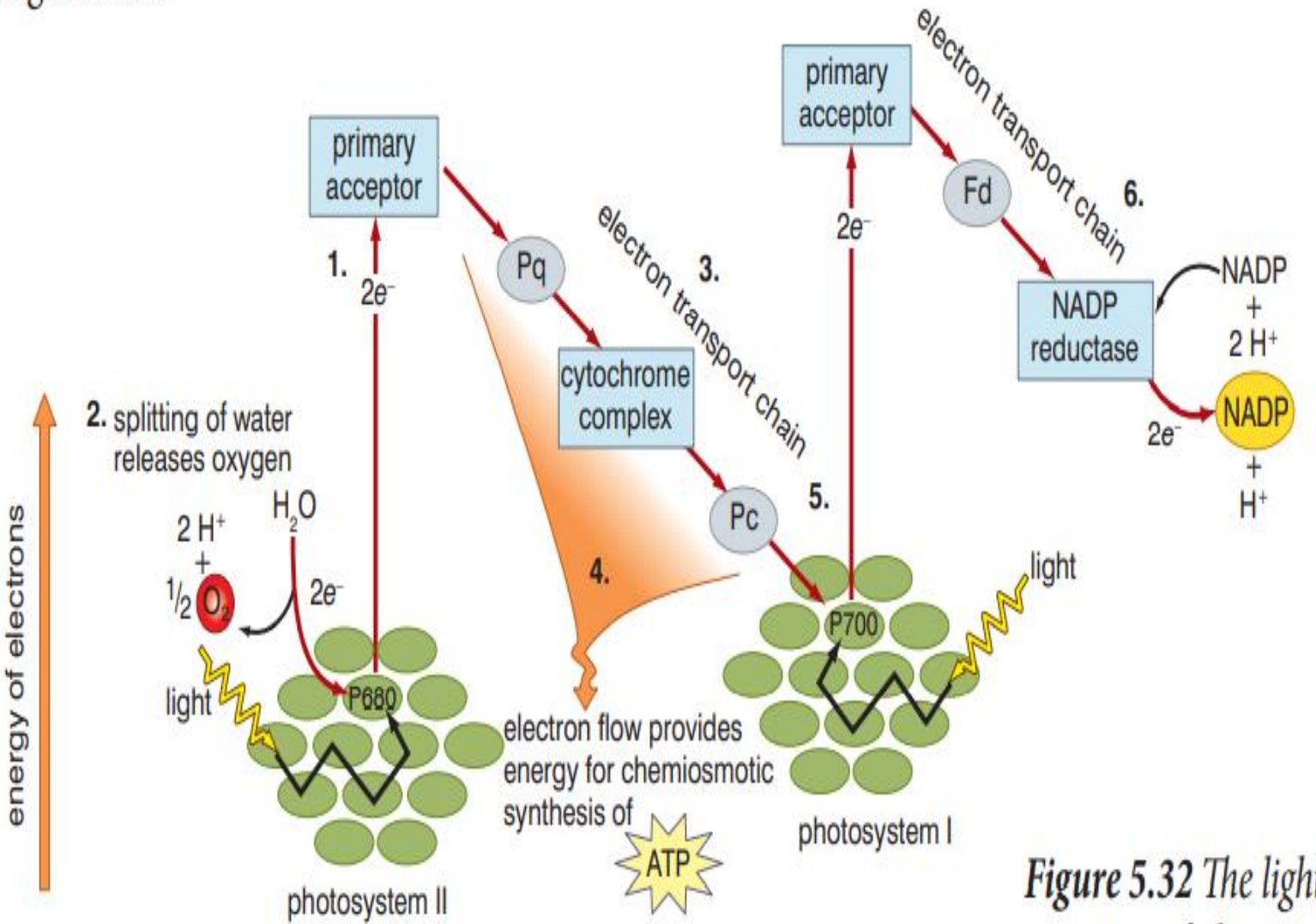
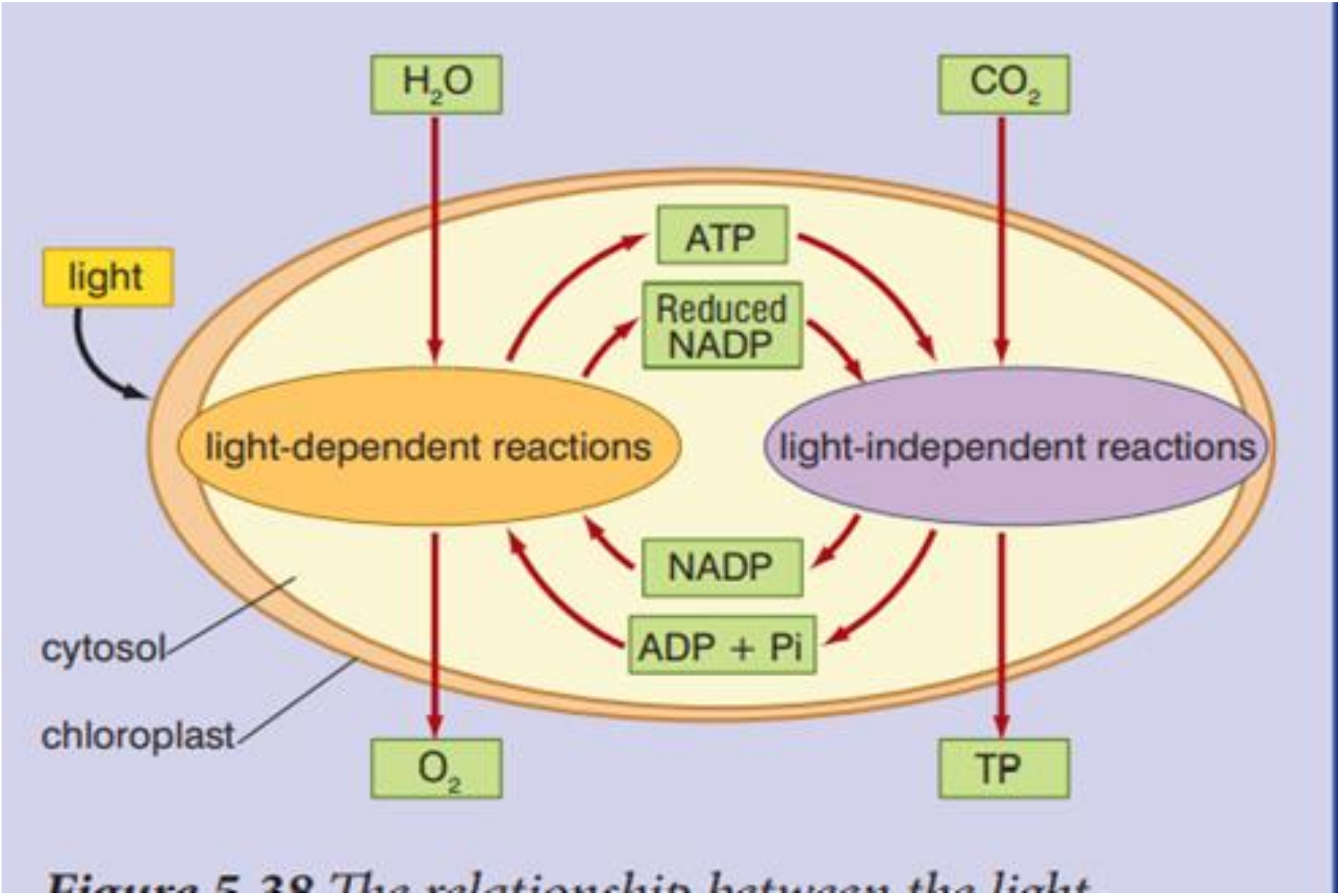


Figure 5.32 *The light-dependent reactions of photosynthesis*

2. Dark reaction

- Also known as light – independent stage,
- 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 product of light reaction ATP and NADPH used in the reduction of carbondioxide to glucose.
- It takes place in the stroma of the chloroplast.
- 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 result of the dark reaction.



The relationship b/n light dependent and light-independent reaction



Light and Dark Reactions of photosynthesis teaching tool.mp4

Group Work

Q. Why is photosynthesis important for humans?

2.7.4. Testing a leaf for starch

- If you put iodine solution on powdered starch, piece of bread or potato slice a blue-black colour will develop confirming the presence of starch.
- However, the cuticle of the leaf is impermeable to iodine.
- Moreover, the leaf has green pigment chlorophyll that interferes with the colouring effect of iodine.

ACTIVITY 2.14: TESTING LEAF FOR STARCH

Materials required: fresh green leaf, beaker, heat source (Bunsen burner or electric stove), test tube, alcohol, iodine solution

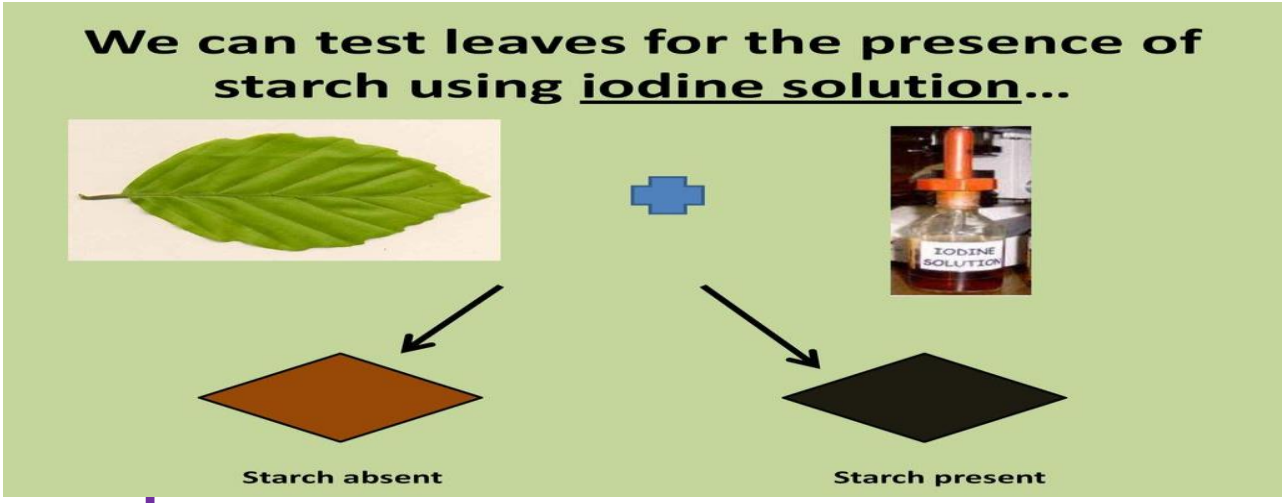
Procedure

- Depending on the availability of the materials required, you can perform the experiment in a group or follow your teacher when the experiment is demonstrated in class.
- Follow the experimental design illustrated hereunder and write the purpose of each step (Steps 1 – 4).
- For the sake of safety use forceps to put the leaf into or take it out from beakers with boiling water and hot alcohol.

What is the danger that can possibly happen in step 2 if you do not first turn off the Bunsen burner?



- To investigate the presence of starch in leaf
- **Iodine solution** is a test for the presence of starch in a leaf.



Procedure

Step1: Leaf is boiled in water to dissolve the cuticle.

Step 2: Boil Leaf in alcohol to remove the pigment chlorophyll

Step 3: Leaf is immersed in cold water to wash a way the dissolved cuticle and green colour.

Step 4: Iodine is added to leaf goes blue black colour if starch is present

- The blue black colour is a positive test for presence of starch in a leaf.

Q. write the purpose of each step (Steps 1 – 4) in testing leaf for starch.

Class Work

1. Compare the light dependent and light-independent reactions of photosynthesis.

2. What are the products of the light reaction and the calvin cycle?

3. What is the source of Oxygen gas produced during light reaction of photosynthesis ?

4. What is the energy source for the light-independent reactions of photosynthesis?

5. What is the procedure for testing a leaf for starch?

Home Work

1. What happens during light-dependent reactions and dark reaction?
2. Explain why we put the leaf into ethanol/alcohol during investigate the presence of starch in leaf?
3. what chemicals/solution we use to test the presence of starch in a leaf?

2.8 Transport in plant

Objectives

At the end of this section, the student will be able to:

- Know the function of xylem and phloem tissues
- Identify routes of water, mineral, and organic matter transport in plants,
- Tell the importance of transport in plants
- Discuss the mechanism of transport in plants
- Demonstrate water transport in plants using simple experiments

2.8 Transport in plant

1. Why is transport needed?

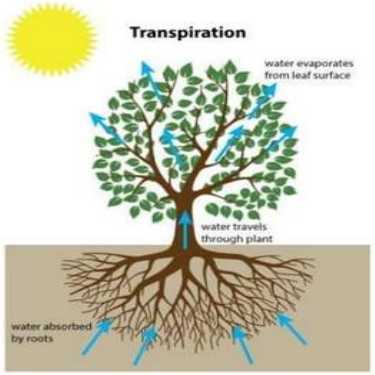
2. What is transported?

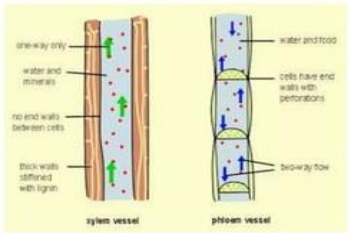
3. What are the routes of material transport in plants?

4. How are different materials, such as water, mineral and food transported to and from different parts of the plant such as root, stem and leaf?

2.8 Transport in plant

- The two transporting vessels
  - ✓**Xylem**
  - ✓**Phloem**
- They are collectively known as vascular bundles.
- Water and minerals are transported from the root to the leaf via the stem through conducting vessel known as **xylem**, which consists of elongated dead cells, joined end to end to form continuous vessels.





- Organic matter (food) manufactured in the leaf is transported to the rest of as opposed to xylem, **phloem** consists of living cells arranged end to end.
- allows transport of food (sucrose and amino acids) up and down the plant.
  - ✓This is called translocation.

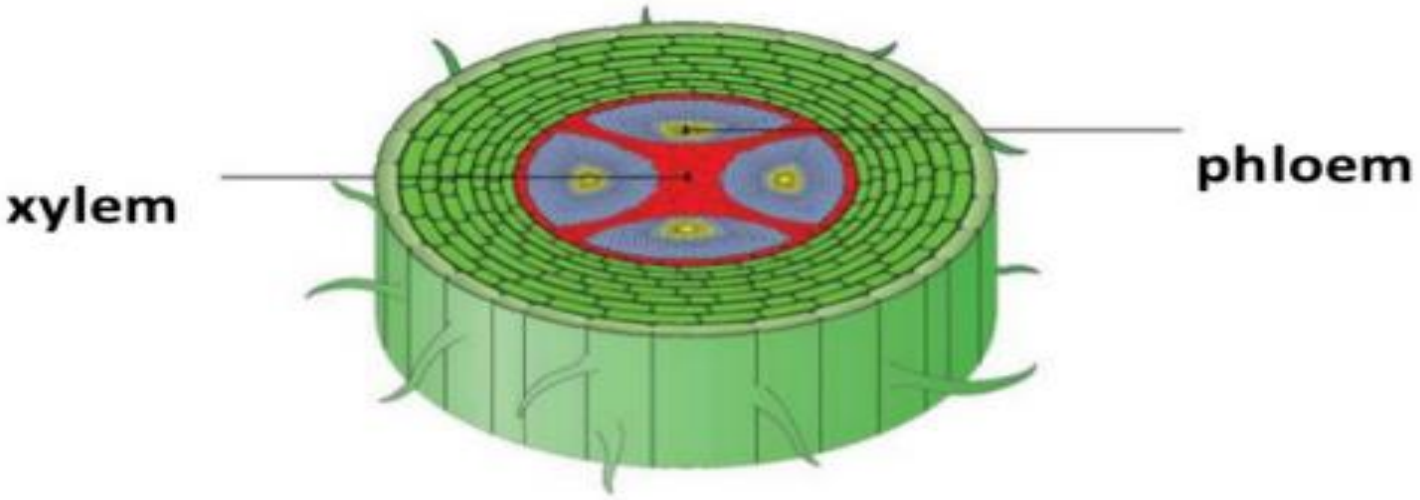


Figure 2.15 Root vascular bundles

Group Work

ACTIVITY 2.15: GROUP WORK

Hint

Water is a raw material for photosynthesis. Water is badly required at the seedling stage as it gives strength to the plant. A young seedling is delicate and easily wilts if there is a scarcity of water or loss of water by evaporation.

Direction

- Discuss with your small group how drought affects agricultural productivity or food production.
- Why are rainy months the best time for agriculture? Why is irrigation needed, particularly during drought or in dry areas?

What is the main importance of transport systems in plants?

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.
- Root hairs 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 across the cell membrane and cytoplasm 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.
- Transpiration pull: is pulling force caused by transpiration
- **Transpiration**
  - ✓is a process of loss of water in the form of water vapours from the surface of leaves.
  - ✓It occurs through stomata
  - ✓Creates transpiration pull for transport

- Transpiration is the main force responsible for the upward movement of water from the root to the leaves through the xylem vessel.
- During transpiration water that evaporates from the leaves serve to pull or drag water from the root to leaves.
  - ✓ This mechanism of water transport is called **transpiration pull**

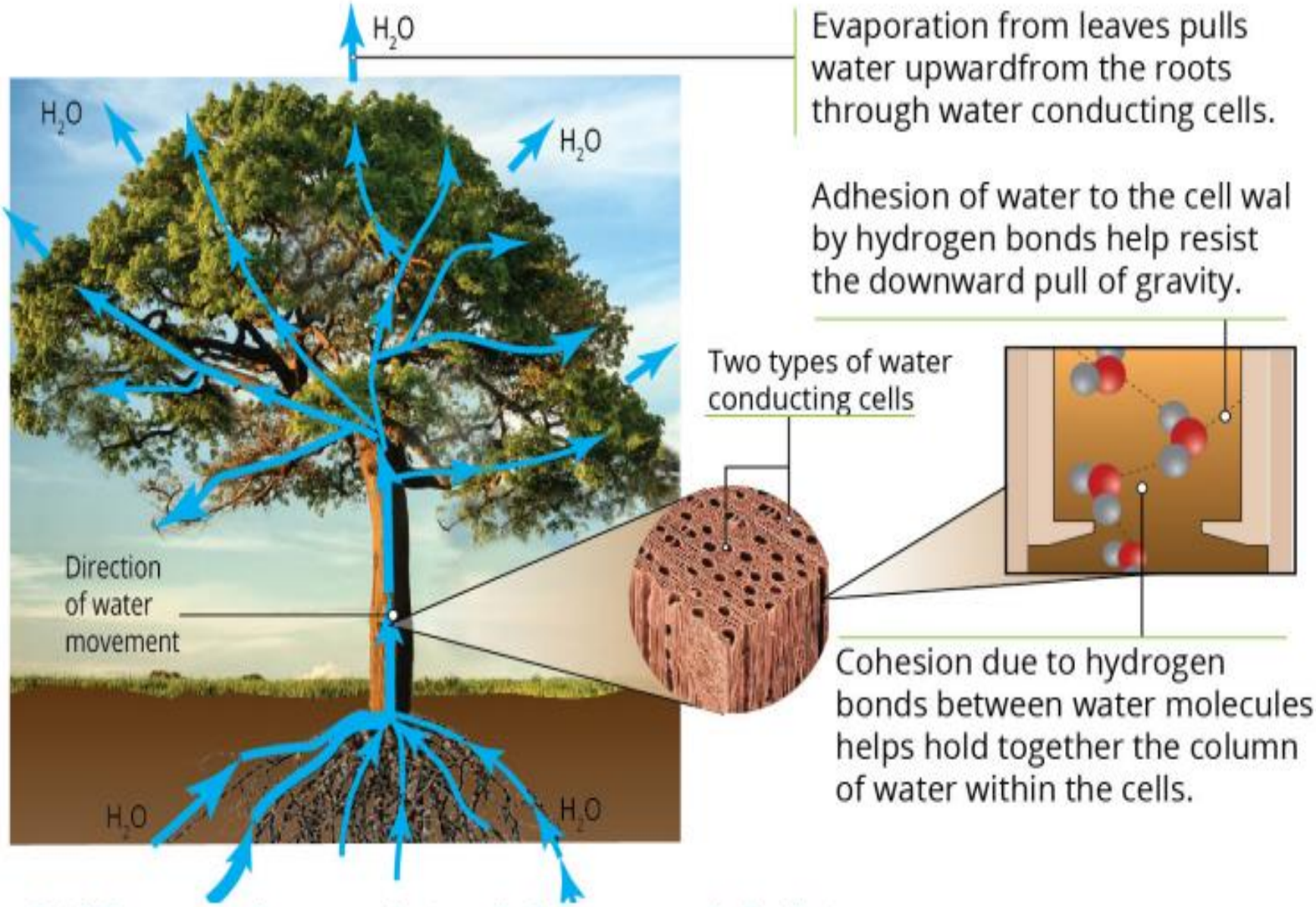


Figure 2.16 Transport of water and minerals from root to the leaf via the stem

- Minerals enter the root in the ionic (charged) form 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.

ii. Translocation of organic matter (food)

- **The phloem** transports synthesized plant food.
- **Translocation** in plants is transport of food from the site of synthesis (source), which is the leaf, to the site of utilization or storage (sink), which can be either the stem or the root.
- 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.

- The ringing or girdling experiment as designed in Figure 2.17 helps to identify the food conducting vessels.

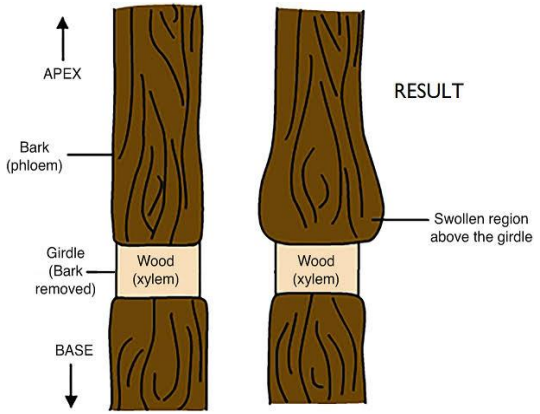




Figure 2.17 Ringing /Girdling experiment

- The experiment involves removing the ring of bark with the phloem and the plant is placed in a beaker of water.
- Xylem will be the only vessel in the girdled area, which connects the upper and lower part of the plant.

- After few days, a swelling will be observed in the upper girdle.
- This is due to the accumulation of food materials, mainly sugar which was translocated from the photosynthesizing leaf towards the root.
- Ringing will ultimately kill the plant, because of disruption of food transport through the phloem.
- The root dies first, because supply of food to the root will be discontinued.
- As the root dies, the upper part and finally the whole plant, which depends on root for water and minerals, will die.

Class Work

1. Define transpiration?
2. What is translocation?
3. State the function of xylem and phloem vessels?
4. Structure responsible for the absorption of water and mineral from the soil is called_____
5. Girdling of a tree by completely removing a ring of bark affect the process of _____

2.9 Response in plants

- Objectives

At the end of this section, the student will be able to:

- ✓ recognize that plants are capable of giving response
- ✓ explain some common responses in plant
- ✓ tell the importance response in plants and
- ✓ demonstrate response in plants using simple experiments

2.9 Response in plants

2.9.1 Tropism as growth response

- plants like other living things to respond to stimuli, that is, changes in the environment.
  - ✓This may be to find food, move towards the light or avoid danger.
  - ✓To take information about the surroundings and then react in the right way
- plants respond to:
  - ✓ light (phototropism),
  - ✓water (hydrotropism) and
  - ✓ gravity (geotropism).

PLANT TROPISMS

Phototropism

Plants response to
Light



Geotropism



Plants response to
gravity

Thigmotropism



Plants response to
touch

Hydrotropism

Plants response to
water



@MsGroverTweets

Tropism:

- Growth response
- It is bending towards (positive response) or opposite/away (negative response) to the direction of the stimulus.
- the response is a unilateral stimulus (coming from one side only),
- which causes unequal production or distribution of growth hormone resulting in unequal growth.
- This means one side grows more or less than the other side and these results in bending towards or away from the stimulus.

- **The responses of plants towards things such as light and gravity are called tropisms**
- Tropism is exhibited by the shoot and root of a plant due to unequal concentration of growth hormone, commonly auxin, resulting in unequal growth.

Auxin, particularly Indole Acetic Acid (IAA),

- ✓ is plant growth hormone.
- ✓ It is produced at the tips of shoot and root.
- ✓ It is transported to the region of active growth
- ✓ affects cell elongation, Shoot and roots respond differently to different auxin concentration.

Q. How does auxin affect shoot and root growth?

- Figure 2.18 helps to know how shoots and roots respond differently to unilateral (one sided) stimulus
- The graph 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.

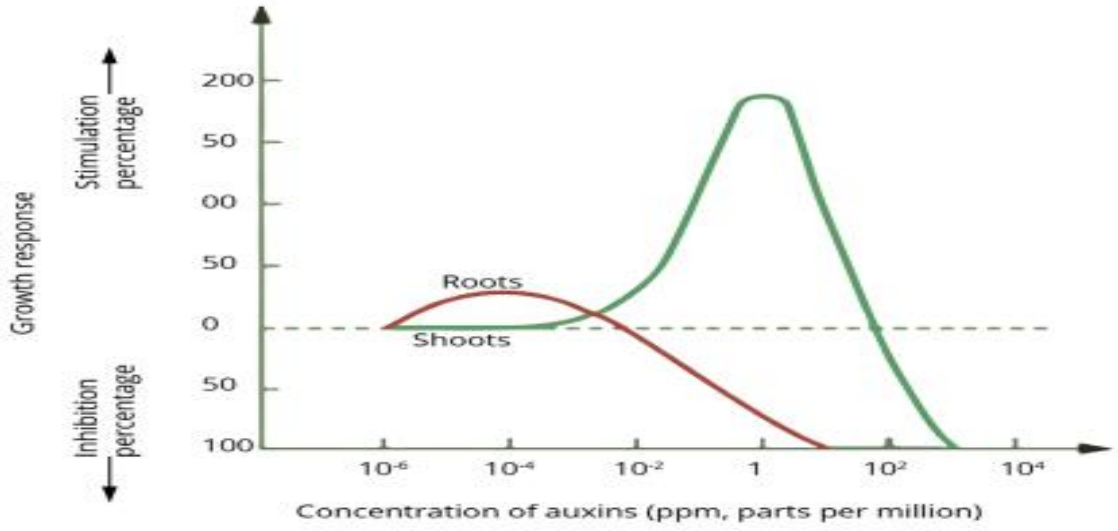


Figure 2.18 Effects of auxin concentrations on the growth of shoots and roots

- How shoot and root respond to unilateral light is well demonstrated by Figure 2.19.
- As a result of 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.

What is the response of the shoot to unilateral (one - sided) light ?

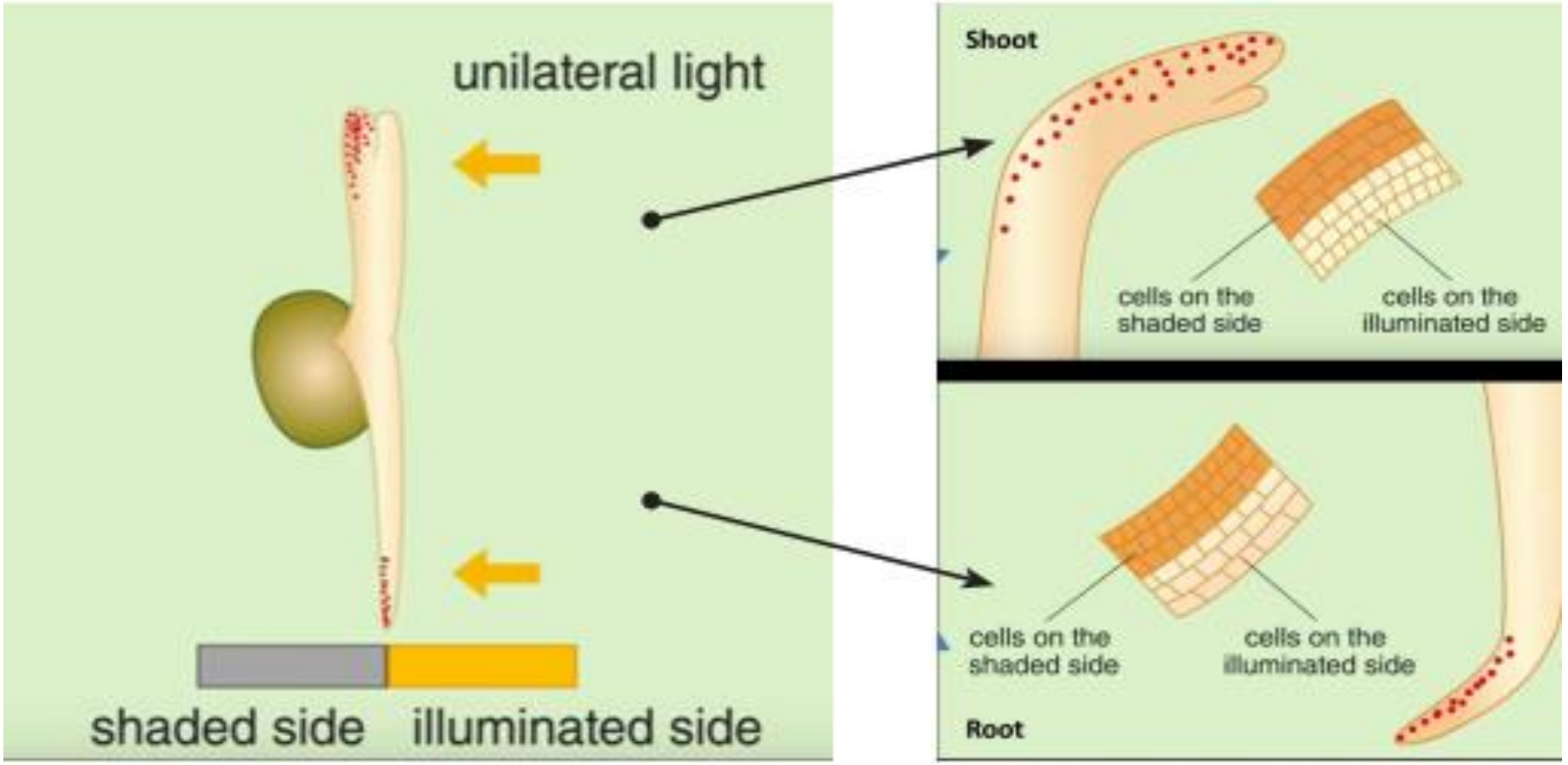


Figure 2.19 How unilateral light affects shoot and root response

Types of tropisms

A) Phototropism

- Plants need sunlight for photosynthesis.
- 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.
- Type of response in which shoots grow towards the light is termed **positive phototropism.**

- The earliest experiment on phototropism was conducted by Charles Darwin, "father of evolution", (Figure 2.20).
- He noticed that if the light is shone on a coleoptile (shoot tip of young seedling) from one side, the shoot bends or curves (grows) toward the light (Seedling '1' and partially seedling '4').
- The bending did not occur in the tip itself but in the elongating part just below.

- When the tip is removed (Seedling ‘2’) or covered with opaque foil (Seedling ‘3’), the shoot could no longer bend toward the light.
- Moreover, covering the lower shoot part (Seedling ‘5’) did not affect the response to light at all.
- Based on his experiment, Darwin concluded that “some influence is transmitted from the tip to the more basal regions of the shoot thereby regulating growth and inducing bending”.

- At present, it is well known that it is a growth hormone known as auxin that will be distributed more on the tip side opposite to light.
- This causes more growth on the shaded side and curving will occur toward the light.

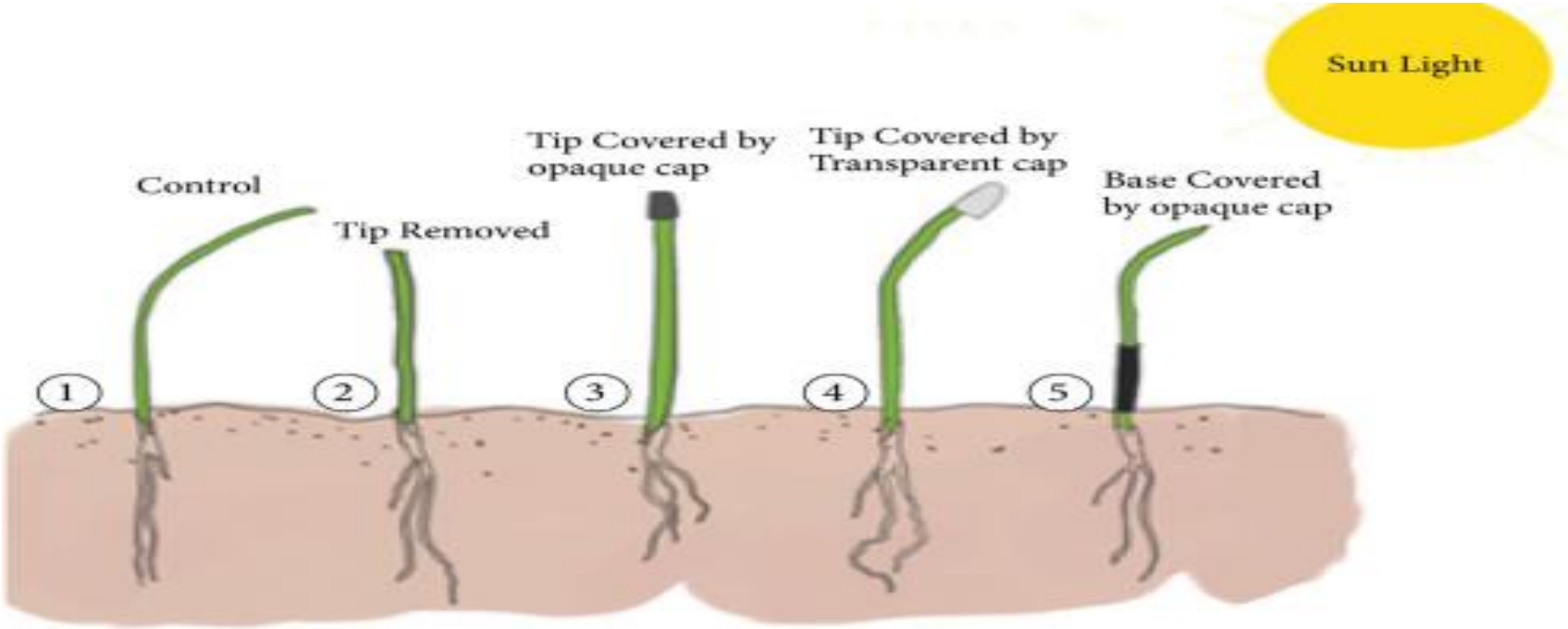


Figure 2.20 Darwin's experiment on phototropism

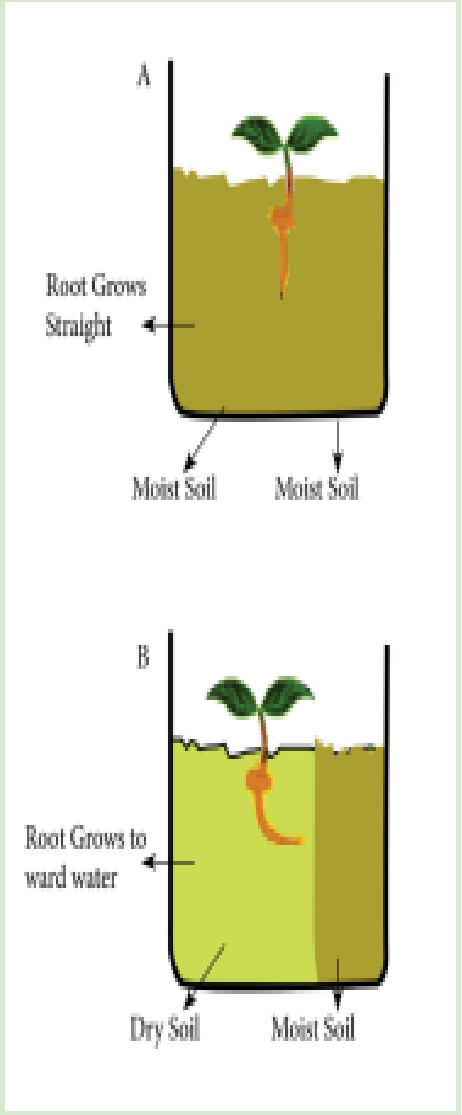
B) Hydrotropism

- Roots search for and grow toward water because it is needed for photosynthesis and to support cell structure (make them turgid and strong).
- Hydrotropism exhibited by root is biologically important and vital for the survival of plants.
- The type of response by which roots grow towards water is termed **positive hydrotropism**.

ACTIVITY 2.18: Demonstration of hydrotropism

Procedure

Take two beakers – "A" and "B". Follow the picture below and add moist soil and sow the seed in Beaker "A". In beaker "B" add dry soil in half part and moist soil in another part and sow the seeds. keep both beakers for 2–3 days for germination to take place



Questions

1. How do you explain what you observed in Beaker "A" and "B"?
2. If you had filled the whole beaker with dry soil and put wet cotton or wet sponge on the top of the soil at one side, how would the root have grown? Downward (toward gravity) or upward (against gravity)? Is the root response stronger, for water or gravity? [You need to do the experiment in order to answer these questions]

C) Geotropism

- The seed embryo that develops into a seedling will form root from the radicle and shoot from the plumule.
- How the seedling (young plant) stands erect (Figure 2.21).

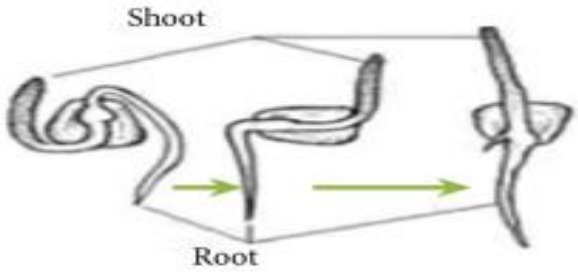


Figure 2.21 Seed embryo developing into a seedling in an upright position

- This is the result of a response to gravity, known as geotropism.
- The root progressively bends downward while the shoot bends upward until root–shoot system orient itself in an upright (standing position)

- Movement in response to the stimulus of gravity is called **geotropism.**
- 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).

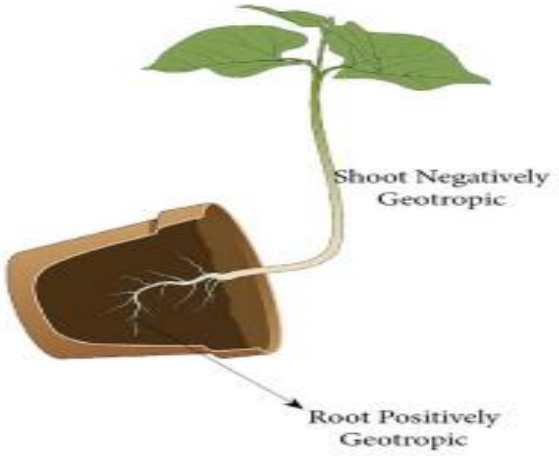


Figure 2.22 Plant responses to gravity

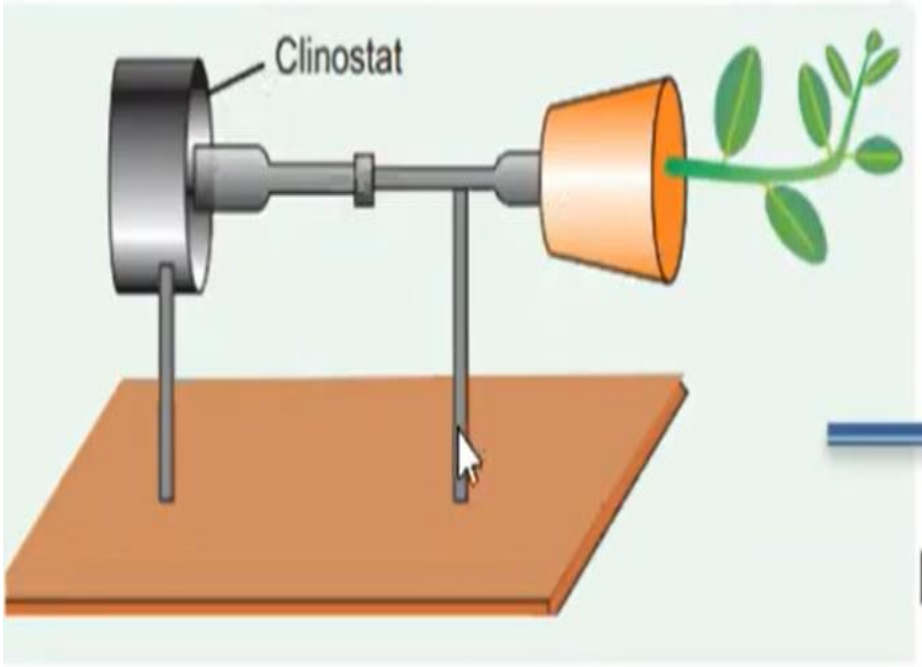
- The effect of gravity in a horizontally placed seedling can be overcome by a clinostat, which is a rotating instrument.
- **Clinostat**-is a devise that slowly rotates a pot or plant holder containing a plant. Used to overcome gravity
  - ✓Slow rotation eliminates the effect of gravity
  - ✓Preventing the root and shoot from showing geotropism
  - ✓Both the shoots and roots grow horozontally.
- A seedling fixed horizontally in a rotating clinostat grows straight (Figure 2.23), because the rotation overcome (gravity acts equally for all sides) the effect of gravity.

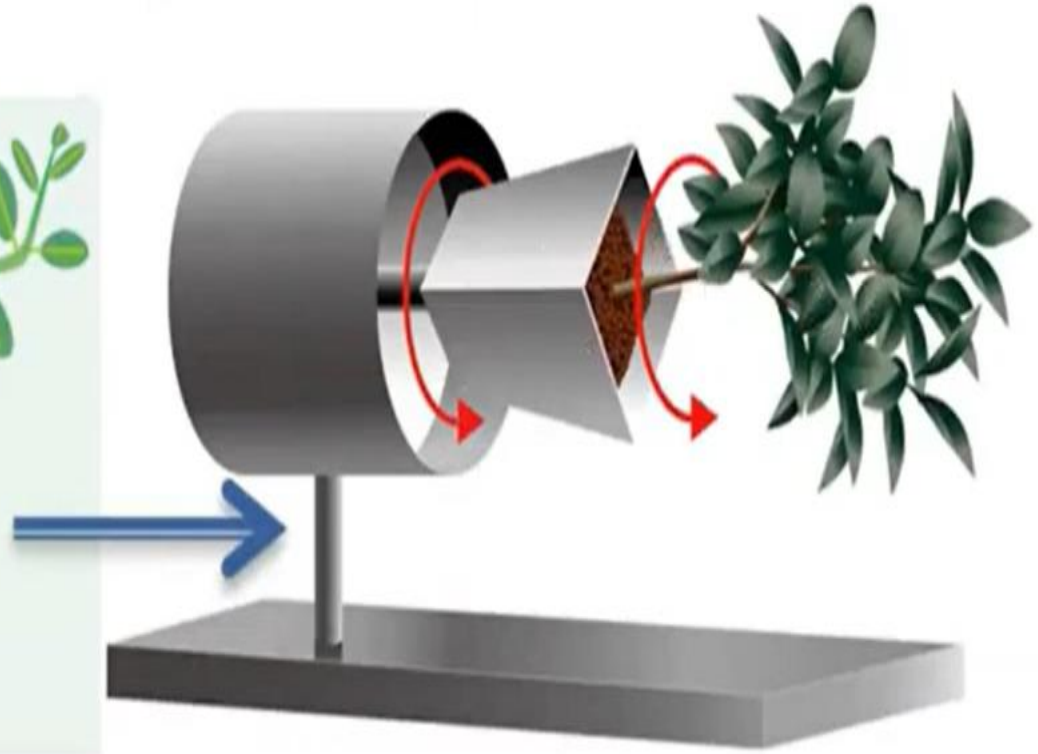


Figure 2.23 Effect of clinostat on gravity (geotropism)

Clinostat (effect)

is a device which uses rotation to remove the effects of gravitational pull on plant growth





1) What is a tropism?

2) Define Geotropism and phototropism?

3) What is a movement away from a stimulus called?

4) List different types of tropism

5) Which of the following is true about tropism?

A. Root is negative to geotropism
B. Shoot is positive to geotropism
C. Shoot is positive to phototropism
D. Root is positive to phototropism

2.10 Medicinal plants

Objectives

At the end of this section, the student will be able to:

- tell the importance of medicinal plants and
- list down locally available medicinal plants

What are medicinal plants?

What is their importance to local people?

- Plants also produce other organic products that have ornamental, commercial and medicinal values.
- Medicinal plants that 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 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

1. **Ruta chalepensis(Teenadem)**



Zingiber officinale(scientific name)





kosso/ hagenia ~ ኮሶ ዛፍ

hagenia abyssinica (scientific name)





Ocimum lamiifolium (scientific name)



Lepiḍium sativum(scientific name)

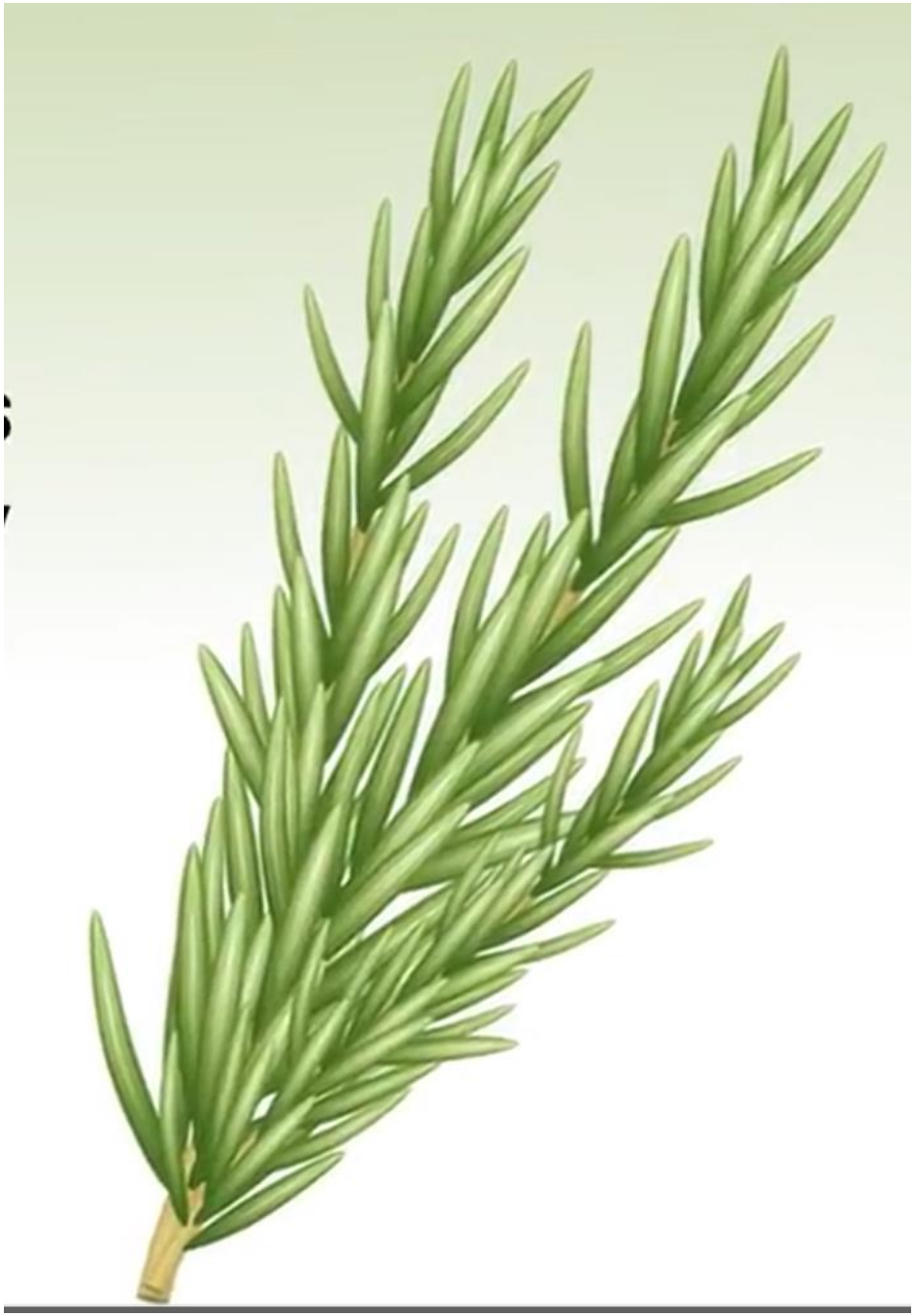






Duba (*Cucurbita Pepo* L.)

Rosmarinus officinalis



Ocimum basilicum (Besobilla)



ACTIVITY 2.20: Group work

Procedure

Divide the following local medicinal plants among your small group.

- *Lippia adoensis* ("Kosseret")
- *Thymus schimperi* ("Tossign")
- *Echinos kebericho* ("Kebericho")
- *Taverniera abyssinica* ("Dingetegna")
- *Moringa stenopetala* ("*Shiferaw*" or "*Aleko*")

Ask your parents or elders in your locality about parts of the medicinal plant used, mode of administration and some examples of human diseases treated

Prepare summary as it is done for the 14 medicinal plants indicated in the previous table.

Submit your summary table to your teacher for comment and presentation to your classmates

Remark :

While collecting medicinal plants student need to use hand gloves (some students can be allergic to the plants), not taste and ingest them or inhale if they have volatile substance. It will be safe to wash hands after handling the plants

Students in the pastoralist areas can form a group to collect key information and the medicinal plants used for livestock. They should ask their teacher for guidance and finally present their result in class as summarized in table 2.2.

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.
- Professor Sebsebe Demissew, a leading Ethiopian botanical scientist, has been elected as a Foreign Member of the Royal Society in London in 2018 for his lifelong work on promoting Ethiopian biodiversity.

- Works in conserving and recording the very diverse Ethiopian flora with many endemic species and
- leadership of the Ethiopian flora project and the Ethiopian National Herbarium at Addis Ababa University

UNIT 3: BIOCHEMICAL MOLECULES

3.1 BIOLCHEMICAL MOLECULES

Objectives:

- Identify inorganic and organic biochemical molecules
- discuss different inorganic ions and their contribution to the cell
- explain the properties of water and its importance for life.

3.1 BIOLCHEMICAL MOLECULES

Q. What are biological molecules?

- Biochemical molecules also known as a biological molecules
- Any of the numerous substances produced by living organisms and cells.
- They serve a variety of functions
- Our body made up of two types of bichemical molecules
- Divided into two categories:
    i. Inorganic biochemical molecules
    ii. Organic biochemical molecules

Q. what is the difference between the two?

Inorganic compounds

- May contain either carbon or hydrogen (or neither), but not both.
- Do not contain carbon except oxides of carbon and carbonate ions.
- Carbon found in some inorganic molecules.
- Play critical roles in the survival of living organisms.

Examples:

- Water (H_2O)
- Salts
- Sodium chloride (NaCl)
- Hydrochloric acid (HCl)
- Carbondioxide (Co_2), Diamond

Organic Compounds

What are organic molecules?

- Contain both carbon and hydrogen atoms.
- Carbon is present in all organic molecules, as is hydrogen in nearly all of them and oxygen in many of them.
- Some times contains N, O, S or P with C
- Are associated with living organisms.

Examples:

- Sugars-sucrose($C_{12}H_{22}O_6$), Fats, Proteins, Nucleic acids
- Benzene(C_6H_6), Methane(CH_4), Ethanol (H_2H_6O), formaldehyde (CH_2O)

Quiz

Place the following substances in the correct columns.

- *Co (carbon monoxide)*
- *$C_5H_{10}O_4$ (deoxyribose)*
- *$C_{18}H_{36}O_2$ (stearic acid – a fatty acid)*
- *NO_2 (nitrogen dioxide)*
- *H_2SO_4 (sulphuric acid)*

Organic	*Inorganic*

Quiz

Place the following substances in the correct columns.

- $C_3H_6O_3$ *(lactic acid)*
- $C_6H_{14}N_2O_2$ *(lysine – an amino acid)*
- $C_{10}H_{16}N_5O_{13}P_3$ *(ATP)*
- *Iron III oxide* (Fe_3O_4)
- *Calcium carbonate –* $CaCo_3$

Organic	*Inorganic*

Chemical elements Found in living organisms

- Which chemical elements are found most frequently in living organisms?
- The most common elements in many cells are: percentage composition in a cell

The six most common elements in living things are:

- Hydrogen (H) 59%
- Oxygen (O) 24%
- Carbon (C) 11%
- Nitrogen (N) 4%
- Others (such as phosphorus (P) and sulphur (S)) 2% combined

3.1.1 Inorganic molecule: Water

Objectives:

At the end of this section, the student will be able to:

- mention properties of water,
- discuss the importance of water for the living organisms.

3.1.1 Inorganic molecule

Water

- List down the properties of water and its importance in the living system.
- Water is an example of an inorganic molecule.
- Water is an inorganic molecule composed of two elements: hydrogen and oxygen.
- H_2O is its chemical formula.
- Each water molecule is composed of two hydrogen atoms linked to a single oxygen atom.

- Life would not exist on our planet if it did not have access to water.
- It is significant for two reasons:
  - ✓It is a key component of cells, accounting for 70 to 95% of the cells mass.
  - ✓You are around 60% water.
- In a water molecule, each hydrogen atom shares an electron pair with the oxygen atom.
- In the O-H bonds in water, oxygen is more electronegative than hydrogen.
- The sharing of electrons between H and O is unequal.

- The electrons are more often in the vicinity of the oxygen atom than hydrogen.
- This unequal electron sharing creates two electric dipoles in the water molecule with oxygen-bearing a partial negative charge and hydrogen bearing a partial positive charge.
- This makes water a polar molecule

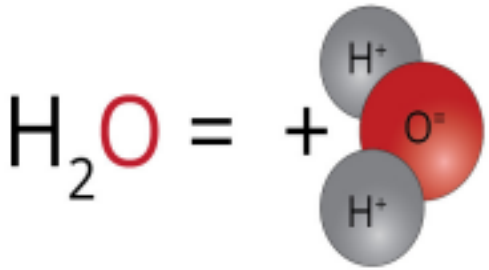


Figure 3.1 Structure of water molecule

- The polarity of water has important chemical implications conferring its typical properties.
- Another important consequence of the polarity of the water molecule is that water molecules attract one another.
- The partially positively charged hydrogen atom of one water molecule can interact with the partially negatively charged oxygen atoms of another molecule of water.
- This interaction is called a hydrogen bond.

KEY WORD

hydrogen bonds *bonds that join the oxygen in one water molecule to the hydrogen in another*

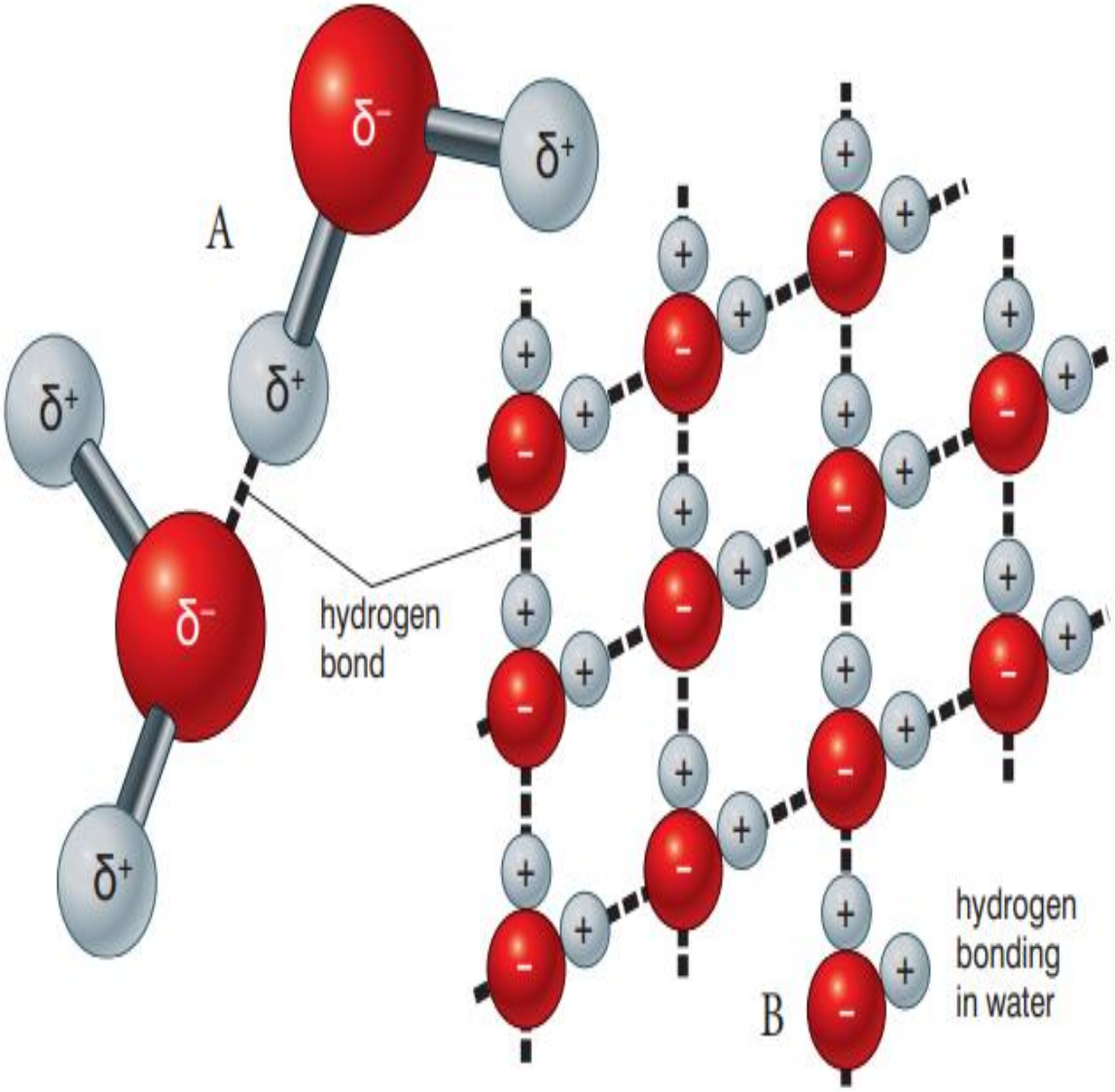


Figure 2.6 *Hydrogen bonding in water.*
A Two water molecules hydrogen-bonded together
B Many water molecules hydrogen-bonded together

- The hydrogen bond network of water molecules confers several unique properties on water that are important for sustaining life.

❑Water has many properties that make it important to living things in a number of ways, such as:

- ❖a place to live
- ❖ a transport medium
- ❖a reactant in many chemical reactions
- ❖a place for other reactions to take place

3.1.1.1. The properties of water

What typical properties of water do you know?

Some typical properties of water are:

1. Water as a solvent

- Water is an effective solvent for ions and polar molecules (molecules with an unequal charge distribution, such as sugars and glycerol) because the water molecules are attracted to the ions and polar molecules, causing them to congregate and separate (Figure 3.2).
- When a chemical dissolves in water, it is free to move about and react with other chemicals.

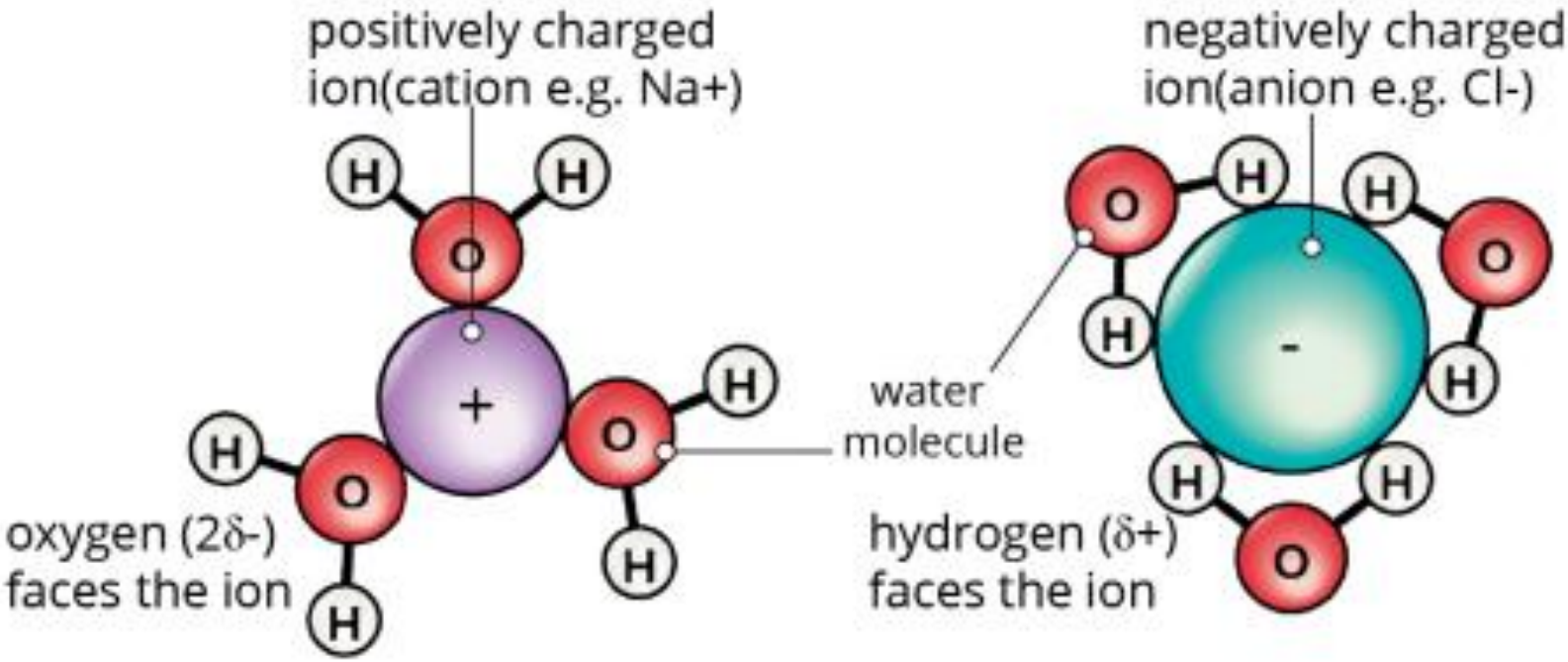


Figure 3.2 Distribution of water molecules around ions in a solution.

- Non-polar molecules such as lipids are insoluble in water and, if surrounded by water, tend to be pushed together by the water, since the water molecules are attracted to each other.

2. High specific heat capacity

- Specific heat capacity is the amount of heat required to raise its temperature by a particular amount.
- The specific heat capacity of water is the amount of heat energy necessary to raise the temperature of one gram of water by one degree Celsius.
  - ✓b/c you must break hydrogen bonds
- Water has a high heat capacity.
- To raise the temperature of a liquid, the molecules must obtain energy and so move more quickly.

- The hydrogen bonds that cause water molecules to adhere together make it difficult for the molecules to move freely; the ties must be broken to allow free mobility.
- This explains why more energy is required to raise the temperature of water than would be required if hydrogen bonds did not exist.
- It makes the water more resistant to temperature changes.
- Important for organisms to maintain a constant temperature(homeostasis)

3. High latent heat of vaporization

- The latent heat of vaporization is a measure of the thermal energy required to vaporize a liquid, converting it from a **liquid** to a **gas**.
- it takes a lot of energy to transform liquid water into water vapor.
- Water has a comparatively high latent heat of vaporization due to its high heat capacity b/c water molecules tend to stick together via hydrogen bonds

- Water has high latent heat of vaporization.
- Significant quantities of energy are required for vaporization to occur because hydrogen bonds must be broken before molecules can escape as gas
- Evaporation has a strong cooling effect

eg. When humans sweat they release water on their skin

- Removing a lot of heat and cooling the organism.

4. Density and freezing properties

- Water is a unique molecule in that its solid form, ice, is less dense than its liquid form.
- Water density begins to fall below 4°C.
- As a result, ice floats on liquid water and insulates the water beneath it.
- This minimizes the likelihood of big amounts of water freezing entirely and increases the likelihood of life surviving under cold temperatures.
- Changes in water density as a result of temperature generate currents, which aid in the circulation of nutrients in the oceans.

5. High surface tension and cohesion

- Water molecules have very high cohesion
- Cohesion-Water molecules stick to each other(due to H-bo).
- Cohesive forces are the attraction of water molecules to other molecules.
- This attraction can be stronger than water's cohesive forces, especially when the water is exposed to charged surfaces like those found on the interior of thin glass tubes known as capillary tubes (Figure 3.3).
- Water "climbs" up the tube placed in a glass of water, causing the water to look higher on the sides of the tube than in the middle. This is due to the fact that water molecules are more attracted to the charged glass walls of the capillary than to each other and hence adhere to it.

- Capillary action is the name given to this sort of adhesion.
- Cohesive and adhesive forces are crucial for the transport of water from the roots to the leaves in plants.
- High cohesion also results in high surface tension at the surface of the water.
- This allows certain small organisms, such as raft spiders, to exploit the surface of the water as a habitat, allowing them to settle on or skate over its surface (Figure 3.4).

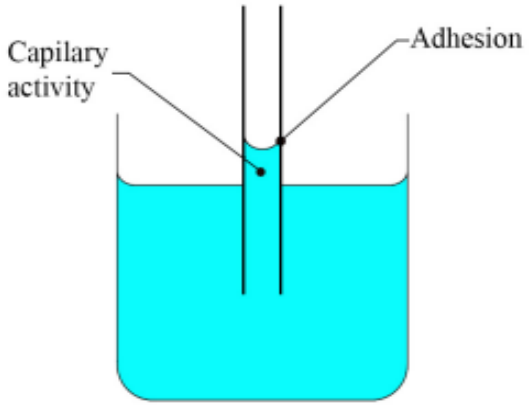


Figure 3.3 Cohesion and adhesion (H2O)



Figure 3.4 Surface tension allowing Raft spider to walk on the water surface

6. Boiling and Freezing Points

- The ability of water molecules to form hydrogen bonds is responsible for many of water's unique properties.
- Despite its low molecular weight, it has a very high boiling point (100°C) this is due to water requires more energy to break its hydrogen bonds before it can begin to boil.
- The same concept is used to calculate the freezing point.
- The boiling and freezing points of water is important for aquatic ecosystems.

- If water is easily frozen or boiled, drastic changes in the environment would affect bodies of water such as oceans or lakes, killing all organisms that live in water.
- This is also why sweat can keep our bodies cool.
- Consider how water differs from most other compounds in terms of its boiling and freezing points (Table 3.1).

Table 3.1 Boiling and freezing points of water

Compound	Boiling Point	Freezing Point
Ethanol	78.4°C	-114.6°C
Acetic acid	117.9°C	16.6°C
Hydrogen Sulfide	-62°C	-84°C
Water	100°C	0°C

7. Water is a transparent
9. Water as a transport medium

Class Work

1. Which of the following describes a hydrogen bond?

A. The bond between two hydrogen atoms within a molecule of water

B. The bond between hydrogen in one water molecule and another hydrogen in a different water molecule

C. The bond between hydrogen and oxygen within a molecule of water

D. The bond between hydrogen in one water molecule and oxygen in a different water molecule

2. Which property of water provides the cooling effect of sweating?

A. cohesive *B. surface tension*

C. high heat of vaporization *D. high heat capacity*

Why does ice float on liquid water?

3. Which property of water helps to explain that it takes a time for a pot of water to boil?

A. adhesion B. density C. specific heat D. universal solvent

4. Water is a polar molecule that attracts other polar molecules. What is this property property of water?

5. The hydrogen and oxygen atoms are held together by ____ bonds.

6. Water molecules stick to other water molecules. This property is called ____.

7. What property of water allows raft spiders to walk on water?

What is the difference between cohesion and adhesion?

3.1.2 Inorganic ions

Objectives

At the end of this section, the student will be able to:

- *mention important inorganic ions that are necessary for life,*
- *mention diets that contain inorganic ions,*
- *discuss the effect of deficiency of nutrient elements in our body,*
- *explain the importance of each nutrient element to the human body.*

3.1.2 Inorganic ions

1. What are inorganic ions?
2. List three examples of inorganic ions.
3. Where are inorganic ions formed?

- They are atoms with unshared electrons in their outer shell.
- Inorganic ions are charged entities
- They have either positive (Cations) or negative (Anions) charged.
- They are virtually usually coupled with an oppositely charged ion.

- are found in living bodies in two forms:
  - ✓free and
  - ✓dissolved in the cytoplasm, where they are associated with complex organic substances.
- They participate in a variety of vital functions in living beings.
- Although they are only found in trace amounts in our bodies, their significance cannot be overstated.

- Any variations in their concentrations inside the human body can have catastrophic implications.

What is the difference between inorganic ions and minerals?

- When discussing inorganic ions in the context of the human body, they are frequently referred to as minerals.
- In this section, you will go over some of the most important inorganic ions in the human body, including their occurrence, sources, and role in homeostasis maintenance. You will also investigate the clinical conditions caused by alterations in their usual concentrations as part of your tasks.

Classification of inorganic ions

- Based on their requirement in the daily diet of a normal individual, inorganic ions or minerals in the human body are divided into two categories;
  - ✓Macro-nutrients &
  - ✓Micro-nutrients

Table 3.2 Macro and micro-nutrients in living systems

Macro-nutrients: required in bigger quantities in the daily diet	Micro-nutrients/trace elements: required in small amounts
Sodium, Phosphorus, Magnesium, Potassium, Sulfur, Chloride	Iron, Copper, Iodine, Manganese, etc

A. Hydrogen ions

What is the importance of the hydrogen ion?

- High amount in our body.
- These are the most important ions to maintain balance and equilibrium in living systems.
- They are released in the cells during various metabolic processes.
- They are found in the cytoplasm of cells as well as in the intercellular fluid, blood, cerebrospinal fluid (CSF), and other body fluids.

- The concentration of hydrogen ions is expressed as pH.
- The pH scale ranges from 1 to 14.
- The pH value has an inverse relationship with the concentration of hydrogen ions
- The higher the pH, the lower concentration of hydrogen ions.

Importance of the hydrogen ions in cells:

i. Enzyme action

ii. ATP synthesis

iii. Oxygen delivery

B. Sodium ions

- The sodium ion is the body's second most important positively charged ion.
- The concentration of sodium ions in extracellular fluids is higher than in cell cytoplasm.
- Consumed in order for the human body to function normally.
- The average person's salt need is between 3 and 6 grams per day.
- It is commonly consumed in the form of common salt found in our foods.

- The average daily sodium intake exceeds the body's requirements.
- The urines of the body eliminate excess salt.
- To maintain normal blood pressure in patients with high blood pressure, lesser salt intakes are required.
- It is an extracellular cation that is common in body fluids but is present in lower concentrations within cells.

What is the other importance of Sodium ions?

Importance of Sodium ions:

i. Conduction of nerve impulses
ii. Maintain fluid balance in our bodies
iii. Absorption of nutrients in the intestine
iv. Heart contraction

Q. How much is the body requirement of sodium ions for a human being?

Q. What is the impact of high sodium intake?

C. Potassium ions

- These are also positively charged ions abundantly present in our bodies.
- Contrary to sodium ions, potassium ions are the major intracellular cations, being in higher concentration within the cytoplasm of the cells.
- Potassium ions must be taken in daily diet.
- An average human being must intake 3 to 4 grams of potassium daily.
- Source: fruits like bananas, oranges, vegetables like potatoes, and meat like chicken and liver.

- Potassium is one of the body's electrolytes that carry an electric charge when dissolved in body fluids such as blood.
- Most of the body's potassium is located inside the cells.
- Potassium is necessary for
  - ✓the normal functioning of cells,
  - ✓Nerve impulse transmission, and
  - ✓Muscles contractions.

- The body can use the large reservoir of potassium stored within cells to help maintain a constant level of potassium in blood.
- Its concentration in plasma is much raised during hemolysis (destruction) of red blood cells.

1) How much is the body requirement of potassium and where do we get it from?

2) What is the importance of Potassium ions?

D. Calcium ion

- Calcium is the most abundant inorganic ion present in our body having great importance.
- It is a positively charged ion mainly present in the cytoplasm of cells.
- Importance
  - ✓Required for formation, growth and development of Bones and teeth.
  - ✓Muscle contraction
  - ✓help for the transmission of nerve impulses
  - ✓Blood coagulation
- Calcium requirements of a healthy human are around 800 mg/ day.

- sources : Milk and milk products , leafy vegetables, egg yolk, fish, and beans
- Calcium makes around 1 to 1.5 kg of our body weight.
- 99% of calcium is present in bones and teeth.



- around 1% of calcium is in the cytoplasm of other cells and extracellular fluid performs several important functions in our body.
- Calcium concentration in the plasma is around 9-11 mg/dl.

E. Phosphate ions

- These are the negatively charged inorganic ions abundantly present in our bodies.
- The body of an average man contains around 1 Kg of phosphate ions.
- Most of the phosphate ions are presently combined with calcium in bones and teeth.
- Its requirements are equivalent to calcium.
- Importance:
  - ✓ For formation of teeth and bones
  - ✓ ATP synthesis
  - ✓ Nucleic acid synthesis
  - ✓ Protein and enzyme activation
  - ✓ Acid base balance

- An adult male needs to take 800 mg of phosphate ions daily in his diet.
- Milk, cereals, meat, and eggs are rich sources of phosphate ions.
- The plasma concentration of phosphate ions is around 3-4 mg/dl.
- It is more abundantly present in the cells.

What is the importance of phosphate ions?

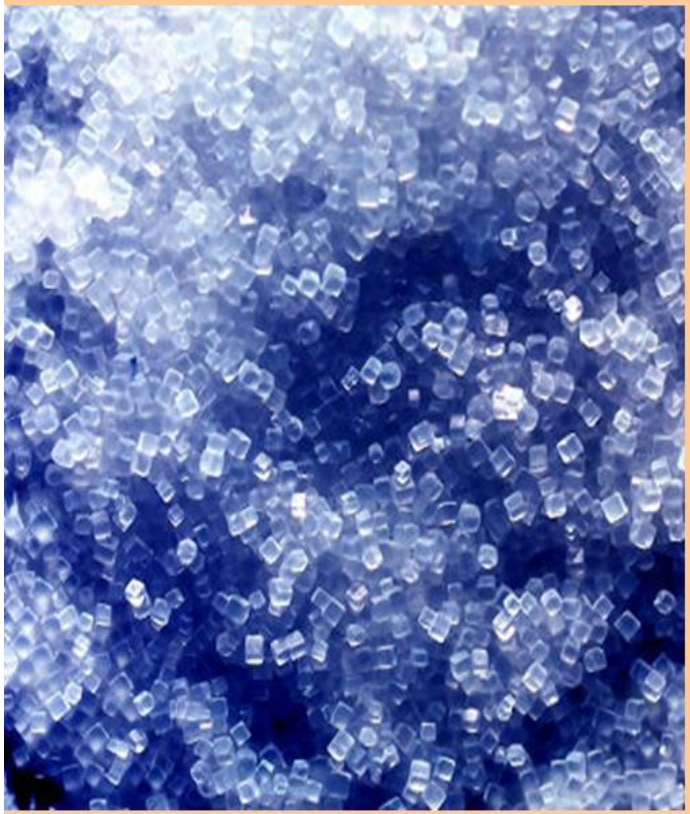
How much is the body requirement and from where do we get Phosphate ions?

F. Chloride ions

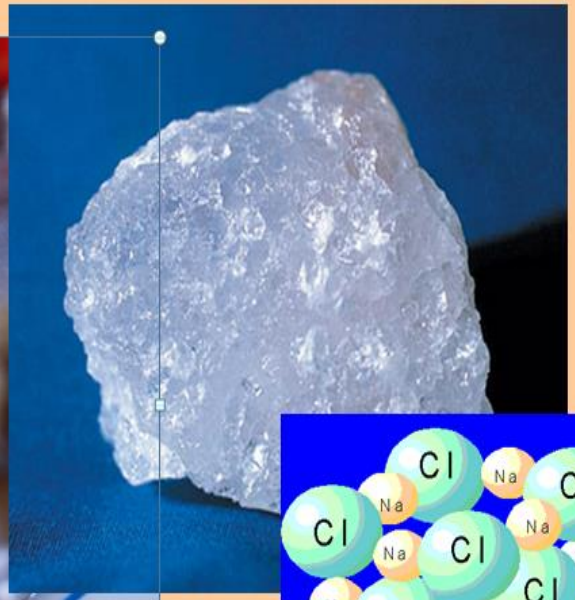
What are the sources and body requirements of Chloride ions?

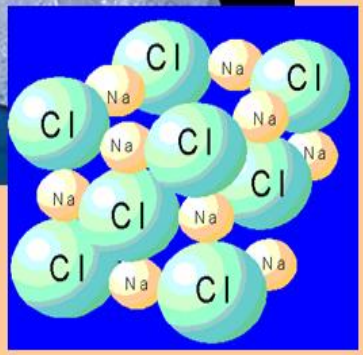
- These are the negatively charged inorganic ions present in extracellular fluids.
- Its concentration in the body is almost similar to that of sodium ions, the major extracellular anions.
- Its average daily requirement is 5-10 gm per day.
- Exist in the form of NaCl present in cooked food.
- Chloride ions perform their role in combination with sodium ions.

Together they form salt









Sodium and chloride are essential macrominerals.

- They are involved in maintaining :
  - ✓ the osmotic pressure,
  - ✓ fluid balance, and
  - ✓ acid-base balance in our body, just like sodium.
  - ✓ to make Hydrochloric acid (HCl) present in gastric juice, which is necessary to digest proteins in the stomach.
- Hydrochloric acid (HCl) in return kills bacteria and other pathogens in food when it enters the stomach.
- Salivary amylase is an enzyme to digest starch that is activated by chloride ions.

G. Iron ions

- These are the positively charged ions present in our body.
- Iron is needed for the transport of oxygen and carbon dioxide in our bodies.
- Around 70% of iron ions in our body are present in haemoglobin within the red blood cells.
- **Source** of iron: legumes such as beans, red meat, liver, spinach, pumpkin seeds, fish, kidney, etc.

What is the importance of Iron ions to human beings?

- As a component of haemoglobin and myoglobin

- It is an essential component of cytochromes that are a component of the electron transport chain.
- Iron is a component of the peroxidase enzyme, a lysosomal enzyme necessary for bacteria and other phagocytosed particles in the white blood cells.

What could be the consequence of abnormal Iron metabolism in our body?

- Three clinical conditions associated with the abnormal iron metabolism in our body are:

- Iron-deficiency Anemia: a common condition in individuals with an iron-deficient diet,
- Hemosiderosis: characterized by **excess iron** in the body
- Hemochromatosis: a condition which **abnormal iron deposits** are formed in the liver, spleen, skin, and pancreas.

H. Copper ions

- Copper ions are the positively charged inorganic ions that are present in our bodies.
- Sources: shellfish, nuts, organ meats, wheat, whole-grain, chocolate, etc.
- It is an essential component of several important proteins and enzymes.
- They are needed for the synthesis of haemoglobin, collagen, and elastin.
- Also, it is required for the normal development of the nervous system.

What happens during abnormal copper metabolism?

- Wilson disease is a rare clinical condition caused by abnormal copper metabolism in our body.
- It is characterized by abnormal copper deposition in the liver and brain causing hepatic cirrhosis and brain damage.
- The copper deposition in kidneys can cause renal failure.

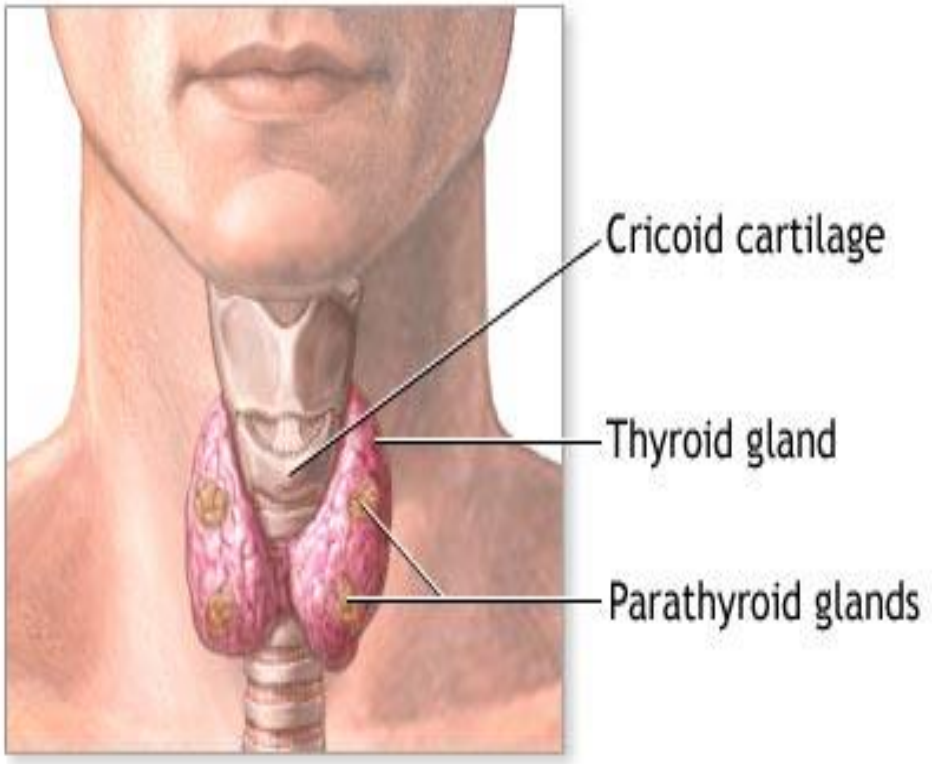
I. Iodine ions

What are the sources and body requirements of iodide ions?

- Iodine is a type of mineral found naturally in the earth's soil and ocean waters.
- Many salt water and plant-based foods contain iodine, and this mineral is most-widely available in iodized salt.
- Iodine plays a vital role in the thyroid health.
- Makes thyroid gland to work properly.

Cont..

- Thyroid gland, which is located at the base of the front of the neck, helps regulate hormone production.
- These hormones control metabolism, heart health, etc.



- To make thyroid hormones, thyroid gland takes up iodine in small amounts.
- Without iodine, thyroid hormone production can decrease.
- A "low" or underactive thyroid gland can lead to a condition called hypothyroidism.
- You can get enough iodine from your diet by eating dairy products, fortified foods, and salty water fish.

- Iodine is also available in plant foods that grow in naturally iodine-rich soil.
- You can also get the mineral by adding iodized salt in your food.
- Effects of deficiency: Goiter
- Goiter is an enlarged thyroid gland.
- Your thyroid may become enlarged as a result from either hypothyroidism or hyperthyroidism.
- Hyperthyroidism is an overactive thyroid gland.
- Amount of iodine ions required for the normal function in adolescents and adults is 150 micro gram/day.

Home work

Activity 3.5 Fill in the blank spaces in the table

Fill in the blank spaces in the table with appropriate answers

Type of Inorganic Ions	Source of inorganic ions	Amount required	Importance	Type of deficiency disease	Excess intake results in
Hydrogen ions					
Sodium ions					
Potassium ions					
Calcium ions					
Phosphate ions					
Chlorine ions					
Chloride ions					
Iron ion					
Copper ions					
Iodine ions					

3.1.3. Organic molecules

What are organic molecules?

- An organic molecule is a compound that contains carbon and hydrogen and is found in living things.
- Carbon forms the basis of organic life due to its ability to form large and complex molecules via covalent bonding.
- There are four major groups of organic compounds:
- These are carbohydrates, lipids, proteins, and nucleic acids.
- They are large molecules containing C and H.

What monomers do make up organic molecules?

- Organic molecules (carbohydrates, lipids, proteins, and nucleic acids) are made up of small, single molecular units (monomers).
- Monomers are connected by strong covalent bonds to create polymers.
- Polymers are long chains of molecules formed of many single units bonded one after the other.
- Carbohydrates, lipids, proteins, and nucleic acids are made of glucose, fatty acid and glycerol, amino acids and nucleotide monomers respectively.

Table 3.3 Elements and monomers forming organic molecules

Organic molecules	Elements forming the molecule	Monomer
Proteins	C, H, O and N	Amino acids
Lipids	C, H, O	Glycerol and fatty acid
Carbohydrates	C, H, O	Monosaccharides Glucose Galactose Fructose
Nucleic acids	C, H, O, N and P	Nucleotides

Carbohydrates

What are carbohydrates?

- Carbohydrates are biological macromolecules
- Carbohydrates provide energy to the body, particularly through glucose, a simple sugar.
- Also store energy in humans, animals, and plants.
  - ✓Starch in plants and glycogen in human and animal
- Structural support for plant cells, fungi and other arthropods.
- Sources: fruits,

  vegetables

  grains



Figure 3.5 Food items rich in carbohydrate

- made of three major elements; carbon, hydrogen, and oxygen.
- the ratio of hydrogen to oxygen is 2:1
- There are three main groups of carbohydrates based on the number of monomers in the molecule;

    A. Monosaccharides,

    B. Disaccharides

    C. Polysaccharides.

A. Monosaccharides

- are molecules that contain only one sugar unit(mono.
- The simplest carbohydrates
- dissolve quickly in water, forming sweet-tasting solutions.
- general formula $(CH_2O)n=(CnH_{2n}O_n)$

  where n-number of carbon.
- the ratio of carbon to hydrogen to oxygen is 1:2:1.

- When categorizing monosaccharides based on the number of carbon atoms in each molecule, the following are the most common:

  1) trioses (3C),

  2) pentoses (5C), and

  3) hexoses (6C).

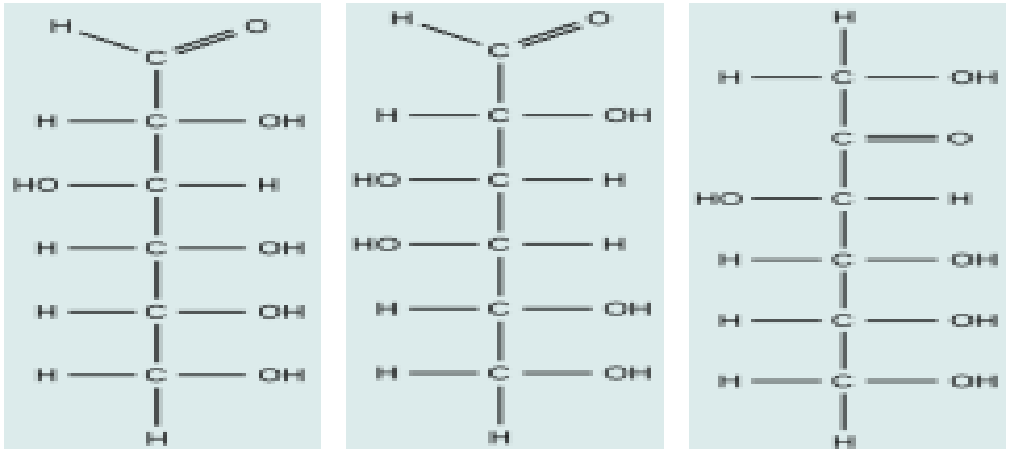
What is the formula of a:

Triose sugar?= $C_3H_6O_3$

Tetrose sugar? = $C_4H_8O_4$

Pentose sugar? = $C_5H_{10}O_5$

- The chemical formula for hexose sugar is $C_6H_{12}O_6$.
- The most common monosaccharides are **Glucose, galactose and fructose.**
  - ✓They have identical chemical formula
  - ✓Differ structurally and chemically
  - ✓Are known as **isomers** due to different atom positions in the carbon chain.



Glucose *Galactose* *Fructose*

Figure 3.6 Structural formula of glucose, Galactose and Fructose

Roles of monosaccharides in living organisms

- Monosaccharides are the simplest forms of sugar and the most basic units (monomers) from which all carbohydrates are built.
- Major functions of monosaccharide in include:

1. as a source of energy in respiration:

✓ due to a large number of carbon-hydrogen bonds.

✓ These bonds can be broken to release a lot of energy, which is transferred to help make ATP from ADP and phosphate.

✓ The most important monosaccharide in energy metabolism is glucose.

2. as building blocks for larger molecules:

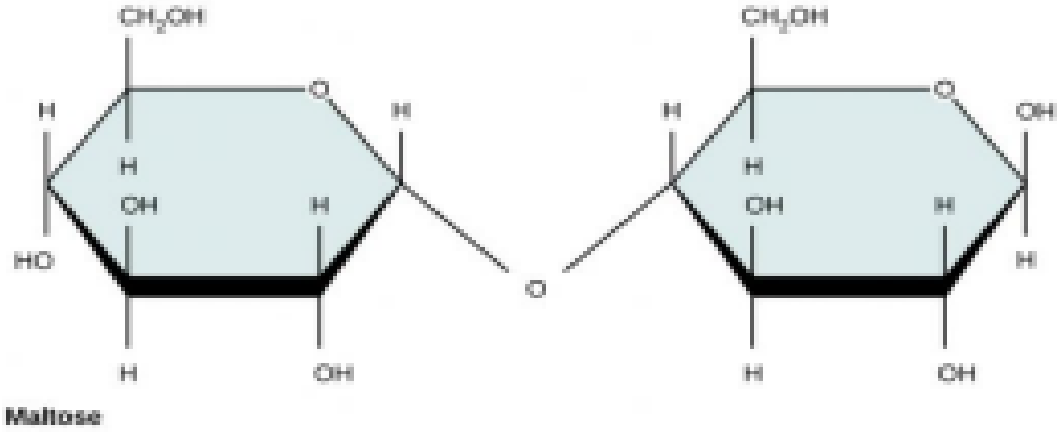
- ✓ for example, glucose is used to make the polysaccharides starch, glycogen, and cellulose.
- ✓ Ribose (a pentose sugar) is one of the molecules used to make RNA (ribonucleic acid) and ATP.
- ✓ Deoxyribose (also a pentose sugar) is one of the molecules used to make DNA.

B. Disaccharides ($C_{12}H_{22}O_{11}$)

- are formed of two monosaccharides.
- The three most common disaccharides are:

1) Maltose, which is composed of glucose + glucose,
2) Lactose, which is composed of glucose + galactose
3) Sucrose, which is composed of glucose + fructose

- **Maltose** or malt sugar is the product of breakdown of starch catalyzed by the enzyme amylase.
- **Sucrose** is the transport sugar in plants and the sugar that is commonly purchased in stores.
- **Lactose** is a sugar found in milk



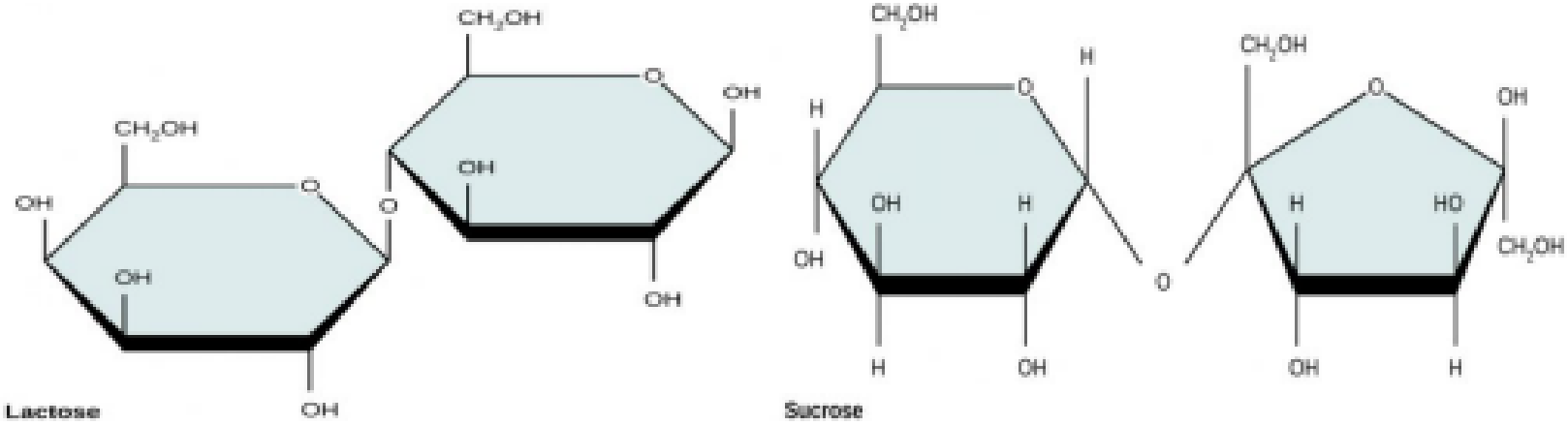


Figure 3.7 Disaccharides a) Maltose b) Lactose c) Sucrose

C. Polysaccharides -$(C_6H_{10}O_5)$-n

- Are complex carbohydrates made of a number of monosaccharides molecules bonded together.
- The most important polysaccharides are starch, glycogen, and cellulose.
- made of polymers of monomer glucose.
- **Starch-** storage forms of glucose in plants
- **Glycogen**- storage forms of glucose in animals
- Glucose is the primary source of energy for cells
- Glucose is a reactive molecule that would disrupt normal cell chemistry.

- Condensation reactions convert glucose to a storage polysaccharide, which is a convenient, compact, inert (un-reactive), and insoluble molecule, avoiding these issues.

Laboratory Activity 3.9 Test for reducing sugars

- All monosaccharides, such as glucose, and some disaccharides, such as maltose, are considered reducing sugars.
- they can carry out a reduction reaction.
- Result: If reducing Sugars present-convert soluble blue copper sulphate, which contains copper(II) ions, to insoluble **brick red** copper oxide, which contains copper (I).
- A brick-red precipitate of copper oxide can be seen.
- Sucrose is the only common non-reducing sugar.
- Result: If there is **no colour change**, there is no reducing sugar
- The Benedict's test, which uses Benedict's reagent.
- Benedict's reagent is a blue-coloured copper (II) sulphate solution in an alkaline solution.

Home Work

Laboratory Activity 3.10: Study of traditional beverages of Ethiopia

In Ethiopia traditional beverages are so delicious with mild alcoholic contents. There are typical procedures to prepare each of these traditional beverages. Being in groups of 3-4, study methods of preparation of one of the traditional beverages: Borde, Shameta, Tej or Tela

Methods of study:

Interview local producers

Observation

Using internet, books, or articles

a) What is the purpose of malting?

b) Do they use Gesho? If so why?

c) Discuss the content of the traditional beverage and the process of their preparation.



Starch [-($C_6H_{10}O_5$)-n]

- Is a polymer of glucose molecules.
- Starch is the plant's stored form of sugar.
- Plants can produce glucose, and the surplus glucose is stored as starch in roots and seeds.
- Starch is produced by plants.
- Animals ingest starch, which is broken down into smaller molecules glucose.
- branched molecule.

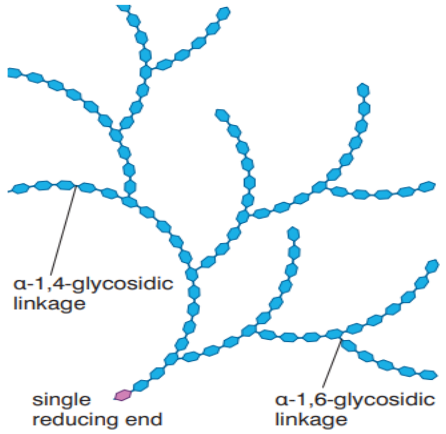


Figure 2.25 *The structure of amylopectin*

Glycogen [-($C_6H_{10}O_5$)-n]

- made up of monomers of glucose
- storage form of glucose in humans and animals.
- Glycogen, the animal analogue of starch, is a highly branched polymer that is often stored in liver and muscle cells.
- Glycogen is produced by animals and is refered to as animal starch.
- if glucose levels fall glycogen is broken down to release glucose.

Cellulose [-($C_6H_{10}O_5$)-n]

- Is made up of glucose monomers
- naturally occurring biopolymer that is abundant.
- Makes plant cell walls, which provides structural support to the cell.
- Wood and paper are examples of cellulosic materials.
- Every glucose monomer in cellulose is densely packed as long extended chains gives its rigidity and high strength, which are critical for plant cells.
- Unbranched polysaccharide.

- *Dietary fiber is cellulose that passes through our digestive system.*
- *Human digestive enzymes cannot break down the glucose-glucose linkages in cellulose,*
- *Herbivores such as cows, buffalos, and horses can digest cellulose rich grass and use it as a food source.*
- *Certain bacteria live in these animals' rumens secrete enzyme cellulase.*
- *Cellulases may degrade cellulose into glucose monomers, which the animal can utilize as an energy source.*
- *Despite their strength, cellulose fibers are porous, allowing water and solutes to pass between the cell surface membrane and the surrounding environment.*

Laboratory activity 3.11: Test for polysaccharides- starch and glycogen

- This test is specific for polysaccharides.
- It is used to differentiate polysaccharides from the rest of carbohydrates.
- This test can be used to differentiate between glycogen, and starch.
- When the iodine reagent is added to the solution, the colour of the solution may change to Blue black, Reddish-purple.

Major functions of carbohydrates

1. Primary source of energy for most organisms.

2. They act as a storage form of energy in the body (e.g. Starch and Glycogen).

- Starch in plants.
- Glycogen in animals, bacteria, and fungi.
- In mammals, glycogen is stored in the liver and muscle

3. They serve as cell membrane components that mediate intercellular communication.

4. They form the structural component of many organisms

- ✓ the cell walls of bacteria, fungi, and the exoskeleton of many insects.
- Chitin-form fungal cell wall

Lipids

What are lipids?

- Lipids are biochemical macromolecules made of elements carbon, hydrogen and oxygen.
- It includes fats and oils and cholesterols.
- Fats are solid at room temperature and oils are liquid at room temperature.
  - ✓Chemically, they are very similar.
- Lipids are insoluble in water but soluble in nonpolar solvents such as benzene, chloroform, and acetone b/c they are nonpolar molecules.

- Lipids are organic compounds formed by fatty acids combining with glycerol(alcohol).

  Examples butter, cooking oil, and the meat

- Lipids are polymers of fatty acids and glycerol molecules.

Fatty acids [$CH_3(CH_2)nCOOH$]

- **$CH_3(CH_2)nCOOH$** is the general formula for fatty acids.
- Contain the acidic group(carboxyl group) –COOH.

- have long hydrocarbon tails attached to the acid 'head' of the molecule.
- hydrocarbon tails consist of a chain of carbon atoms combined with hydrogen.
  - ✓The chain is often 15 or 17 carbon atoms long.
- there are two types of fatty acids: based on the presence or absence of double bonds (–C=C–) in their structure
  - ✓ *Saturated fatty acids*
  - ✓ *Unsaturated fatty acids*

i. **Unsaturated fatty acids**

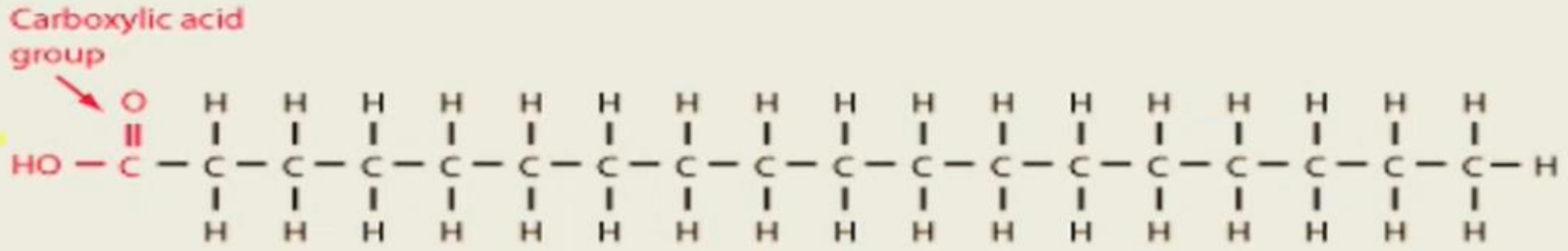
- consist of one or more double bonds in their structure.
- do not contain the maximum possible amount of hydrogen.
- Double bonds make fatty acids and lipids melt more easily.

  Eg. most oils are unsaturated.
- If there is more than one double bond in their structure-polyunsaturated;
- if there is only one double bond, they are called monounsaturated.

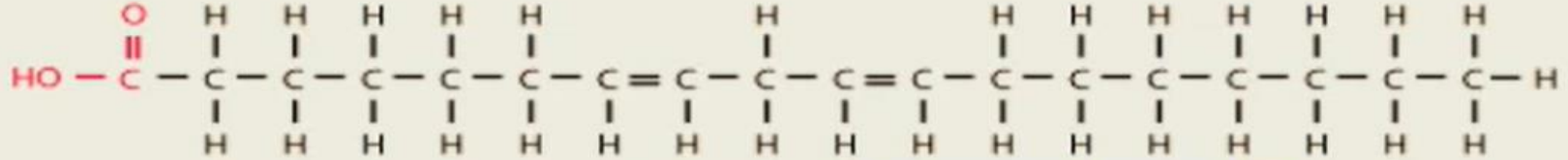
- Plant lipids are often unsaturated and occur as oils, e.g. olive oil and sunflower oil.

ii. Saturated fatty acids

- have no double bonds in their carbon-carbon chain.
- All are solid at room temperature.
- Animal lipids are often saturated and occur as animal fat.
- Fat is stored below the dermis of the skin(acts as an insulator against loss of heat) and around the kidneys.

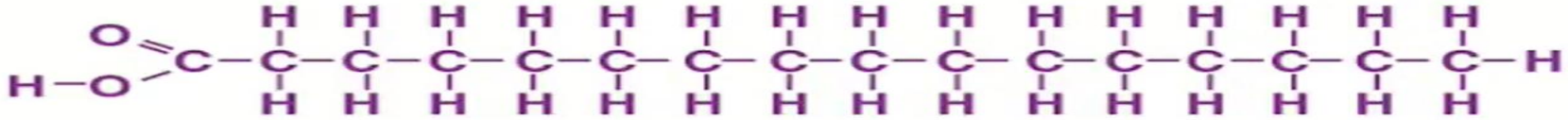


Stearic acid, an example of a saturated fatty acid

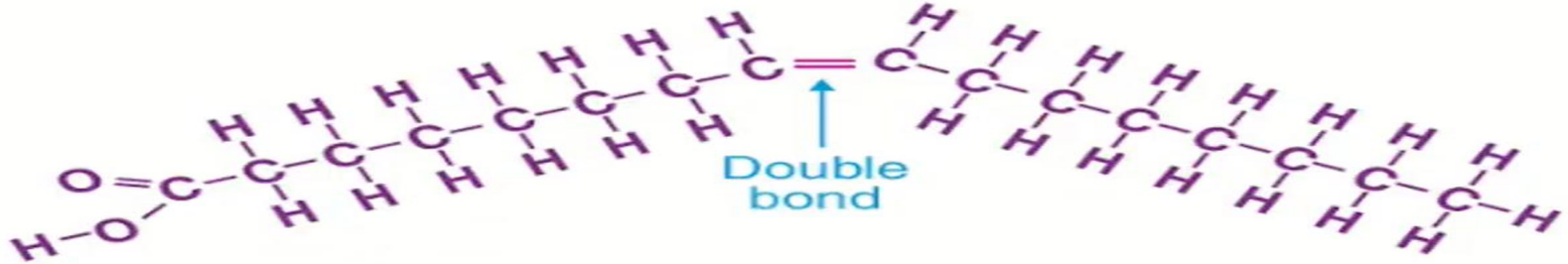


Linoleic acid, an example of an unsaturated fatty acid

Saturated Fatty Acid



Unsaturated Fatty Acid



Lipids are a varied group of compounds that include:

- Phospholipids
- Triglycerides
- Waxes
- steroids

Phospholipids

- ❖ Phospholipids are a subset of lipids.
- ❖ Has unusual property of having one water-soluble end.
- ❖ because one of the three fatty acid is replaced by a phosphate group, which is polar and thus dissolves in water.
- ❖ formed from glycerol, two fatty acids and a phosphate group

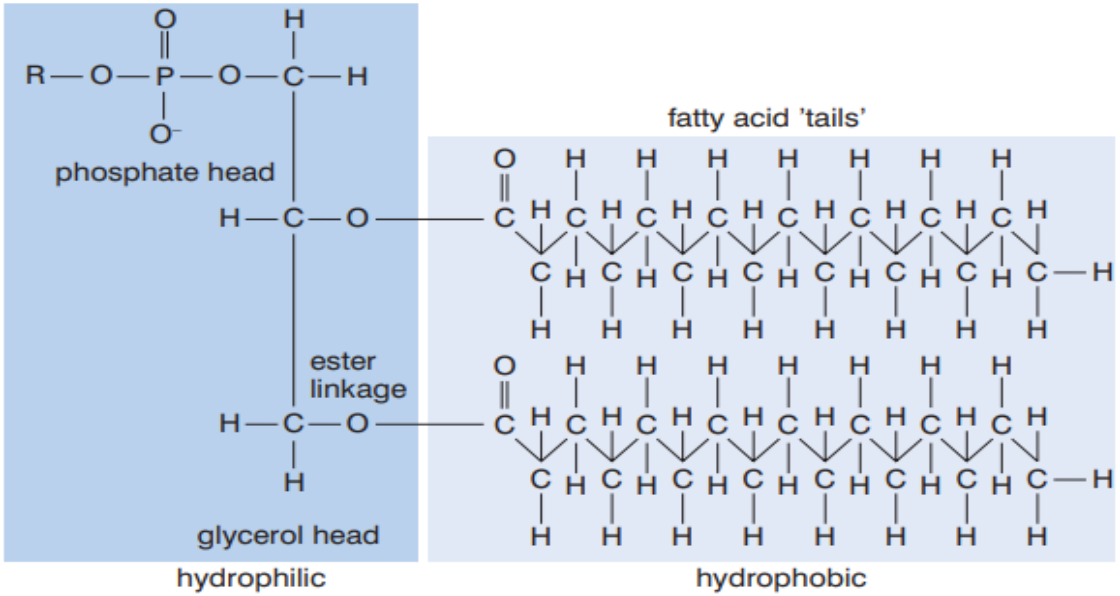
There are two distinct regions to a phospholipid molecule:

i. hydrophilic (water-loving) region,

✓consisting of the phosphate 'head'

ii. hydrophobic (water-hating) region,

✓ consisting of the hydrocarbon 'tails'



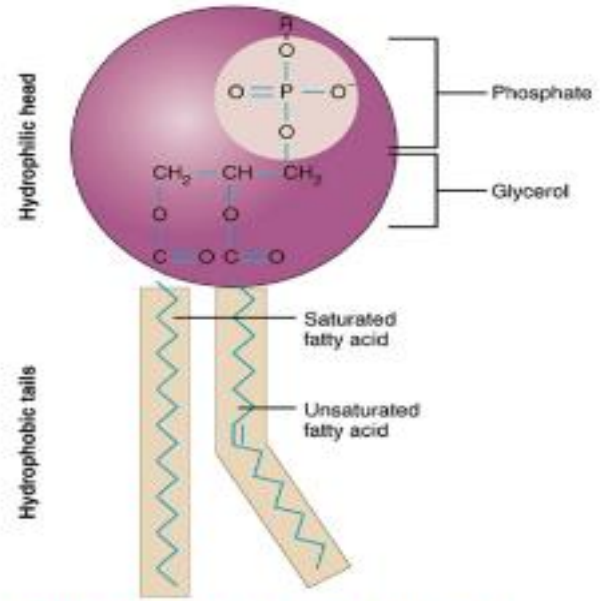


Figure 3.8 A phospholipid molecule

The structure of a phospholipid

- The phosphate group is **hydrophilic** (water-loving) and makes the head of a phospholipid molecule hydrophilic, although the two remaining **tails are still hydrophobic** (water-hating).
- This allows the molecules to form a membrane around a cell
- hydrophilic heads lie in the watery solutions on the outside of the membrane, and
- the hydrophobic tails form a layer that is impermeable to hydrophilic substances.

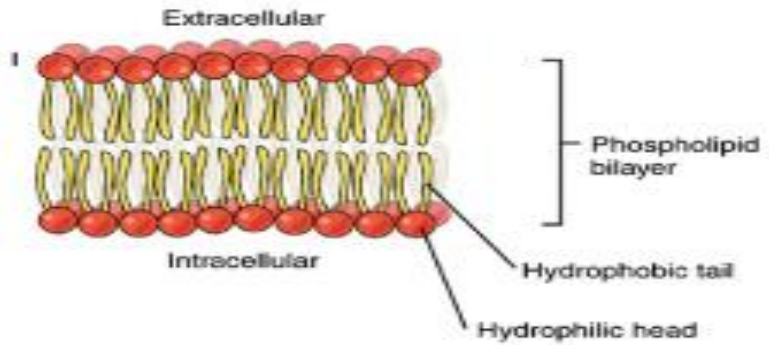


Figure 3.9 Phospholipid bilayer

Major of functions of lipids

1. serve as stored energy(major fuel store).
   - Oil major dietary lipid in plants
   - Fat major dietary lipid in animals

- Fats are stored in specialized cells called adipose cells (fat cells) provide insulation at low temperatures.

2. They serve as structural components in cell membranes (e.g., phospholipids);

3. precursors for the synthesis of
   - Vitamin D,
   - Bile acids,
   - cortisol, and aldosterone(hormones of adrenal cortex);
   - progesterone and estrogen(female sex hormones)
   - Testosterone(male sex hormones) (Cholesterol).

4.Some serve as protective coatings on skin, fur and feathers of animals, birds and fruit and leaves of plants (Example, Wax).

- Waxes also serve as a water barrier for animals, birds and insects; and also protects against cold.

Proteins

What are proteins?

- Proteins are biological molecules
- composed of carbon, hydrogen, oxygen, and nitrogen and sometimes contain phosphorus and sulphur.
- are made up of amino acids monomers.
- They are one of the most abundant organic molecules in living systems and have the widest range of functions of any macromolecule.
- Proteins can be structural, regulatory, contractile, or protective.

- They could be toxins or enzymes, or they could be used in transportation, storage, or membranes.
- Each cell in a living system may contain thousands of proteins, each with a distinct function.
- They are all amino acid polymers arranged in a linear sequence (also referred to as a "peptide").
- They are an extremely important class of macromolecule in living organisms.
- More than 50% of the dry mass of most cells is protein.

- Protein rich food items include; meat, cheese, milk, fish, beans, vegetables, etc.
- Amino acids in protein invariably have the general formula **RCH(NH2)COOH**, where
  - C is carbon,
  - H is hydrogen,
  - N is nitrogen,
  - O is oxygen, and
  - R is a group, varying in composition and structure, called a side chain.

Amino acids

What are amino acids?

- Amino acids are the monomers that make up proteins. Amino acids have:
  - ❖ a central carbon atom which is bonded to
  - ❖ an amino group, –NH2,
  - ❖ a carboxylic acid group, –COOH and
  - ❖ a hydrogen atom
- The only way in which amino acids differ from each other is in the remaining, fourth, group of atoms bonded to the central carbon.
  - ✓This is called the R group

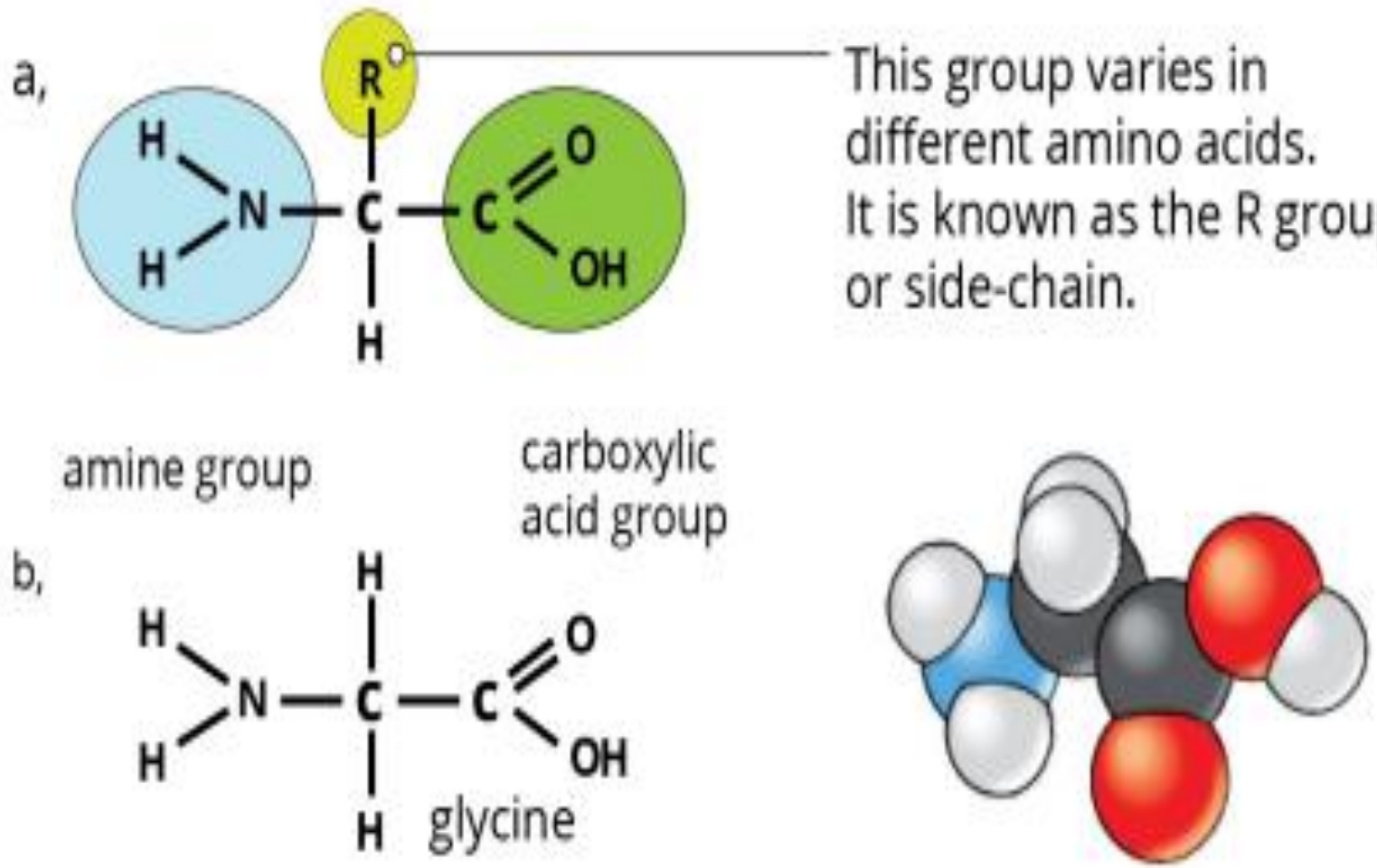


Figure 3.10 General formula of amino acids

- There are 20 different amino acids occur in the proteins of living organisms, all with a different R group.
- The R group is the only difference in structure b/n the 20 amino acids; otherwise, the amino acids are identical.
- Examples of some amino acids (Alanine, valine, lysine, and asparatic acid) are given in figure 3.11 below.

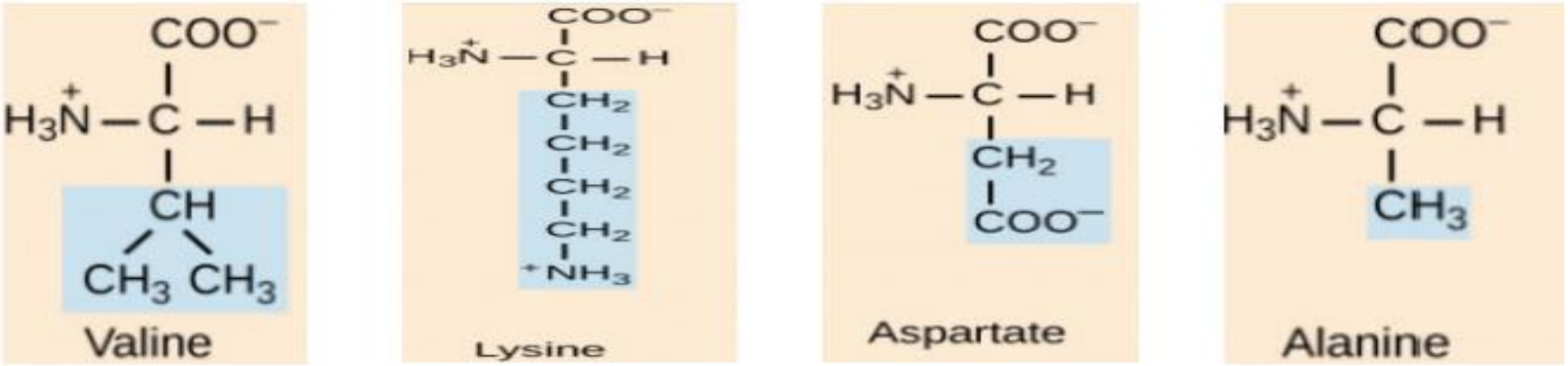


Figure 3.11 Examples of amino acids

- In the process of protein synthesis amino acids join by covalent linkage forming a peptide bond that elongates further and form a polypeptide bond.

The peptide bond

- Each amino acid is attached to another amino acid by a covalent bond.
- One loses a hydroxyl (–OH) group from its carboxylic acid group, while the other loses a hydrogen atom from its amine group.
- Carbon atom of the first amino acid-free to bond with the nitrogen atom of the second.
- The link is called a peptide bond(bond b/n aa).
- The oxygen and two hydrogen atoms removed from the amino acids form a water molecule.

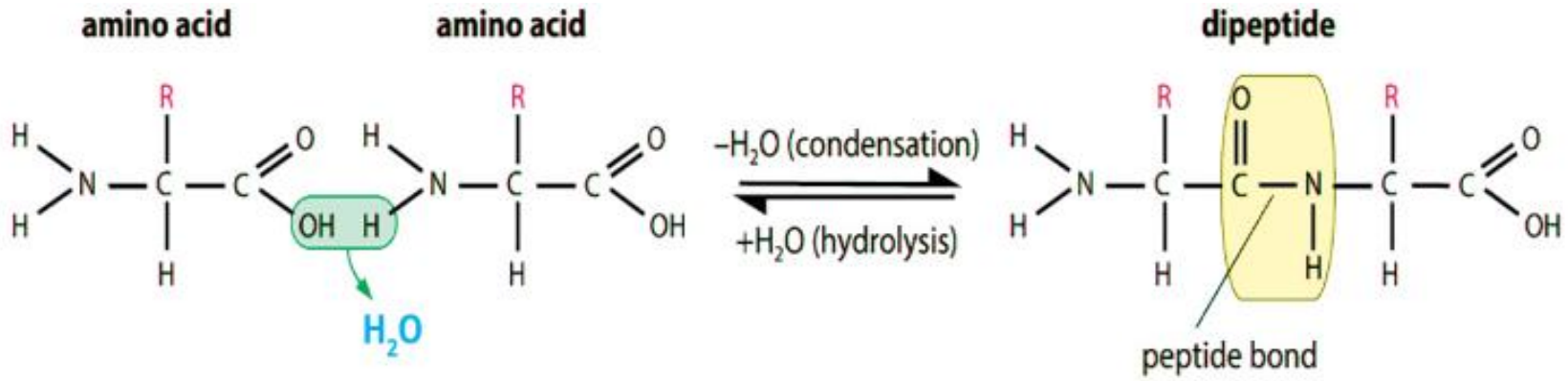


Figure 3.12 Amino acids link together by the loss of a molecule of water to form a peptide bond.

- The new molecule which has been formed is made up of two linked amino acids, and is called a dipeptide.
- Any number of extra amino acids could be added to the chain in a series of condensation reactions.
- A molecule made up of many amino acids linked together by peptide bonds is called a polypeptide.

- In living cells, ribosomes are the sites where amino acids are joined together to form polypeptides.
- The reaction is controlled by enzymes.
- Polypeptides can be broken down into amino acids by breaking the peptide bonds.
- This is a hydrolysis reaction, involving the addition of water, and happens naturally in the stomach and small intestine during digestion.
- Here, protein molecules in food are hydrolyzed into amino acids before being absorbed into the blood.

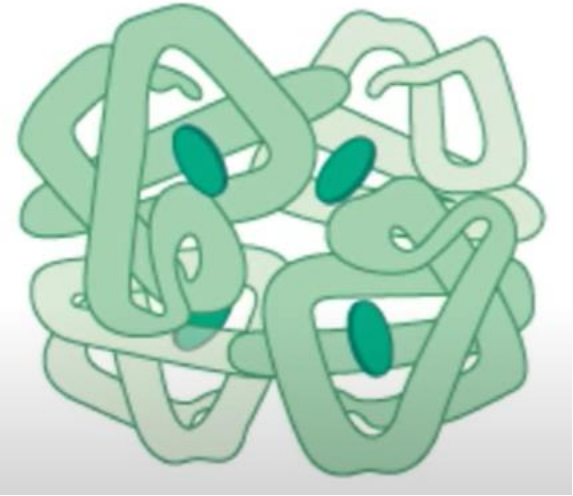
According to their shape, proteins can also be classified into two:

i. Globular proteins

- are protein whose molecules curl up into a **'ball' shape**, such as myoglobin or haemoglobin.
- In a living organism, proteins may be found in cells and other aqueous environments such as blood, tissue fluid, and in the phloem of plants.
- Their non-polar, hydrophobic R groups point into the center of the molecule, away from their watery surroundings.

- Water molecules are excluded from the center of the folded protein molecule.
- Many globular proteins have roles in metabolic reactions.
- Their precise shape is the key to their functioning.

Example: Enzymes, haemoglobin, antibodies



ii. Fibrous proteins

- are protein molecules that do not coil up into a ball but form **long strands**.
- not usually soluble in water and most have structural roles.

Eg.

- ✓ keratin forms hair, nails, and the outer layers of the skin making these structures water proof.
- ✓ collagen which is found in skin, tendons, cartilage, bones, teeth, and the walls of blood vessels.

Major functions of proteins

1. Structural proteins:
   - ✓ are fibrous and tough, as well as insoluble in water.
   - ✓ They are structural elements of connective tissues, bones, tendons, cartilages, nails, hair, and horns.

     Eg. Collagen, elastin, and keratin

2. Enzymes:
   - ✓ are globular proteins that serve as biological catalysts.
   - ✓ They catalyze metabolic reactions by lowering the activation energy, which increases the reaction rate.
   - ✓ include DNA polymerase, lysozyme, nitrogenase, and lipase.

3. Hormones: are polypeptides that are made up of long chains of linked amino acids. They play critical roles in the regulation of the body's physiological processes, which include reproduction, growth and development, electrolyte balance, sleep, and so on. Growth hormone (GH) and follicle-stimulating hormone are two examples of these hormones (FSH).

4. Respiratory pigments: are globular protein pigments that are typically water-soluble. Myoglobin, which provides oxygen to working muscles; and haemoglobin, which transports blood to all tissues and organs via the blood, is the two examples.

5. Transport proteins:

- ✓ They create channels in the plasma membrane to transport specific molecules within the cells.
- ✓ Serum albumin (which transports hemin and fatty acids), channel proteins, and carrier proteins are examples of transport proteins.

6. Motor proteins:

- ✓ are involved in muscle contraction and relaxation (muscle movement).
- ✓ Actin, myosin, kinesin, and dynein are all components.

7. Storage proteins:

- ✓ In cells, these proteins serve as a storage reserve for amino acids and metal ions.
- ✓ They can be found in eggs, seeds, and pulses.

  Eg. Ferritin, ovalbumin, and casein

8. Toxins:

- ✓ Bacteria are the most common producers of these proteins.
- ✓ Diphtheria toxin, Pseudomonas exotoxin, and ribosome-inactivating proteins are among them.
- ✓ By causing cytotoxicity, they aid bacteria in attacking and killing their host organism.

Laboratory Activity 3.18: The Biuret test for proteins

- Proteins react with Biuret reagent to give a mauve/purple colour.

- Laboratory Activity 3.19: Xanthoproteic Test

Nucleic acids(DNA and RNA)

What are nucleic acids?

Are polymers of nucleotides

- Nucleic acids are macromolecules made up of phosphoric acid, sugars, and organic bases.
- C H O N P
- information-carrying molecules, and they determine every living thing's inherited features by directing the process of protein synthesis.
- The two main types of nucleic acids are:
  - Deoxyribonucleic acid (DNA) and
  - Ribonucleic acid (RNA)

The structure of DNA and RNA

- DNA stands for deoxyribonucleic acid and
- RNA for ribonucleic acid.
- DNA and RNA are macromolecules.
- They are also polymers, made up of many similar, smaller molecules joined into a long chain.
- The smaller molecules(monomer) that form DNA and RNA are called nucleotides.
- DNA and RNA are therefore polynucleotides.
- The nucleotides combine to form a polynucleotide.

- Most organisms carry their genetic information in the nucleotide sequences of DNA, but a few viruses carry it in RNA.
- Along the length of the DNA is a series of chemical structures called genes.
- Genes are stretches of DNA that code for RNA and amino acids and, therefore, proteins.

Nucleotides

- Is a building blocks of DNA or RNA
- Figure 3.13 shows the structure of nucleotides.
- Nucleotides are made up of three smaller components.
- These are:
  - ✓ a nitrogen-containing
  - ✓a pentose sugar
  - ✓a phosphate group

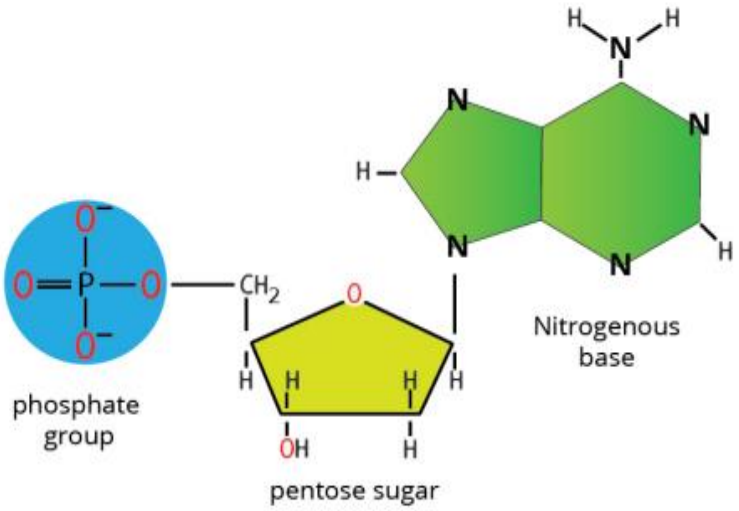


Figure 3.13 The components of nucleotides.

- There are five different nitrogen containing bases in DNA and RNA.

- The four nitrogenous bases in the DNA molecule are adenine, thymine, guanine, and cytosine.
- An RNA molecule also contains four bases, but have Uracil instead of thymine.
- These bases are often denoted by their first letters: A, T, C, G, and U.
- A pairs with T and G with C
- The order and composition of the different nucleotides sequences determines the hereditary function of the nucleic acids.

- The **RNA** pentose (5-carbon) sugar is ribose ($C_5H_{10}O_5$)
- **DNA** 5-carbon sugar is deoxyribose ($C_5H_{10}O_4$) .
- As their names suggest, deoxyribose is almost the same as ribose, except that it has no oxygen atom on its second carbon atom.

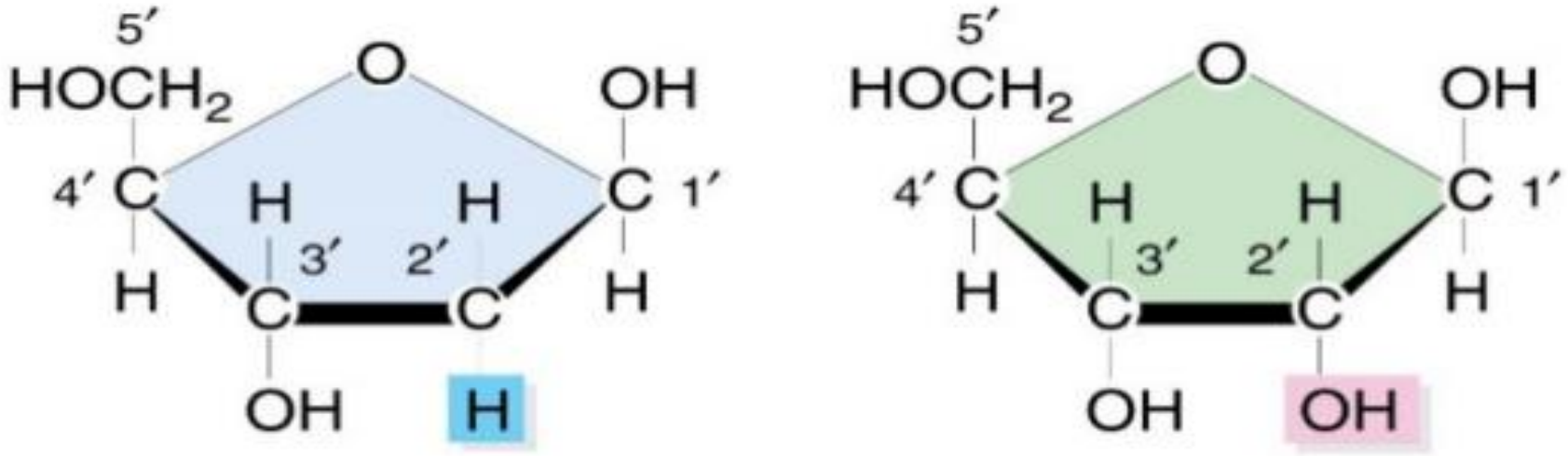


Figure 3.14 Structures of deoxyribose and ribose sugars

- DNA is a large molecule made up of two strands (made of two chains) of nucleotides wounded into a double helix.
  - Two DNA strands linked by bases
  - Adenine pairs with thymine and (A=T)
  - Cytosine pairs with Guanine and C=G
- RNA is much smaller and is single-stranded (made of a single chain).
- There are three types of RNA:
  - ✓mRNA (messenger RNA)
  - ✓rRNA(ribosomal RNA), and
  - ✓tRNA(transfer RNA).

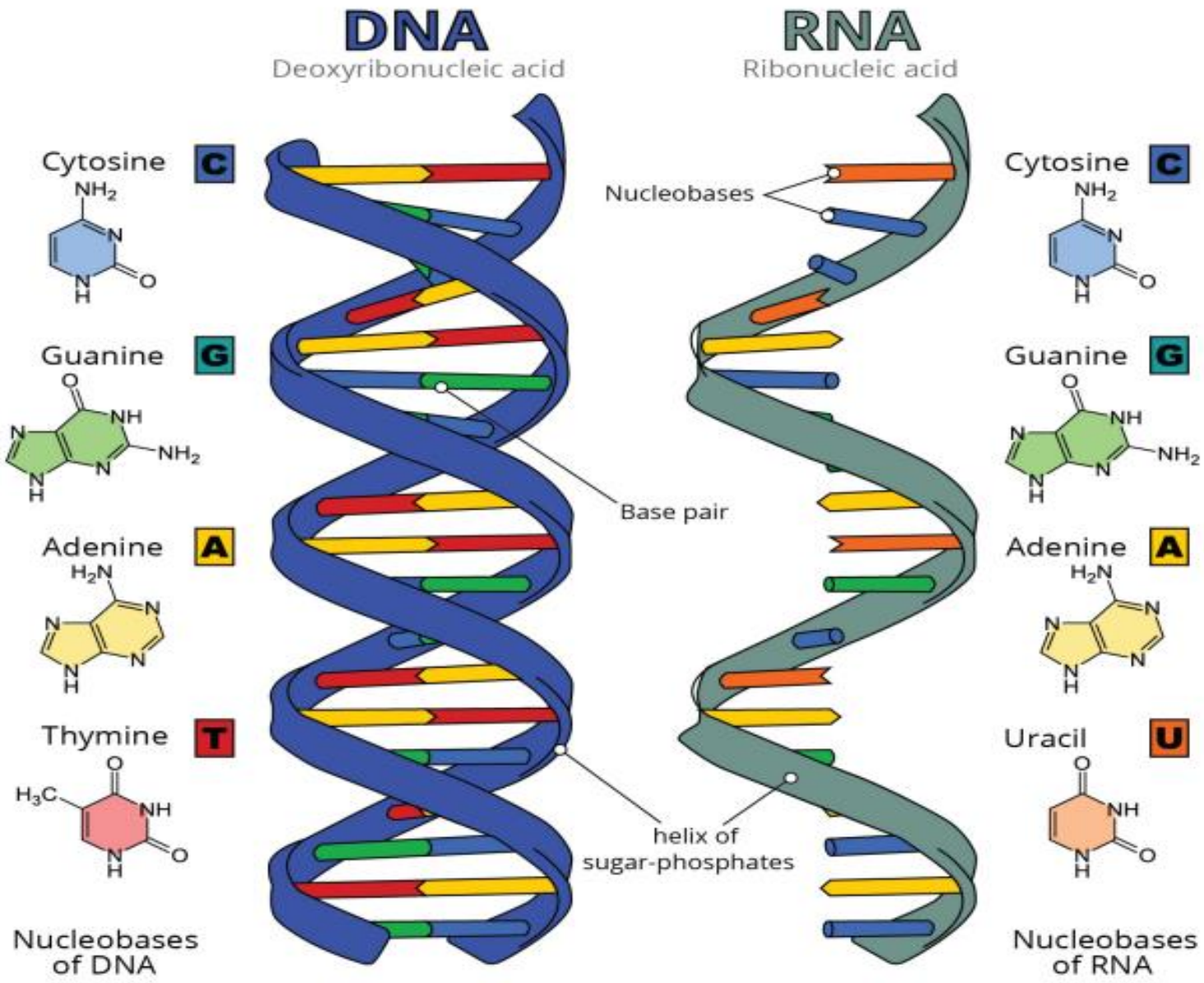


Figure 3.15 The structure of nucleic acids

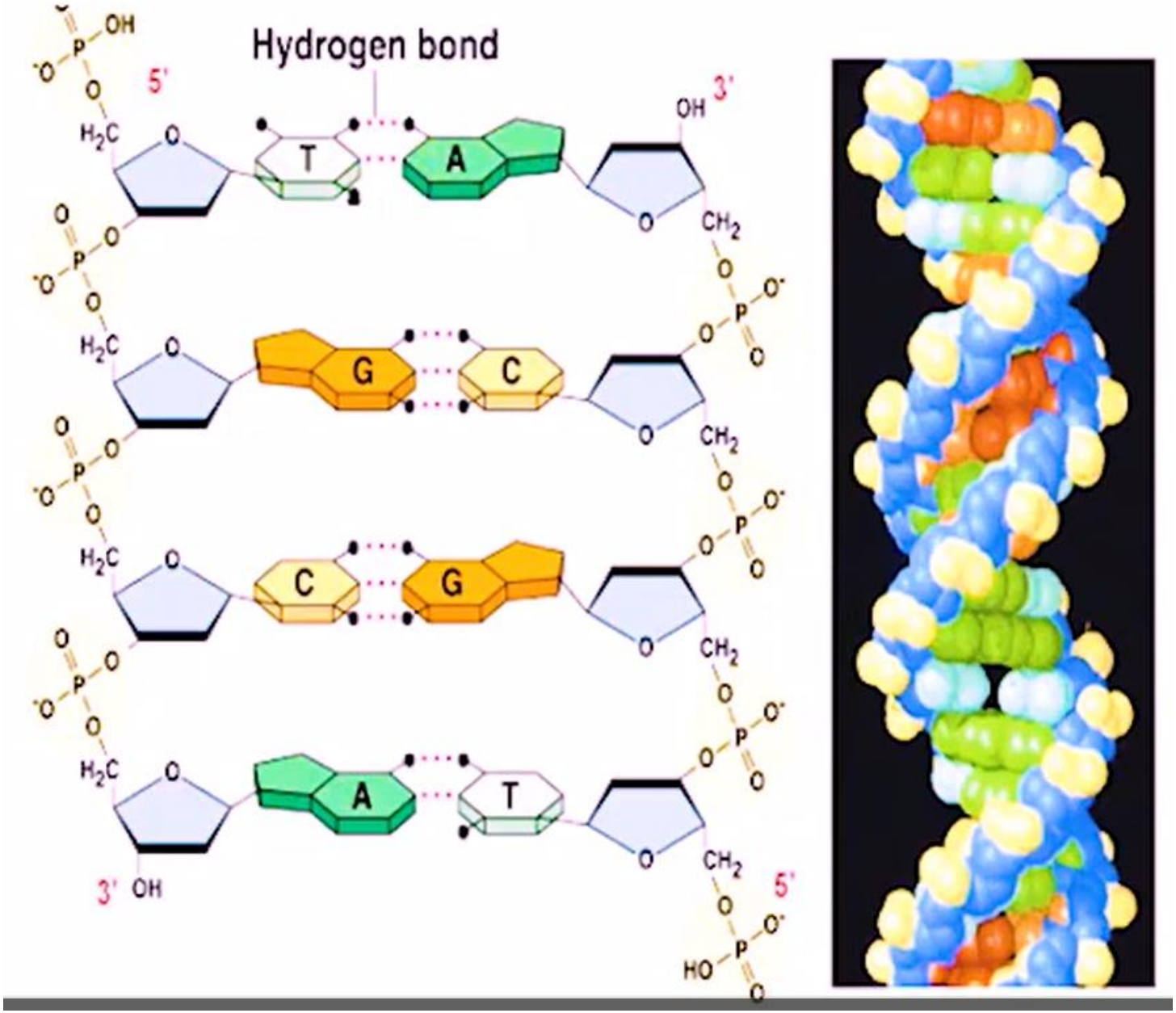

Hydrogen bond
5'
3'
OH
T
A
G
C
C
G
A
T
3'
OH
5'
HO

Table 3.4 Similarities and differences in function and structure of the nucleic acids

Features	DNA	RNA
Nitrogenous bases	Adenine, Guanine, Cytosine, Thymine	Adenine, Guanine, Cytosine, Uracil
Pentose sugar	Deoxyribose sugar	Ribose sugar
Phosphate	Phosphate group	Phosphate group
Size	Huge-allows the molecule to carry the code for many different proteins in the genes	Much smaller-need code for only one protein; small size allows RNA to move out of the nucleus
Stability	Very stable – ensures that the genes remain the same over the generation	Less stable- is degraded quite quickly so does not carry on coding for a protein
Number of strands	Two strands- allow coding of genes and replication during cell division.	Single-stranded- does not replicate

Major functions of Nucleic Acids: DNA and RNA

Deoxyribonucleic acids (DNA)

- It is the genetic material that stores/carries the hereditary information from parents to offspring.
- The genetic information is stored in its nucleotide sequences.
- DNA has a unique property of replication or production of its copy that can be transferred to a daughter cell during cell reproduction.

- It specifies the biological development of all living organisms and viruses.
- It carries the genetic code (instructions for protein synthesis).
- Information coded in the nucleotide sequence of DNA for a particular protein is first copied to mRNA (by the process of transcription).
- The code in the mRNA is then translated into amino acid sequences of protein.
- Proteins are required to build an organism and catalyze all of its biochemical reactions

Ribonucleic acids (RNA)

- It acts as genetic material in some viruses and has enzymatic activity in other organisms (where it is called ribozyme).
- Is mostly involved in protein synthesis
- Three types of RNA are present among organisms:
  - ✓ mRNA,
  - ✓ tRNA and
  - ✓ rRNA.
- All three have essential roles in the development and maintenance of life.
- RNA is transcribed from the DNA, then translated into the proteins.

- mRNA moves the **genetic code** (information for protein synthesis) from DNA to ribosomes (protein-synthesizing machinery in the cell).
  - ✓ The process of making mRNA from the DNA is called transcription
- tRNA helps the proteins synthesis by providing a source of **amino acids** (the building blocks of proteins).
- rRNA form a complex with proteins making the structure the ribosome.

Class Work

- What are examples of globular and fibrous proteins?
- List four nitrogenous bases making DNA molecule.
- List components of nucleotides.
- DNA and RNA are made up of monomers known as .

1. If a strand of DNA is **5'-CATGCGAT-3'**, So, the other strand is---?

A/5'-GTACGCTA-3' **B**/3'-GTACGCTA-5'

C/5'-GUACGCUA-3' **D**/3'-GUACGCUA-5'

2. Based on Chargaff rule, for the base composition of a double helix sample contains 19 % of **T**, what is the percentage of **C** in the DNA?

A/ 31% B/71% C/62% D/19%

Unit 4: Cell Reproduction

4.1 Cell Cycle

What is a cell cycle?

A cell cycle is a sequence of events that takes place in the parent cell as a means of distributing genetic materials thereby forming daughter cells.

- There are two main divisions of the cell cycle:
  - i. Interphase and
  - ii. cell division.



G1 - growth

S - DNA synthesis

G2 - Growth and preparation for mitosis

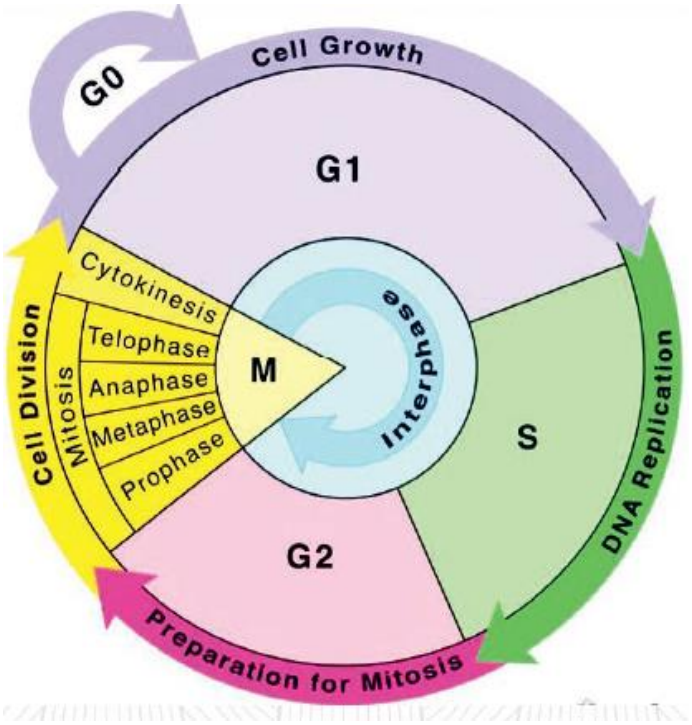
M - Mitosis

Figure 4.1 Stages of the cell cycle

Interphase

- divided into three phases

1. G1 (first gap stage),
2. S (synthesis stage), and
3. G2 (second gap stage).



- is long period of the cell cycle
- **More than 90% of the life of a cell is spent in this phase**

1. G1 Phase (First Gap):

- ☑ is the first stage of interphase.
- ☑ During this stage, cells are quite active metabolically.
- ☑ The cell accumulate the building blocks of chromosomal DNA and the associated proteins
- ☑ as well as store sufficient energy reserves to complete the task of replicating each chromosome in the nucleus.
- ☑ **cell growth, development**

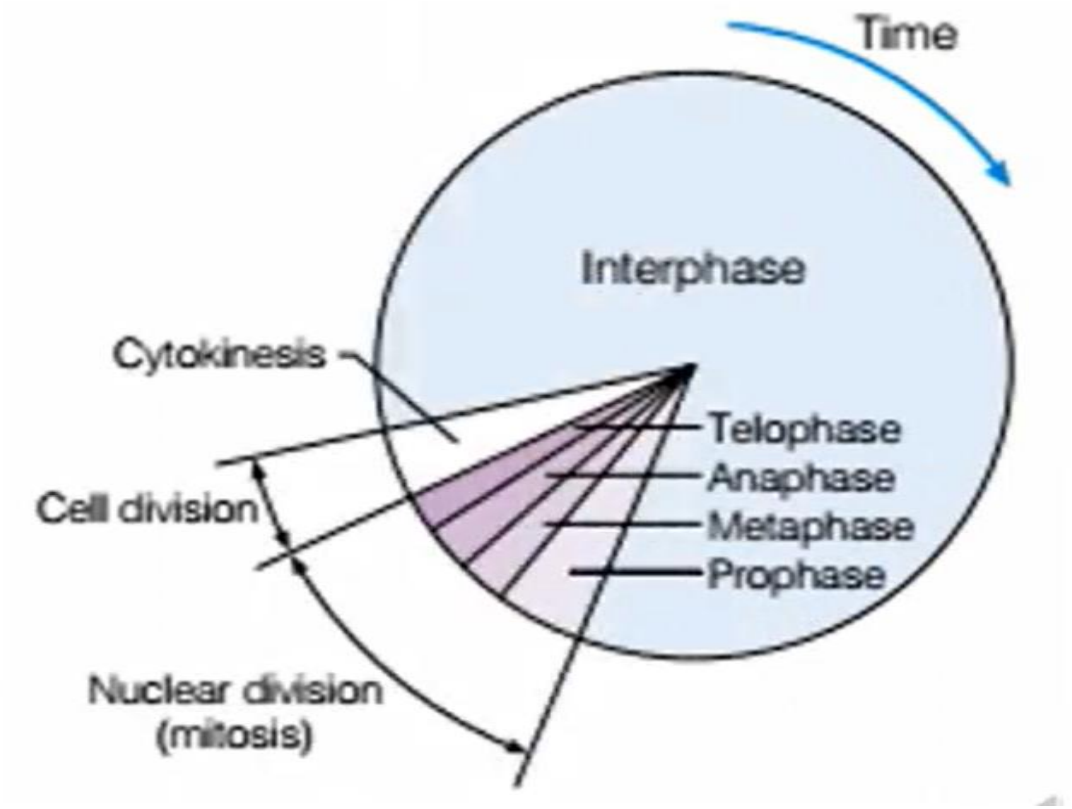
2. S Phase (Synthesis of DNA):

- ✓ is the stage of DNA replication (Synthesis).

3. G2 Phase (second gap):

- ✓ Synthesizes proteins necessary for chromosome manipulation and movement.
- ✓ Some cell organelles are duplicated during this stage.
- ✓ Cells may continue growing during the G2 phase.
- ✓ Cells make the final preparations before entering into the mitotic phase.

- ✓ The cell division includes
  - ✓ nuclear division – Karyokinesis (mitosis, or, M - stage) followed by
  - ✓ cytoplasmic division (Cytokinesis).
- ✓ This ultimately results in two identical daughter cells.



4.2 The Cell division

Q: WHY DO CELLS DIVIDE?

- **Cell division** is a basic process in all living things where a parent or mother cell, divides into two daughter cells.
- An ordered series of events involving cell growth and cell division that produces two new daughter cells are termed the cell cycle.
- Cells on the path to cell division proceed through a series of precisely timed and carefully regulated stages of growth, DNA replication, and nuclear and cytoplasmic division that ultimately produces two identical (clone) cells.

- As the cell grows the volume of cytoplasm relative to the cell membrane will be small that it will have low surface area to volume ratio.
- As a result material transport across the cell membrane by simple diffusion will be inadequate for the cell to survive.
- Thus to solve these problems cell employs a mechanism called cell division by which one cell become two or more.

- The cell is increasing its number as it divides repeatedly.
- The increase in cell number in turn is **important for many reasons**.
- In unicellular organisms, cell division is **a means of reproduction** or getting new offspring.
- For instance, Amoeba is unicellular.
- When a single cell Amoeba divides, it has increased its population, i.e. Number of Amoeba (offspring).

- In **multicellular organisms**, cell division is a **means of increasing cell number** either for growth or to replace damaged/dead cells and repair the body.
- In sexually reproducing organisms it occurs around reproductive organs as a means of getting gametes or sex cells.
- Cell division continues after G2 stage of the interphase.

Cell division consists of two sub divisions

i) Nuclear division (Karyokinesis) – results in the separation and distribution of duplicated genetic materials of mother cell (dividing cell) to daughter cells by **mitosis or meiosis**.

ii) Cytokinesis (cytoplasmic division) - is the separation of the cytoplasmic components into the daughter cells.

4.2.1 Mitosis

What is mitosis?

- Mitosis first coined by Walther Flemming in 1882
- Is a division of somatic (body) cells to form identical daughter cells
- is a type of nuclear division
- where duplicated chromosomes of a single mother cell are distributed between two identical daughter cells,
  - ✓having the same number and kind of hereditary materials (chromosomes) as the parent nucleus.
- A diploid (2n) mother cell gives rise to two diploid (2n) identical daughter cells.

Diploid vs Haploid

- **Diploid** – a cell that contains homologous chromosomes (one from each parent)

✓ represented by the symbol 2N

➢ Found in somatic or body cells (ex. Skin, digestive tract)

- Example : Humans → 2N = **46**

Haploid – a cell that contains only a single set of chromosomes (one from either parent, not both);

✓ represented by the symbol N or 1N

➢ **Found in gametes or sex cells – sperm & egg**

Example: Humans → N = **23**

Mitosis

How does a cell divides by mitosis?

- mitosis as nuclear division (Karyokinesis) is divided into a series of phases namely;
  - prophase,
  - metaphase,
  - anaphase
  - telophase

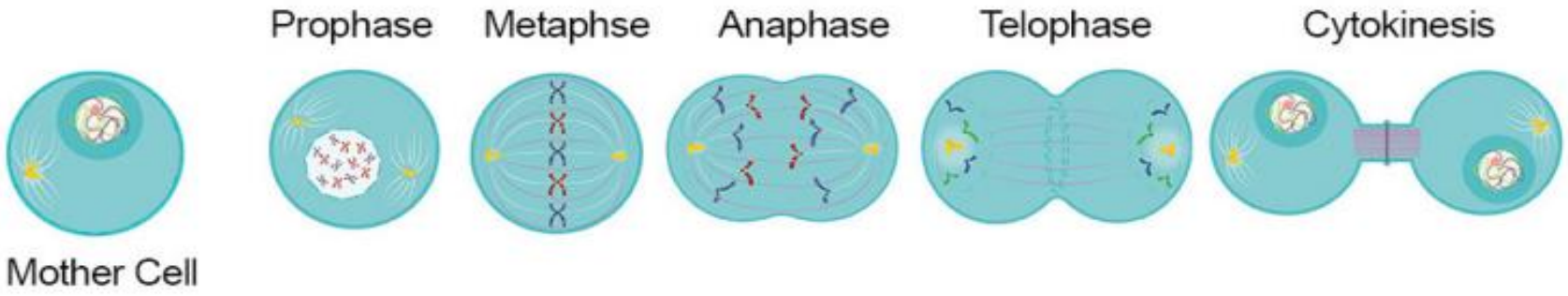


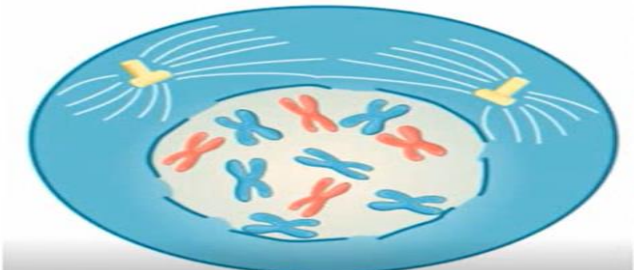
Figure 4.2 Illustration of cell division by mitosis

What happens in the different phases while a cell undergoes mitosis?

1. Prophase (the "first phase"):

During this phase

- ✓ each duplicated chromosome, composed of two sister chromatids and, containing identical genetic material pairs up.
- ✓ the nuclear membrane breaks down, the nucleolus disappears.
- ✓ chromosomes shorten, thicken and become visible.



✓ the centrosomes begin to move to opposite poles of the cell, and spindle fibres emerge from the centrosomes (two in numbers and located outside the nucleus) - Figure 4.2

Sister chromatids:

- Two copies of one maternal or paternal Chrms linked together

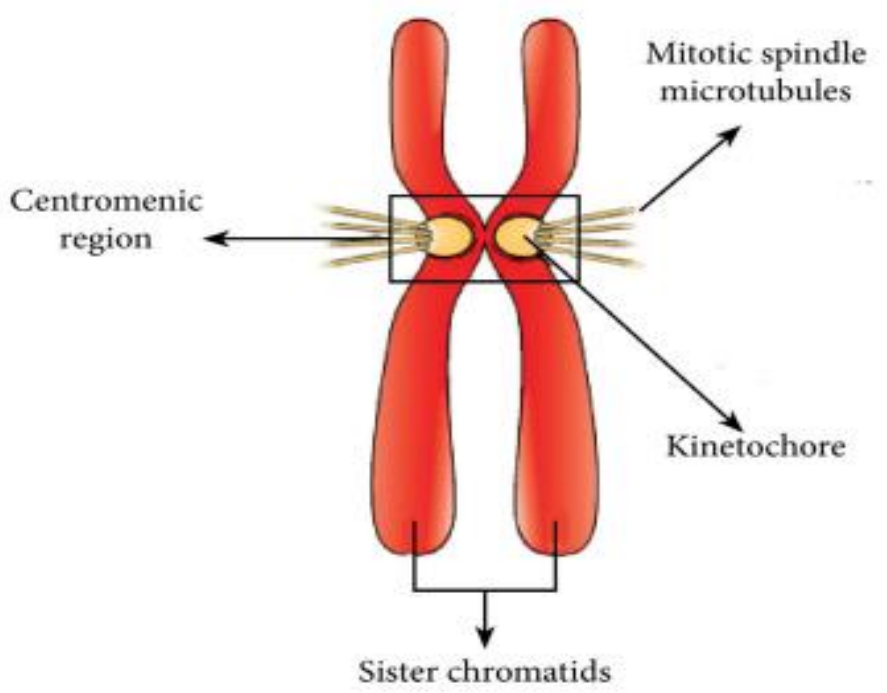
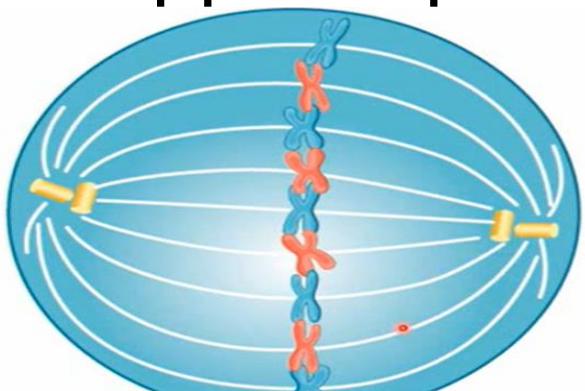


Figure 4.3 Sister chromatids: Mitotic spindle emerging from the centrosomes

2. Metaphase (arrangement phase)

During this phase

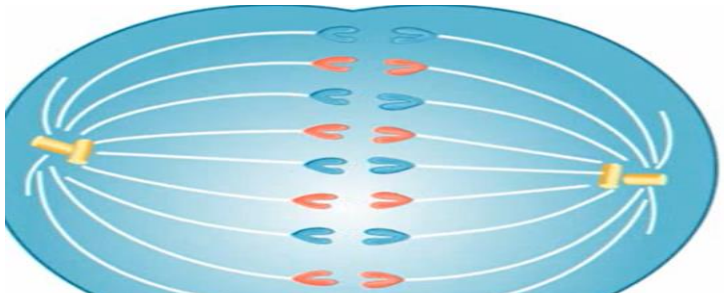
- ✓ mitotic spindles are fully developed with centrosomes at the opposite poles.
- ✓ chromosomes line up (arrange themselves) end–to–end along the centre or metaphase plate (equatorial plane) of the cell.
- ✓ each sister chromatids are attached to a spindle fibre originating from opposite poles.



3. Anaphase (migrating phase)

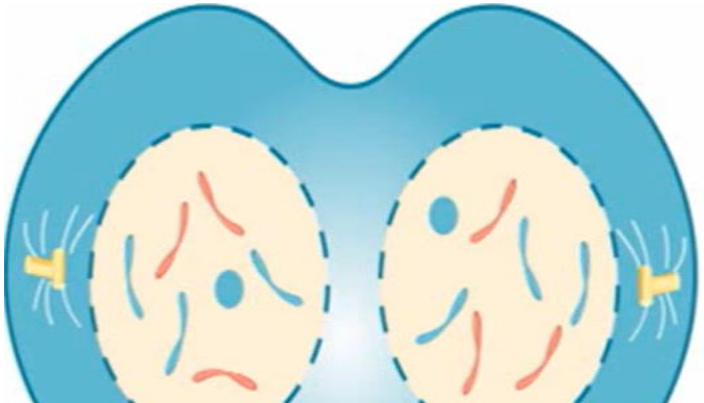
During this phase

- ✓ cohesion proteins binding the sister chromatids together known as centromere, breakdown.
- ✓ separated sister chromatids are pulled apart by the mitotic spindle which drags one chromatid to one pole and the other chromatid to the opposite pole.
- ✓ This will ensure daughter cells receive chromosomes that are the same in number and kind.



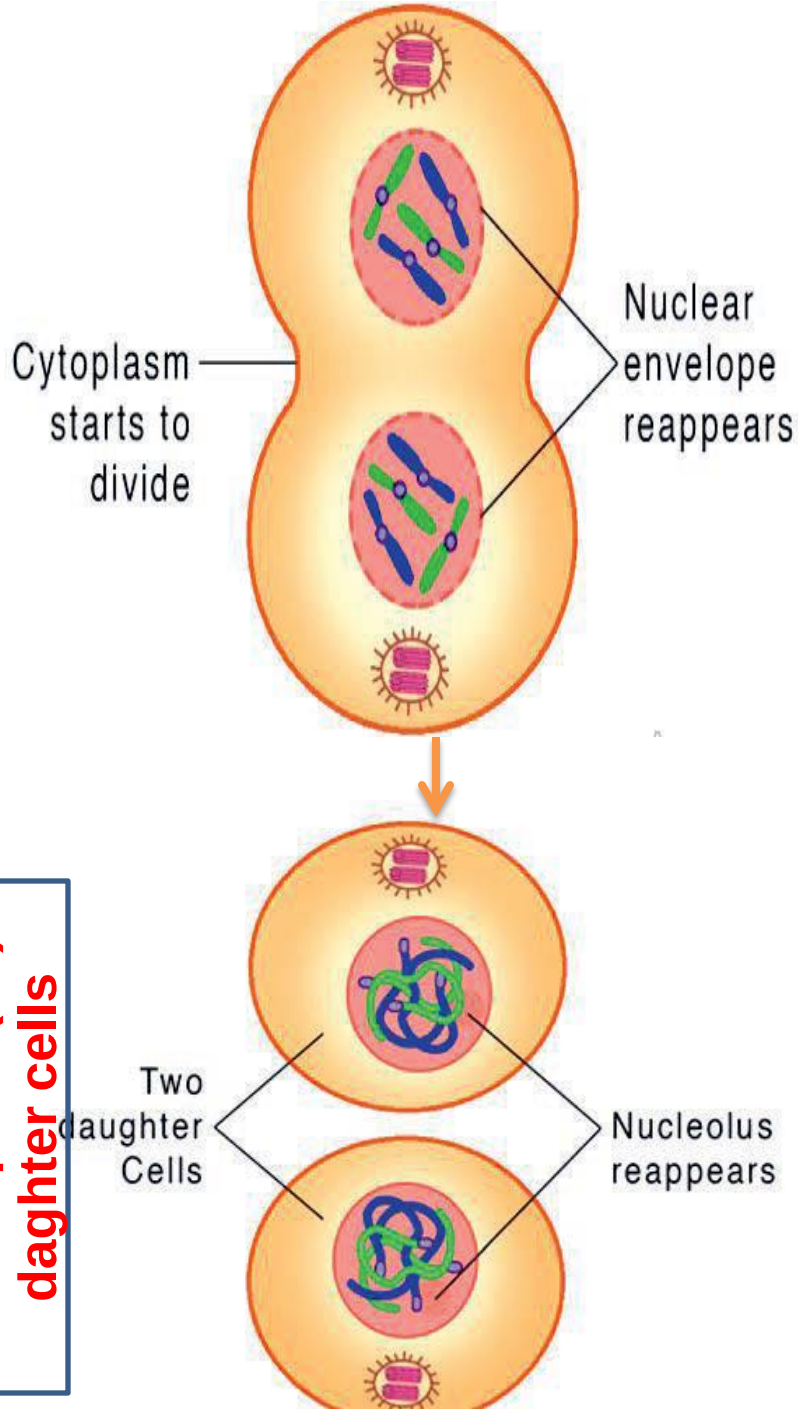
4. Telophase (a reverse of prophase)

- ✓ This phase is also known as a reversed prophase because what has disappeared during the interphase will reappear during the telophase and vice versa. Accordingly,
- ✓ nuclear membrane reappears and surrounds each set of chromosomes to create two new nuclei arriving at opposite poles.
- ✓ The mitotic spindle breaks down and disappears.



Cytokinesis

- known as cytoplasmic division
- separation of the cytoplasmic components resulting in two genetically identical daughter cells
- take place after the four stages of mitosis (nuclear division) are completed.



- However, its completion in animal cell is different from plant cell.
- As animal cell is surrounded only by cell membrane, cytokinesis enables the cytoplasm of the mother cell to pinch or constrict in the middle.
- However, as plant cell is surround by hard cell wall in addition to the cell membrane , the cytoplasm cannot simply pinch off and fully separate; instead a new wall will be laid down between the two daughter cells,
- Thus, the two adjacent cells remained joined together by the middle wall – called middle lamella

- The redistribution of duplicated chromosomes through mitosis is important to get two daughter cells from single diploid mother cell that are identical in quality and quantity of chromosomes.
- The process of mitosis is important to increase cell number, which in turn is essential for growth.
- We, human beings, after the union of haploid (n) sperm and haploid (n) egg started as a zygote, which is diploid (2n).
- Then the zygote by repeated cell division through mitosis develops into multicellular organism.
- This is how we human beings are made up of million cells.

- Cells have a finite life span; they wear out or become damaged; so they need to be replaced continuously.
- The process of growth, repair and replacement of dead cells all rely on cell division through mitosis.
- Unicellular organisms like Amoeba also use cell division through mitosis to increase their number or population.

Class Work

1. List the importance of mitosis to living organisms?
2. If a human skin cell has 46 chromosomes and undergoes mitosis. How many chromosomes will present in each daughter cells when mitosis is complete?

   A. 23 B. 46 C. 92 D. 5

3. Replication of DNA occurs during

A. Prophase B. Anaphase

B. C. Methaphase D. Interphase

Quiz (2.5) Match column A with column B

No	A	B
1	Chromosomes line up along the centre (equatorial plane) of the cell.	A. Cytokinases
2	Separated sister chromatids are pulled apart by spindle & move to the opposite pole.	B. Metaphase
3	The nuclear membrane breaks down, the nucleolus disappears.	C. Anaphase
4	Nuclear membrane reappears	D.Telophase
5	Separation of the cytoplasmic components resulting in two genetically identical daughter cells	E. Prophase

The End of Seml

Thank you!