Anfal academy

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BIOLOGY – DIVE INTO LIFE

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ANFAL ACADEMY

PREFACE

Biology is a natural science concerned with the study of life and living organisms including their function , Structure , growth , evolution , distribution , identification and Taxonomy. Modern Biology is vast and eclectic field composed of many branches and sub disciplines.
‘ Biology is the most powerful technology ever created. DNA is software, protein are hardware, cells are factories.’ -- Arvind Gupta

This brief book can be used by teachers and students in Biology field Specially this book is meant for students of S.S.T , SDO Wildlife , Matriculation F.Sc, B.Sc., B.S(Hons.) of biological group. Students appearing in exams of S.S.T Science in Education department may be immensely benefited by this book.

This book has been written strictly according to syllabus of H.E.C. It is copied from different sources mostly from Zoology of Miller and Harley, and extra material is also included. I am highly thankful to my Friends Shahnawaz Silachi & Abdul Hameed Korai . who means a lot for me because their inspiration always remained encouraging for me.

I am also thankful to Mr. Adnan Jaskani C.E.O of Anfal Academy I dedicate my this brief book to Students of Anfal and every student of Balochistan .I am sure this book will prove to be an invaluable asset for the students and teachers.

To enhance your concept in Biology please study 1: Campbell Biology By Jane B Reece 2: Biology By Raven & Johnson 3: Zoology by Miller and Harley 4: Integrated principles of Zoology by Hickman 5: Biology by P.S Verma and Agarwal, and study three Books A.B.C Zoology and Botany for B.Sc.

I shall feel highly obliged if suggestions for the improvement of the book are brought to my notice, so that future edition of the book may become more useful.

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Biology is the most powerful technology ever created. DNA is software, protein are hardware, cells are factories.

------ Arvind Gupta

Biology is the study of complicated things that have the appearance of having been designed with a purpose.

------ Richard Dawkins

I believe God controls the universe. I don't believe Biology works in an uncontrolled fashion.

------ Richard Mourdock

A cell is regarded as a true biological atom.

------ George Henry Lewes

TABLE OF CONTENTS

BIOLOGY – Introduction

• Bio – means life

• Ologos – to study / the study

• BIOLOGY – is the study of life / the study of living things • Biologist – the person who studies Biology

2. • Aristotle – Greek philosopher; first who classified living things as to air, land, or water dwellers; **Father of Biology**

3. • Galen – Greek physician; first to dissect apes and pigs; Father of Anatomy

4. • Andreas Vesalius – made the first dissection on human anatomy; discovered Comparative Anatomy

5. William Harvey – showedconclusively that the heartpumps blood and the bloodcirculates

6. • Marcello Malphigi – Italian physician & anatomist, founder of microscopic anatomy

7. • Anton Van Leeuwenhoek first to use microscope; discovered microorganisms such as protozoans called animalcules

8. • Charles Darwin – wrote the book On the Origin of Species By Means of Natural Selection

2 Major Divisions of Biology

• Botany – the study of PLANTS

• Zoology – the study of ANIMALS

Study of trees and their **Dendrology**

Study of fungi and some **Mycology**

Study of fossil plants **Paleonbotany**

Study of diseases of **Phytopathology**

Study of cultivating fruits **Pomology**

Arachnology Study of single class of invertebrate (scorpions, spiders, etc.)

Conchology Study of mollusks

Embryology Study of the development of animal forms

Entomology Study of insects

Herpetology Study of reptiles

Mammalogy Study of mammals

Ornithology Study of birds

Ichthyology Study of fishes

Anatomy – the study of structures of entire organisms and their parts

Physiology – the study of how the body and its parts work

Ecology – studyof how organisms interact with their environment &with other organisms

Parasitology – the study of the organisms that live in or on other organisms that caused diseases

Taxonomy – the study of the classification & evolutionary interrelationships among organisms
Embryology – study of the development & growth of organisms

Cytology – the study of the structures & functions of cells

Microbiology – the study of microorganisms such as bacteria, protozoans, and viruses

Paleontology – the study of fossils, the preserved remains and traces of organisms from the past

Genetics – the study of how traits are inherited & passed on one generation to the next

Morphology – the study of gross structures & forms of organisms

Histology – study of tissues

CELL

What is a cell?

Cells are the basic building blocks of living things. The human body is composed of trillions of cells, all with their own specialised function.

Cells are the basic structures of all living organisms.

Cells provide structure for the body, take in nutrients from food and carry out important functions.

Our cells contain a number of functional structures called organelles.

These organelles carry out tasks such as making proteins, processing chemicals and generating energy for the cell.

Cells:

Cells are the basic building blocks of all living things. The human body is composed of trillions of cells. They provide structure for the body, take in nutrients from food, convert those nutrients into energy, and carry out specialized functions. Cells also contain the body's hereditary material and can make copies of themselves.

CELL THEORY

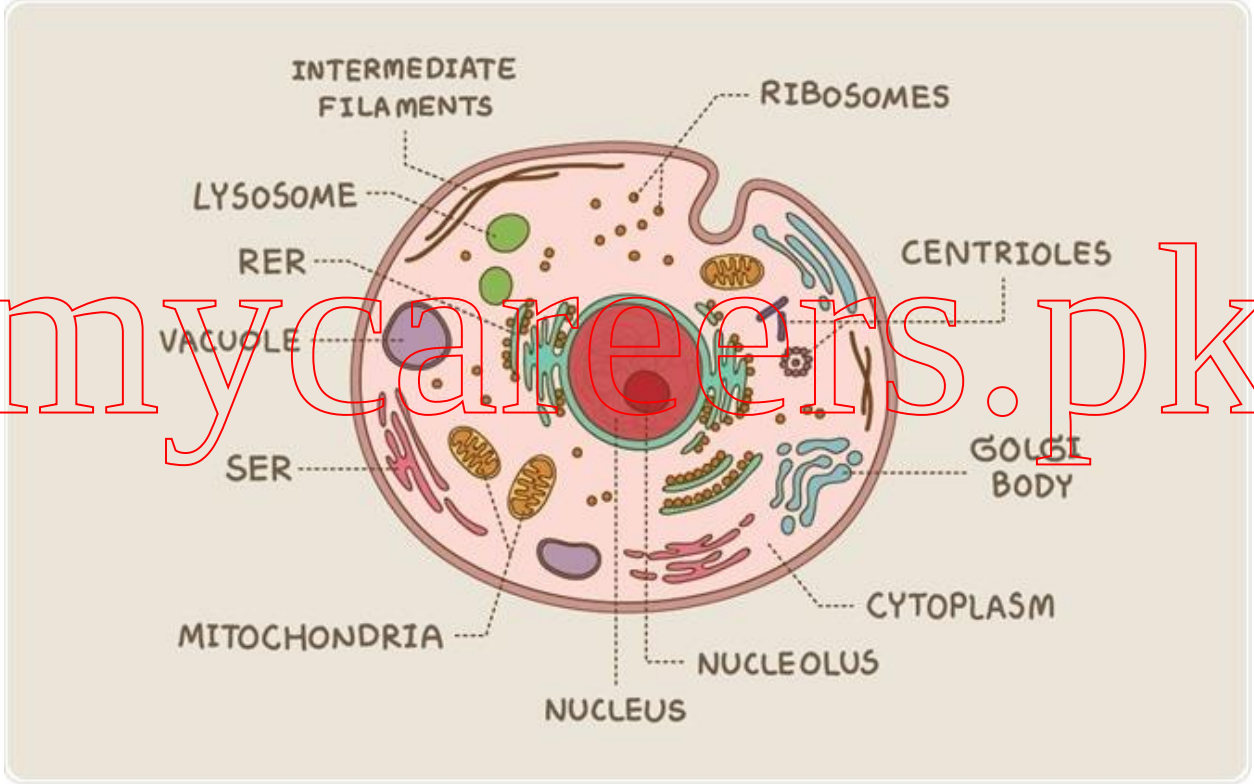
Cells are the basic unit of life.

The Cell Theory states that:

1) All organisms are made up of one or more cells and the products of those cells.

2) All cells carry out life activities (require energy, grow, have a limited size).

3) New cells arise only from other living cells by the process of cell division.



THE THREE MAIN COMPONENTS OF ANY PLANT OR ANIMAL CELL ARE:

1. PLASMA MEMBRANE/ CELL MEMBRANE

Structure- a bilipid membraneous layer composed of proteins and carbohydrates. It is fluid like.

Function - the cell membrane separates the cell from its external environment, and is selectively permeable (controls what gets in and out). It protects the cell and provides stability.

Proteins are found embedded within the plasma membrane, with some extending all the way through in order to transport materials. Carbohydrates are attached to proteins and lipids on the outer lipid layer.

2. CYTOPLASM

Structure - The jelly-like substance composed of mainly water and found between the cell membrane and nucleus. The cytoplasm makes up most of the "body" of a cell and is constantly streaming.

Function - Organelles are found here and substances like salts may be dissolved in the cytoplasm.

3. NUCLEUS

Structure - The largest organelle in the cell. It is dark and round, and is surrounded by a double membrane called the **nuclear envelope/membrane**. In spots the nuclear envelope fuses to form pores which are selectively permeable. The nucleus contains genetic information (DNA) on special strands called **chromosomes**.

Function - The nucleus is the "control center" of the cell, for cell metabolism and reproduction.

THE FOLLOWING ORGANELLES ARE FOUND IN BOTH PLANT AND ANIMAL CELLS.

1. "ER" OR ENDOPLASMIC RETICULUM

The Endoplasmic Reticulum is a network of membranous canals filled with fluid. They carry materials throughout the cell. The ER is the "transport system" of the cell.
There are two types of ER: rough ER and smooth ER.
Rough Endoplasmic Reticulum is lined with ribosomes and is rough in appearance and smooth endoplasmic reticulum contains no ribosomes and is smooth in appearance.

2. RIBOSOMES

Ribosomes are small particles which are found individually in the cytoplasm and also line the membranes of the rough endoplasmic reticulum. Ribosomes produce protein. They could be thought of as "factories" in the cell.

3. GOLGI BODY / APPARATUS

Golgi bodies are stacks of flattened membranous stacks (they look like pancakes!). The Golgi Body temporarily stores protein which can then leave the cell via vesiciles pinching off from the Golgi.

4. LYSOSOMES

Lysosomes are small sac-like structures surrounded by a single membrane and containing strong digestive enzymes which when released can break down worn out organelles or food. The lysosome is also known as a suicide sac.

5. MITOCHONDRIA

The mitochondria are round "tube-like" organelles that are surrounded by a double membrane, with the inner membrane being highly folded. the mitochondria are often referred to as the "powerhouse" of the cell. the mitochondria releases food energy from food molecules to be used by the cell. This process is called respiration. Some cells(muscle cells) require more energy than other cells and so would have many more mitochondria.

6. VACUOLES

Vacuoles are fluid filled organelles enclosed by a membrane. They can store materials such as food, water, sugar, minerals and waste products.

Cell Division and Cycle

Living organisms are constantly making new cells. They make new cells in order to grow and also to replace old dead cells. The process by which new cells are made is called cell division. Cell division is occurring all the time. Around two trillion cell divisions occur in the average human body every day!

Types of Cell Division

There are three main types of cell division: binary fission, mitosis, and meiosis. Binary fission is used by simple organisms like bacteria. More complex organisms gain new cells by either mitosis or meiosis.

Mitosis

Mitosis is used when a cell needs to be replicated into exact copies of itself. Everything in the cell is duplicated. The two new cells have the same DNA, functions, and genetic code. The original cell is called the mother cell and the two new cells are called daughter cells. The full process, or cycle, of mitosis is described in more detail below.

Examples of cells that are produced through mitosis include cells in the human body for the skin, blood, and muscles.

Cell Cycle for Mitosis

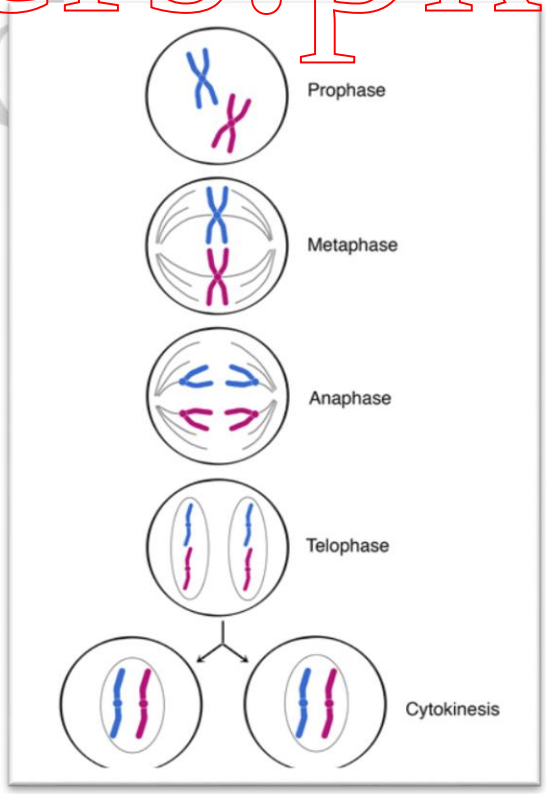
Cells go through different phases called the cell cycle. The "normal" state of a cell is called the "interphase". The genetic material is duplicated during the interphase stage of the cell. When a cell gets the signal that it is to duplicate, it will enter the first state of mitosis called the "prophase".

Prophase - During this phase the chromatin condenses into chromosomes and the nuclear membrane and nucleolus break down.

Metaphase - During metaphase the chromosomes line up along the middle of the cell.

Anaphase - During anaphase the chromosomes separate and move to opposite sides of the cell.

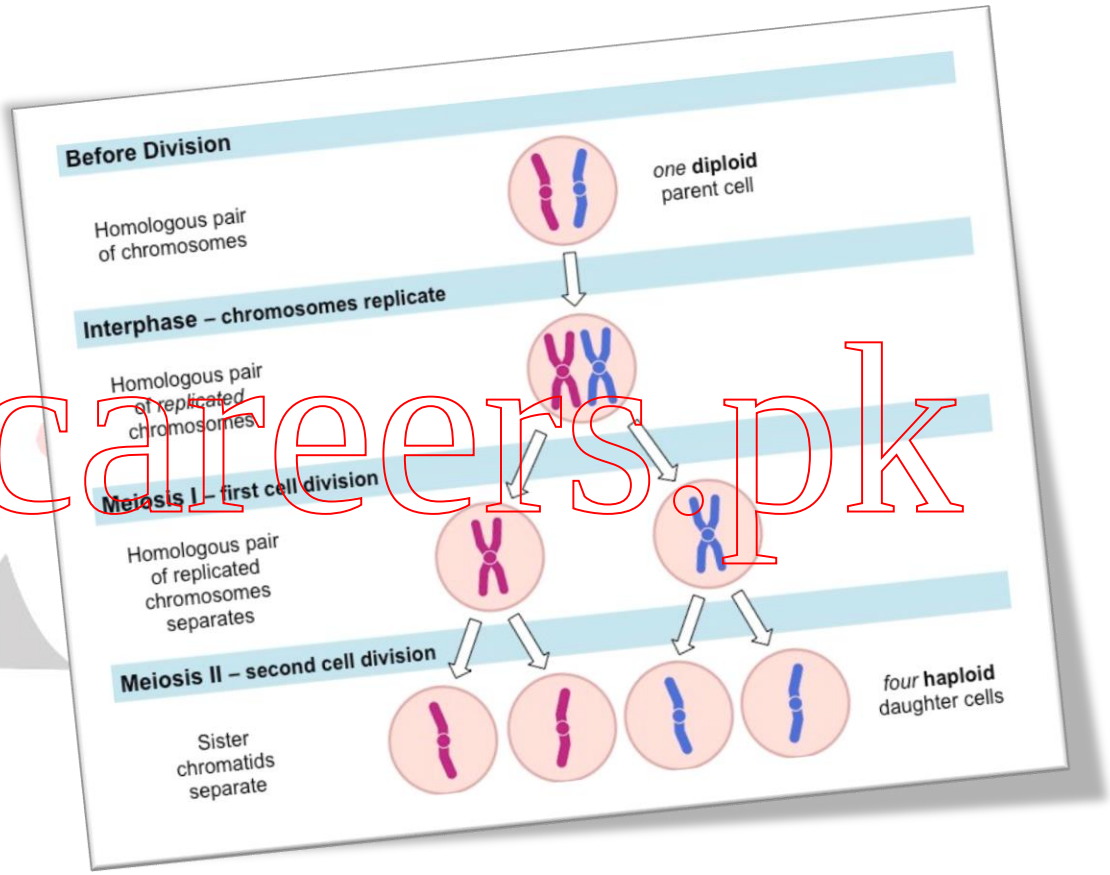
Telophase - During telophase the cell forms two nuclear membranes around each set of chromosomes and the chromosomes uncoil. The cell walls then pinch off and split down the middle. The two new cells, or daughter cells, are formed. The splitting of the cells is called cytokinesis or cell cleavage.



Meiosis

Meiosis is used when it is time for the entire organism to reproduce. There are two main differences between mitosis and meiosis. First, the meiosis process has two divisions. When meiosis is complete, a single cell produces four new cells instead of just two. The second difference is that the new cells only have half the DNA of the original cell. This is important for life on Earth as it allows for new genetic combinations to occur which produces variety in life.
Examples of cells that undergo meiosis include cells used in sexual reproduction called gametes.

Diploids and Haploids
The cells produced from mitosis are called diploids because they have two complete sets of chromosomes. The cells produced from meiosis are called haploids because they only have half the number of chromosomes as the original cell.



CLASSIFICATION OF LIVING ORGANISMS

Classification: The scientific method of dividing organisms into smaller and larger groups, on basis of their similarities.
Swedish botanist **Carolus Linnaeus** is the Father of Systematic Biology.
He believed he could:

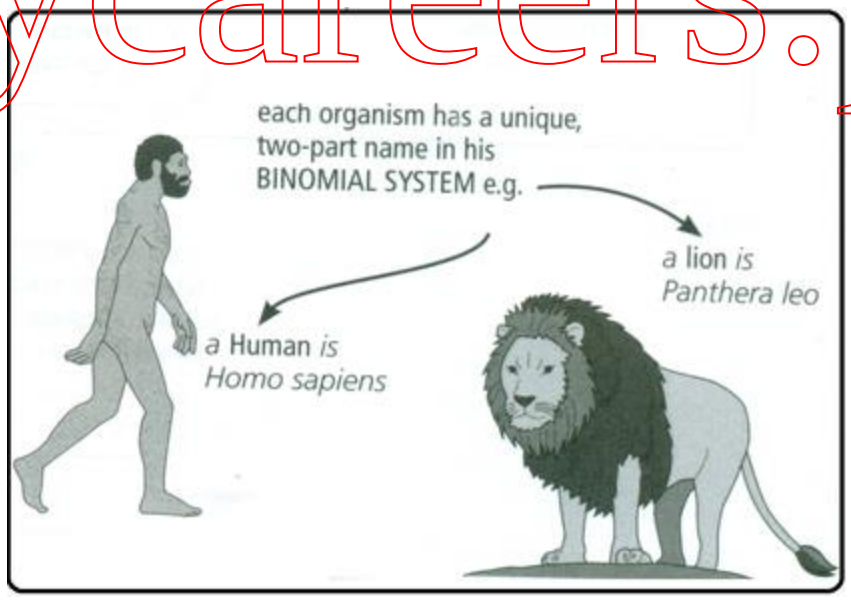
- Put every organism into a group (the science of TAXONOMY)
- Give every organism a name (the science of NOMENCLATURE).

In his **BINOMIAL SYSTEM**, every living organism has a unique, **two-part name**:

- The first name is **Genus,** the second name is **species.**
- Names are written in Latin, printed in *italics*.
- The genus always has a **capital** letter, and the species always has a **small** letter.

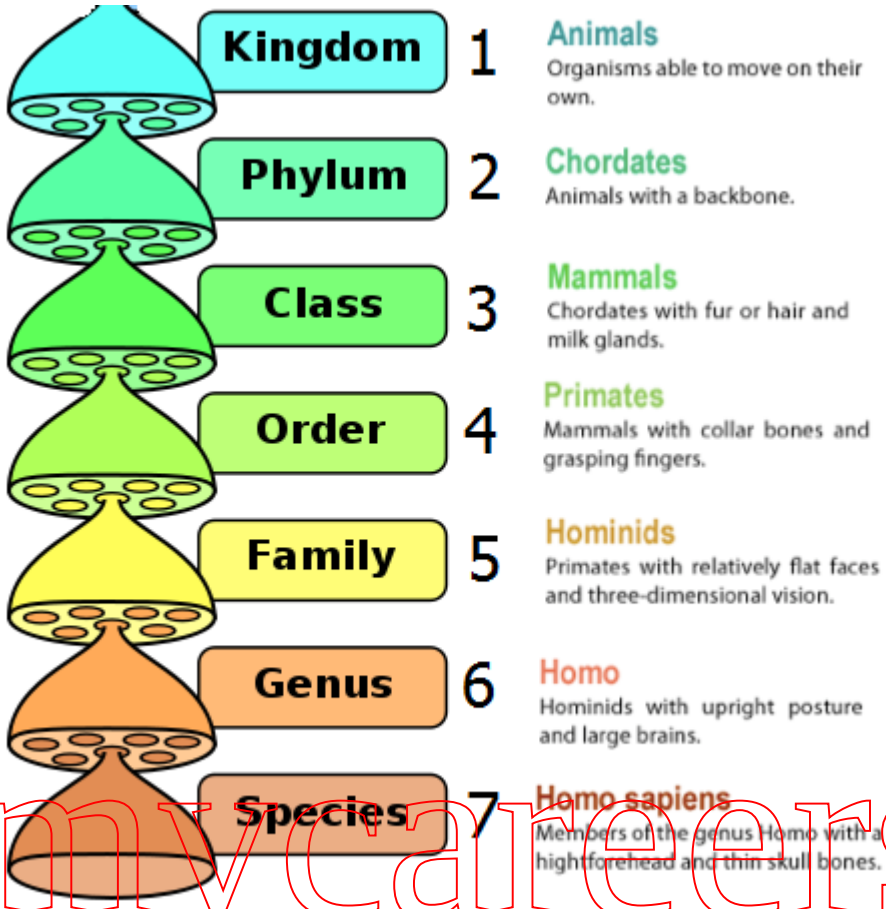
For examples:

	Genus	Species	Abreviation
Human	***Homo***	***sapiens***	***H. sapiens***
Lion	***Panthera***	***leo***	***P. leo***
Wolf	***Canis***	***lupus***	***C. lupus***



All life forms are categorized into a scheme that had 7 categorical terms.
The biggest group are **Kingdom,** the smallest one is **Species**.

Each kingdom is divided into smaller group, which include genus and species. Organisms can exist in only one group at each level of classification. For example, an organism can only belong to one kingdom or one genus.



Viruses

What are viruses?
Viruses are very small particles that can infect animals and plants and make them sick. Viruses are made up of genetic materials like DNA and are protected by a coating of protein.
Viruses hijack the cells of living organisms. They inject their genetic material right into the cell and take over. They then use the cell to make more viruses and take over more cells.

Are viruses alive?
Scientists differ on whether viruses are actually alive or not. Many people say they are non-living because they cannot reproduce without the aid of a host. Viruses also do not metabolize food into energy or have organized cells, which are usually characteristics of living things.

Characteristics of Viruses

- They do not have an organized cell structure.
- They have no cell nucleus.
- They typically have one or two strands of DNA or RNA.
- They are covered with a protective coat of protein called the CAPSID.
- They are inactive when not inside a living cell, but are active when inside another living cell.

Why are viruses bad?
When viruses invade a body's cells and begin to multiply, they make the host sick. Viruses can cause all sorts of diseases.

How do viruses spread?
Viruses are very small and lightweight. They can float through the air, survive in water, or even on the surface of your skin. Viruses can be passed from one person to another by shaking hands, touching food, through water, or through the air when a person coughs or sneezes.
Viruses can also be passed on by insect bites, animals, or through bad food.

Examples of Viruses
There are many viruses that can infect people and make them sick. One of the most common is influenza which causes people to get the flu. Other diseases caused by viruses include the common cold, measles, mumps, yellow fever, and hepatitis.

How to Avoid Getting Infected

There are things you can do to help reduce your chance of getting infected by a virus. Here are a few examples:

- Wash your hands (probably one of the most important ones).

- Don't put your hands or fingers in your mouth, nose, or eyes. Rubbing your nose or eyes can cause a virus on your hands to infect your body.
- Make sure your food is well-cooked, especially meat.
- Take your vitamins each day.
- Get plenty of sleep and exercise. This helps to strengthen your immune system to fight off viruses.

How are viruses treated?

There is little that doctors can do to treat viruses. In most cases our body's immune system fights off the virus. Scientists have developed vaccines that help our bodies to build up immunity to a specific virus. One example of a vaccine is the flu shot. The flu shot helps the body to develop its own defenses against the flu called antibodies.

Interesting Facts about Viruses

- Viruses are not classified in any of the five kingdoms of living things. This means they are not bacteria, fungi, protists, plants, or animals.
- Most viruses are so small they cannot be seen with an optical microscope.
- The word "virus" comes from the Latin word "virulentus" meaning "poisonous."
- Viruses can sometimes attack and kill bacteria.
- The first human virus discovered was the yellow fever virus in 1901 by Walter Reed.
- A virus that contains RNA instead of DNA is sometimes called a retrovirus.
- There are two main types of reproductive cycles for viruses: the lytic cycle and the lysogenic cycle.
- Diseases that are caused by a virus with a lytic cycle show symptoms much faster than viruses with a lysogenic cycle.

Structure of virus / Key Points

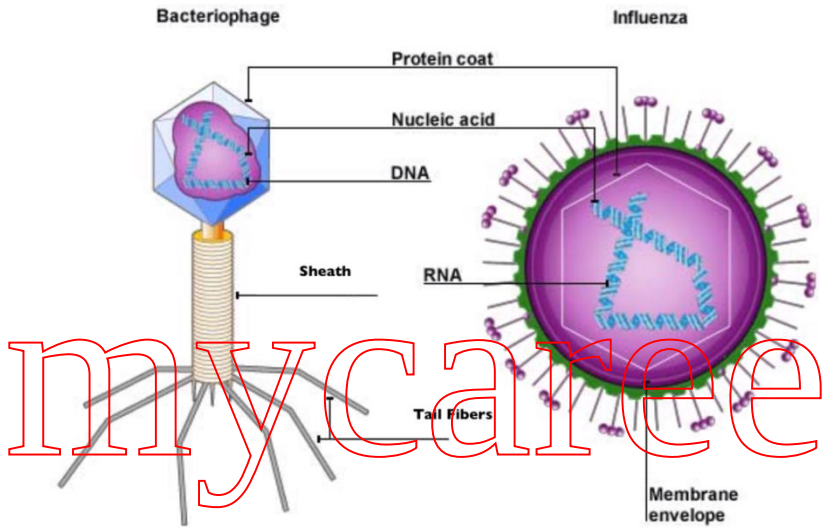
- Viruses are classified into four groups based on shape: filamentous, isometric (or icosahedral), enveloped, and head and tail.
- Many viruses attach to their host cells to facilitate penetration of the cell membrane, allowing their replication inside the cell.
- Non-enveloped viruses can be more resistant to changes in temperature, pH, and some disinfectants than are enveloped viruses.
- The virus core contains the small single- or double-stranded genome that encodes the proteins that the virus cannot get from the host cell.

Key Terms

- **capsid**: the outer protein shell of a virus
- **envelope**: an enclosing structure or cover, such as a membrane
- **filamentous**: Having the form of threads or filaments
- **isometric**: of, or being a geometric system of three equal axes lying at right angles to each other (especially in crystallography)

Viral Morphology

Viruses are acellular, meaning they are biological entities that do not have a cellular structure. Therefore, they lack most of the components of cells, such as organelles, ribosomes, and the plasma membrane. A virion consists of a nucleic acid core, an outer protein coating or capsid, and sometimes an outer envelope made of protein and phospholipid membranes derived from the host cell. The capsid is made up of protein subunits called capsomeres. Viruses may also contain additional proteins, such as enzymes. The most obvious difference between members of viral families is their morphology, which is quite diverse.



What are viral diseases?

Viral diseases are extremely widespread infections caused by viruses, a type of microorganism. There are many types of viruses that cause a wide variety of viral diseases. The most common type of viral disease is the common cold, which is caused by a viral infection of the upper respiratory tract (nose and throat). Other common viral diseases include:

- Chickenpox
- Flu (influenza)
- Herpes
- Hepatitis
- Human immunodeficiency virus (HIV/AIDS)
- Human papillomavirus (HPV)
- Infectious mononucleosis
- Mumps, measles and rubella
- Shingles

- Viral gastroenteritis (stomach flu)
- Viral hepatitis
- Viral meningitis
- Viral pneumonia

Viral diseases are contagious and spread from person to person when a virus enters the body and begins to multiply. Common ways that viruses spread from person to person include:

BACTERIA

What are bacteria?

Bacteria are tiny little organisms that are everywhere around us. We can't see them without a microscope because they are so small, but they are in the air, on our skin, in our bodies, in the ground, and all throughout nature.

Bacteria are single-celled microorganisms. Their cell structure is unique in that they don't have a nucleus and most bacteria have cell walls similar to plant cells. They come in all sorts of shapes including rods, spirals, and spheres. Some bacteria can "swim" around using long tails called flagella. Others just hang out or glide along.

Are bacteria dangerous?

Most bacteria aren't dangerous, but some are and can make us sick. These bacteria are called pathogens. Pathogens can cause diseases in animals and plants. Some examples of pathogens are leprosy, food poisoning, pneumonia, tetanus, and typhoid fever.

Fortunately, we have antibiotics we can take which help to fight off the bad pathogens. We also have antiseptics to help us keep wounds clean of bacteria and antibiotic soap we use to wash to help keep off bad pathogens. Remember to wash your hands!

Are bacteria all bad?

Not at all. Actually most bacteria are very helpful to us. They play an important role in the planet's ecosystem as well as in human survival.

Bacteria in the soil

Bacteria work hard in the soil for us. One type of bacteria, called decomposers, break down material from dead plants and animals. This might sound kind of gross, but it's an important function that helps to create soil and get rid of dead tissue. Another type of bacteria in the soil is Rhizobium bacteria. Rhizobium bacteria helps to fertilize the soil with nitrogen for plants to use when growing.

Bacteria in food

Yep, there's bacteria in our food. Yuck! Well, they aren't really that bad and bacteria is used when making foods like yogurt, cheese, pickles, and soy sauce.

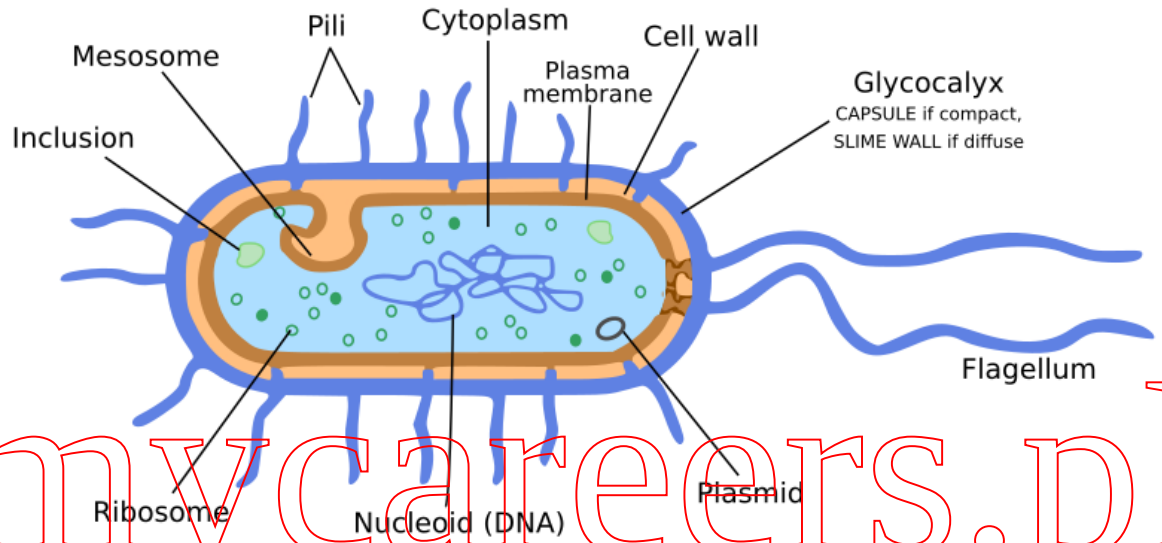
Bacteria in our bodies

There are many good bacteria in our bodies. A primary use of bacteria is to help us digest and

breakdown our food. Some bacteria can also help assist our immune system in protecting us from certain organisms that can make us sick.

Structure

Bacteria (singular: bacterium) are classified as prokaryotes, which are single-celled organisms with a simple internal structure that lacks a nucleus, and contains DNA that either floats freely in a twisted, thread-like mass called the nucleoid, or in separate, circular pieces called plasmids. Ribosomes are the spherical units in the bacterial cell where proteins are assembled from individual amino acids using the information encoded in ribosomal RNA.



Parts of the Bacteria Cell

The scientific name for bacteria cells is prokaryotes. Prokaryotes are fairly simple cells in that they do not have a cell nucleus or other specialized organelles.

1. Capsula
2. Outer membrane
3. Periplasm and Cell wall
4. Cytoplasmic (inner) membrane
5. Cytoplasm
6. Ribosome
7. Reserve food supplies
8. Chromosome
9. Mesosome

Pathogenic bacteria

Harmful bacteria that cause bacterial infections and disease are called pathogenic bacteria. Bacterial diseases occur when pathogenic bacteria get into the body and begin to reproduce and crowd out healthy bacteria, or to grow in tissues that are normally sterile. Harmful bacteria may also emit toxins

that damage the body. Common pathogenic bacteria and the types of bacterial diseases they cause include:

- ***Escherichia coli and Salmonella*** cause food poisoning.
- ***Helicobacter pylori*** cause gastritis and ulcers.
- ***Neisseria gonorrhoeae*** causes the sexually transmitted disease gonorrhea.
- ***Neisseria meningitidis*** causes meningitis.
- ***Staphylococcus aureus*** causes a variety of infections in the body, including boils, cellulitis, abscesses, wound infections, toxic shock syndrome, pneumonia, and food poisoning.
- ***Streptococcal bacteria*** cause a variety of infections in the body, including pneumonia, meningitis, ear infections, and strep throat.

Interesting Facts about Bacteria

- There are around 40 million bacteria in a gram of soil.
- Bacteria can survive in very harsh conditions including deep areas of the Earth's crust and in radioactive waste.
- There are around as many bacteria cells in a human body as there are human cells.
- Bacteria are used to help the environment by treating sewage and breaking down oil from oil spills.
- Some bacteria have chemicals that can generate light. This is called bioluminescence.

CYANOBACTERIA

Also referred to as blue-green algae and blue-green bacteria, **cyanobacteria** is a bacteria phylum that obtain their energy through a process known as photosynthesis. Because they require the basic environmental conditions, this bacteria can be found in a variety of environments ranging from marine to terrestrial habitats.
Cyanobacteria is also composed of a wide variety of bacteria species of different shapes are sizes that can be found in different habitats in the environment. These are spread across the 150 genera that have been identified so far and play various important roles in nature.

Examples include:

- Microcystis aeruginosa
- Cylindrospermopsis raciborskii
- Anabaena circinalis
- Cyanophora paradoxa
- Nostoc commune

ALGAE AND FUNGI

ALGAE:

Algae are organisms, or living things, that are found all over the world. Algae are very important because they make much of Earth's oxygen, which humans and other animals need to breathe. Some algae, such as seaweed, look like plants. However, algae are actually neither plants nor animals. Instead they belong to a group of living things called **protists**.

There are about 27,000 different species, or types, of algae. They are most common in water, such as oceans, rivers, lakes, streams, ponds, and marshes. Some species live in soil or on leaves, wood, and stones. Algae even grow on animals such as turtles and polar bears.

Algae can be green, blue, red, or brown. They vary greatly in size. Some species are so small that they can only be seen through a microscope. On the other hand, the algae called kelp can reach 200 feet (60 meters) in length.

Algae differ from plants in several ways. They do not have stems or leaves, and their roots are different from plant roots. Algae also do not produce flowers or seeds, as plants do. Like plants, however, algae make their own food through a process called **photosynthesis**. Photosynthesis also releases oxygen into the air.

In addition to making oxygen, algae are important for other reasons. Water animals such as whales, seals, fish, octopuses, and starfish depend on algae for food. People also eat some types of algae. In many parts of the world farmers use seaweeds as fertilizer (a material to help crops grow).

Some Important Types of Algae

Cyanophyta

Cyanophyta are the blue-green algae sometimes called "cyanobacteria" because they share many structural features with bacteria. They are the oldest (dating back 3.2 billion years) and one of the most important and ubiquitous groups of algae on the planet. This diverse group of algae can exist in all settings, from freshwater to terrestrial and from oligotrophic (low nutrient) to hypereutrophic (very high nutrient) environments. Some species of blue-green algae have a competitive advantage over other algae: the ability to fix nitrogen. Nitrogen fixation is the process of converting atmospheric nitrogen into usable nitrogen (ammonium). This characteristic allows these species to exist in areas where low nitrogen availability inhibits growth. Some groups of cyanobacteria are of special interest due to their ability to produce toxins potentially harmful to humans and animals:

Lyngbya

Lyngbya is one group of cyanobacteria of special concern. Long and hair-like, this filamentous alga can form large benthic and surface mats (blooms). *Lyngbya* normally grows in dense mats at the bottoms of nutrient-enriched lakes and spring-fed systems. These mats produce gasses during photosynthesis that often cause the mats to rise to the surface. At the surface, winds pile the algal mats against shorelines or in navigation channels. These mats can be several acres in size. Studies continue on what influences the cause and duration of lyngbya blooms. In some areas, the blooms cover so much of the pre-existing vegetation that they cause serious damage and eliminate other species. In some places in Florida,

lyngbya smothers eelgrass, a preferred food of the endangered West Indian manatee. Some lyngbya species in this genus have been linked to a skin irritant that causes "swimmers' itch."

Microcystis

This spherical, unicellular alga can form a colony (group of cells). A microscopic alga, microcystis will turn the water blue-green when it grows to bloom proportions. Some strains of microcystis produce a toxin known as microcystin. In abundance, this toxin is potentially harmful to animals.

Chlorophyta

Chlorophyta is a large and varied group, commonly called green algae. The group includes unicellular, colonial, and filamentous varieties of algae.

Spirogyra

Spirogyra species are mostly freshwater and are commonly found in shallow waters around the edges of lakes and in ditches. This bright green, mat-forming filamentous alga is slimy and has no branching. It is called *Spirogyra* because of the way the chloroplasts wind around the cell.

Cladophora

Cladophora species are also bright green. They are branching, and feel coarse when touched.

Hydrodictyon

Hydrodictyon (also called water net) forms a net by joining five or six cylindrical cells. It can grow so large that the net can be seen by the naked eye. The best habitat is clear, eutrophic water, but the algae are also seen in irrigation ditches and even rice fields.

Bacillariophyta

Diatoms

Diatoms are a group of algae often considered the most beautiful because of the glass-like silica shell that houses them. These "shells" come in a wide variety of shapes and sizes and some species can form long chains when linked together. Their appearance is somewhat kaleidoscopic.

Xanthophyta

Commonly called yellow-green algae, many species belonging to this group were once placed within Chlorophyta. However, the classification was changed after close observation of the type of chlorophyll and its arrangement.

Vaucheria

Vaucheria species are filamentous, with branched cells; they grow in dense mats that look like carpets of green felt.

Charophyta

Charophyta species (commonly called the stoneworts) are considered an evolutionary link to higher plants. They occur in lakes, ponds, and streams attached to the bottom by rhizoids. This group is often mistaken for true plants because of the whorls of filaments at nodes along the shoot of the organism. Charophyta can form relatively large areas of dense underwater monocultures.

Chara

Chara is commonly called muskgrass because of its distinctive odor. This submersed alga grows in slow-moving rivers and lakes, and can overtake other natural vegetation. *Chara* has a strong musk or garlic odor when crushed. It is coarse to the touch.

Nitella, a submersed alga, grows in slow-moving rivers and lakes. It looks like *Chara*, but does not feel rough when touched. It is gray-green or yellow and grows in shallow and deep water attached to the substrate. Some species are a few inches tall; others are three feet or longer.

Introduction to Cyanophyceae:

It is a primitive group of algae, consists of 150 genera and about 2,500 species. In India, the division is represented by 98 genera and about 833 species. Members of the class Myxophyceae (Cyanophyceae) are commonly known as blue green algae. The name blue green algae is given because of the presence of a dominant pigment c-phycocyanin, the blue green pigment.

In addition, other pigments like chlorophyll a (green), c-phycoerythrin (red), β-carotene and different xanthophylls are also present. The members of this class are the simplest living autotrophic prokaryotes.

Important Characteristics of Cyanophyceae:

The important characteristics of the division are as follows:

1. The individual cells are prokaryotic in nature. The nucleus is incipient type and they lack membrane bound organelles.
2. Both vegetative and reproductive cells are non-flagellate.
3. Cell wall is made up of microfibrils and is differentiated into four (4) layers. The cell wall composed of mucopeptide, along with carbohydrates, amino acids and fatty acids.
4. Locomotion is generally absent, but when occurs, it is of gliding or jerky type.
5. The principal pigments are chlorophylls a (green), c-phycocyanin (blue) and c-phyco- erythrin (red). In addition, other pigments like β-carotene and different xanthophylls like myxoxanthin and myxoxanthophyll are also present.
6. Membrane bound chromatophore are absent. Pigments are found embedded in thylakoids.
7. The reserve foods are cyanophycean starch and cyanophycean granules (protein).

Reproduction in Cyanophyceae:

The blue green algae (Cyanophyceae) reproduce by both vegetative and asexual means. Sexual reproduction is absent.

The vegetative reproduction performs through fission (Synechococcus), fragmentation (Oscillatoria, Cylindrospermum muscicola), hormogonia formation (Oscillatoria, Nostoc), hormospores (Westiella lanosa), planococci and Palmelloid stage.

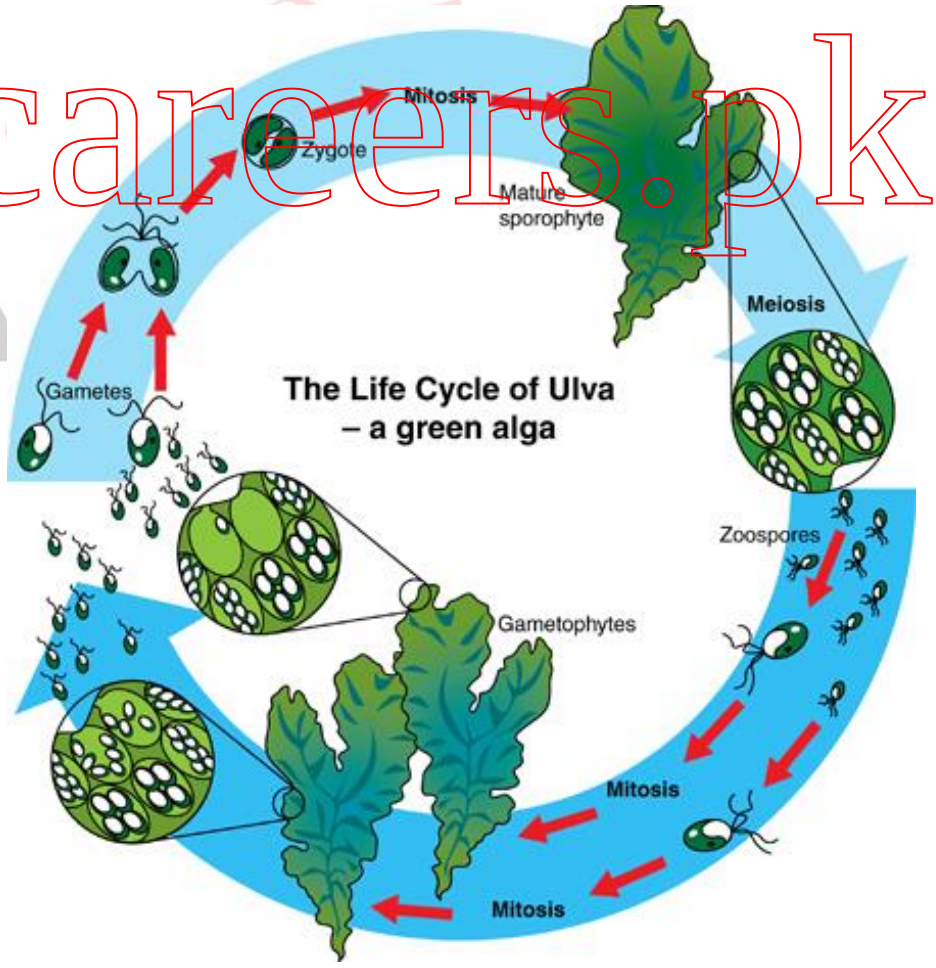
During asexual reproduction various types of asexual spores are formed. These are akinetes (Anabaena sphaerica, Gloeotrichia natans, Calothrix fusca), endospores (Dermocarpa), exospores (Chamaesiphon) and nannocyte (Microcystis)

ULVA LACTUCA,

Ulva lactuca, also known by the common name **sea lettuce**, is an edible green alga in the family Ulvaceae. It is the type species of the genus *Ulva*.

Ulva lactuca is a thin flat green algae growing from a discoid holdfast. The margin is somewhat ruffled and often torn. It may reach 18 centimetres (7.1 in) or more in length, though generally much less, and up to 30 centimetres (12 in) across.The membrane is two cells thick, soft and translucent, and grows attached, without a stipe, to rocks or other algae by a small disc-shaped holdfast.
Green to dark green in colour, this species in the Chlorophyta is formed of two layers of cells irregularly arranged, as seen in cross-section. The chloroplast is cup-shaped in some references but as a parietal plate in others with one to three pyrenoids. There are other species of *Ulva* which are similar and not always easy to differentiate.

The sporangial and gametangial thalli are morphologically alike. The diploid adult plant produces haploid zoospores by meiosis, these settle and grow to form haploid male and female plants similar to the diploid plants. When these haploid plants release gametes they unite to produce the zygote which germinates, and grows to produce the diploid plant.



Fungi

Fungi are a group of living organisms which are classified in their own kingdom. This means they are not animals, plants, or bacteria. Unlike bacteria, which have simple prokaryotic cells, fungi have complex eukaryotic cells like animals and plants.

Fungi are found throughout the Earth including on land, in the water, in the air, and even in plants and animals. They vary widely in size from microscopically small to the largest organisms on Earth at several square miles large. There are more than 100,000 different identified species of fungi.

How are fungi different from plants?

Fungi were once classified as plants. However, they are different from plants in two important ways: 1) fungi cell walls are composed of chitin rather than cellulose (plants) and 2) fungi do not make their own food like plants do through photosynthesis.

Characteristics of Fungi

- They are eukaryotic.
- They get their food by decomposing matter or eating off their hosts as parasites.
- They do not possess chlorophyll like plants.
- They reproduce through numerous spores rather than pollen, fruit, or seeds.
- They are usually not motile, meaning they cannot actively move around.

Roles of Fungi

- Food - Many fungi are used as food such as mushrooms and truffles. Yeast, a type of fungi, is used when baking bread to help it rise and to ferment beverages.
- Decomposition - Fungi play an important role in the decomposition of organic matter. This decomposition is necessary for many of the cycles of life such as the carbon, nitrogen, and oxygen cycles. By breaking down organic matter, fungi release carbon, nitrogen, and oxygen into the soil and the atmosphere.
- Medicine - Some fungi are used to killed bacteria that can cause infections and disease in humans. They make antibiotics like penicillin and cephalosporin.

Types of Fungi

Scientists often divide fungi into four groups: club fungi, molds, sac fungi, and imperfect fungi. Some of the more common fungi that you are likely to see or use everyday are described below.

- Mushrooms - Mushrooms are part of the club fungi group. Mushrooms are the fruiting body of a fungus. Some mushrooms are good to eat and are used as food, while others are very poisonous. Never eat a mushroom you find in the woods!

- Mold - Molds are formed by filaments called hyphae. Molds tend to form on old fruit, bread, and cheese. They sometimes look furry as the hyphae grow upward and release more mold spores from their tips.
- Yeast - Yeasts are small round single-celled organisms. Yeasts are important in making bread rise.

Interesting Facts about Fungi

- Scientists who specialize in the study of fungi are called mycologists.
- The fungi kingdom is more similar to the animal kingdom than the plant kingdom.
- The word "fungus" is a Latin word meaning "mushroom".
- It is estimated that there are at least 1.5 million different species of fungi.
- The top of a mushroom is called the cap. The small plates under the cap are called gills.
- The fungus Trichoderma is sometimes used in the process when making stone-washed jeans.

Gill fungi:

Gill fungi have gills under their caps -- the thin, vertical items beneath the reddish mushroom cap shown above. In most side views of mushroom caps you can't see the gills as nicely as in the photo, but here a critter has nibbled the cap's rim so that it no longer folds over the gills, hiding them. Gills radiate from a mushroom's stem, is better see in photos below. Millions of spores are produced on these gills. The spores fall downward and then are spread elsewhere by the wind.

The "classic" gill fungus has an open-umbrella shape, and a "classic" mushroom is shown at the right. That's the **deadly poisonous** *Amanita verna*, one of several mushrooms going by the quaint name of "Destroying Angel." Only a few gilled mushroom species possess both the ring (also called the **annulus**) and the cup (also called the **volva**). Sometimes a mushroom species arises from a cup but has no ring; sometimes it has a ring, but no cup, and; often it bears neither ring nor cup.

The gilled mushrooms are among the most important fungi not only because they are so common, but also because they provide some the best fungi to *eat*. For example, the mushroom at the right is a member of the genus *Lactarius*. Members of this genus are often called Milk Mushrooms because when they are injured the fungus body "bleeds" a white latex or "milk," as shown by the cut across the gills in the photograph. In this species injured tissue turns brown, as the image also shows. The "milk" and brown bruises are good fieldmarks, and that's good, because many *Lactarius* species are wonderful to eat, and these fieldmarks help us identify them..

The little fungus at the right, about an inch across (2.5 cm), is gilled, grows directly upon dead wood without a stem, and thus is not at all "mushroom shaped." It's an abundant species throughout much of North America, often found on dead twigs fallen onto the forest floor. I can't find a common name for it. It's *Schizophyllum commune*, and if you study experimental genetics you may use this species a lot because it is famous for fruiting readily in culture in the laboratory.

KINGDOM PLANTAE

What are plants?

Plants are living organisms that cover much of the land of planet Earth. You see them everywhere. They include grass, trees, flowers, bushes, ferns, mosses, and more. Plants are members of the kingdom plantae.

- Most plants make their own food through a process called photosynthesis.
- Plants have a cuticle, meaning they have a waxy layer on their surface that protects them and keeps them from drying out.
- They have eukaryotic cells with rigid cell walls.
- They reproduce with spores or with sex cells.

Photosynthesis: **Energy from the Sun**

Term	Definition
Autotroph	Organism that produces complex organic compounds from simple inorganic molecules using a source of energy such as sunlight.
Eukaryotic	Having cells that contain a nucleus and membrane-bound organelles.
Photosynthesis	Process of using the sun's energy to make food in the form of glucose.
Producer	Organism that produces food, such as glucose, for itself and other organisms.

Energy from the Sun

One of the most important functions of most plants is photosynthesis. Plants use photosynthesis to create energy directly from sunlight. You can go here to learn more about photosynthesis.

Types of Plants

There are many different types of plants. They are typically divided into two major groups: vascular and nonvascular.

- **Vascular -** These plants have specific tissues that help to move materials such as water through the plant. They are further divided into non-flowering plants and flowering plants. Most of the organisms you probably think of as plants, such as trees, bushes, and flowers, fit into this group.
- **Nonvascular -** These are smaller plants, such as mosses, that use diffusion and osmosis to move material through the plant.

Basic Structure of Plants

The three basic parts of most vascular plants are the leaf, the stem, and the roots.

Leaf - The leaf is an organ of a plant that is specialized for photosynthesis. Leaves capture energy from sunlight as well as collect carbon dioxide from the air. Many leaves are flat and thin in order to catch as much sunlight as possible. However, leaves come in many different shapes including long skinny needles that are found on pine trees.

Stem - The stem is the main structure that supports leaves and flowers. Stems have vascular tissues that move food and water around the plant to help it grow. Plants often store food in their stems.

Roots - The roots of a plant grow underground. Roots help to keep the plant from falling over and gather water and minerals from the soil. Some plants store food in their roots. The two major types of roots are fibrous roots and taproots. Taproots tend to have one major root that grows very deep, while fibrous roots have many roots that grow in all directions.

CLASSIFICATION OF PLANTS

- they have an autotrophic mode of nutrition. The plant kingdom is a vast group; therefore, the kingdom is further classified into subgroups. Levels of classification are based on the following three criteria:
- **Plant body**: whether the body has well-differentiated structures or not.
- **Vascular system**: whether the plant has a vascular system for the transportation of substances or not
- **Seed formation**: whether the plant bears flowers and seeds or not; if it does, then whether it is enclosed within fruits or not.

The plant kingdom has been divided into five subgroups. They are as follows:

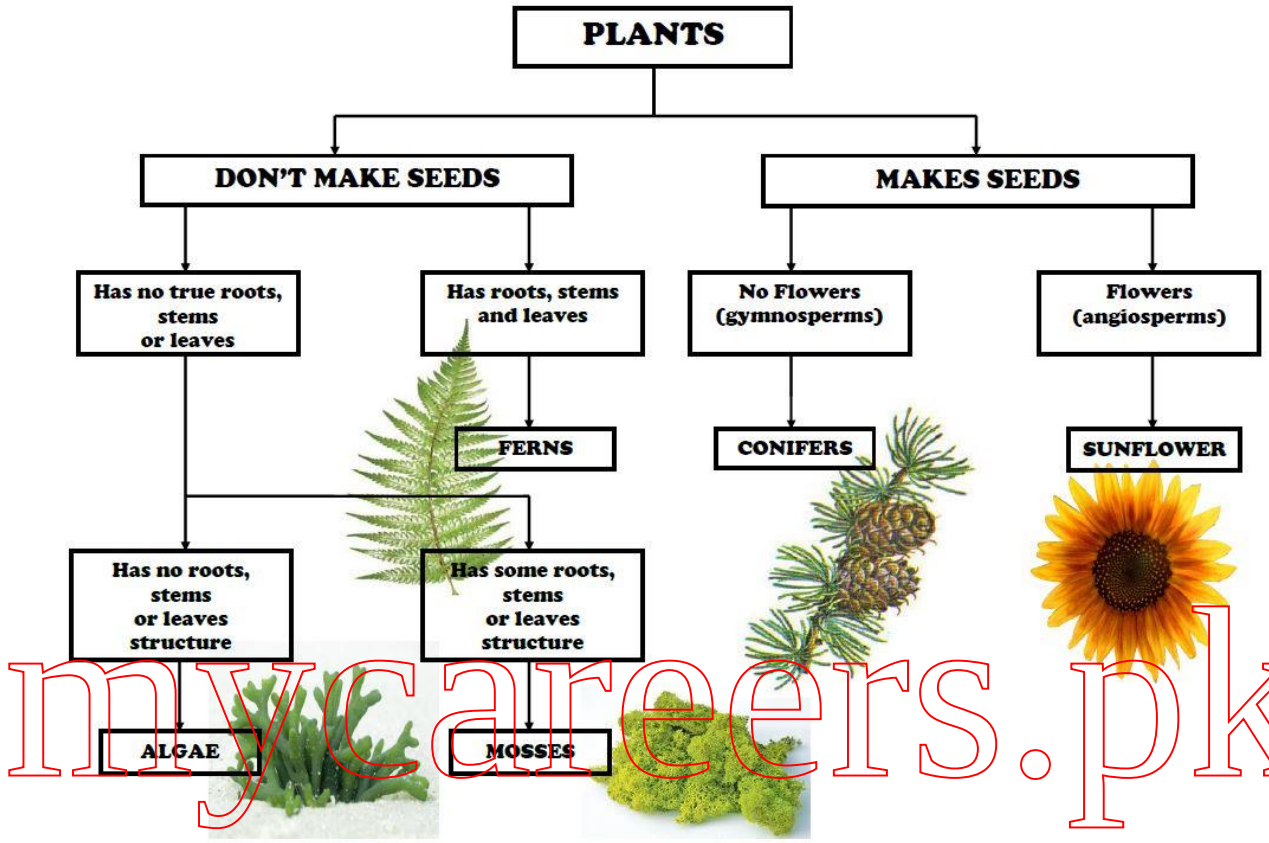
1. Thallophyta They are usually found in moist or wet places. This is due to the **absence of "true roots" and vascular tissue** that is needed to transport water and minerals.

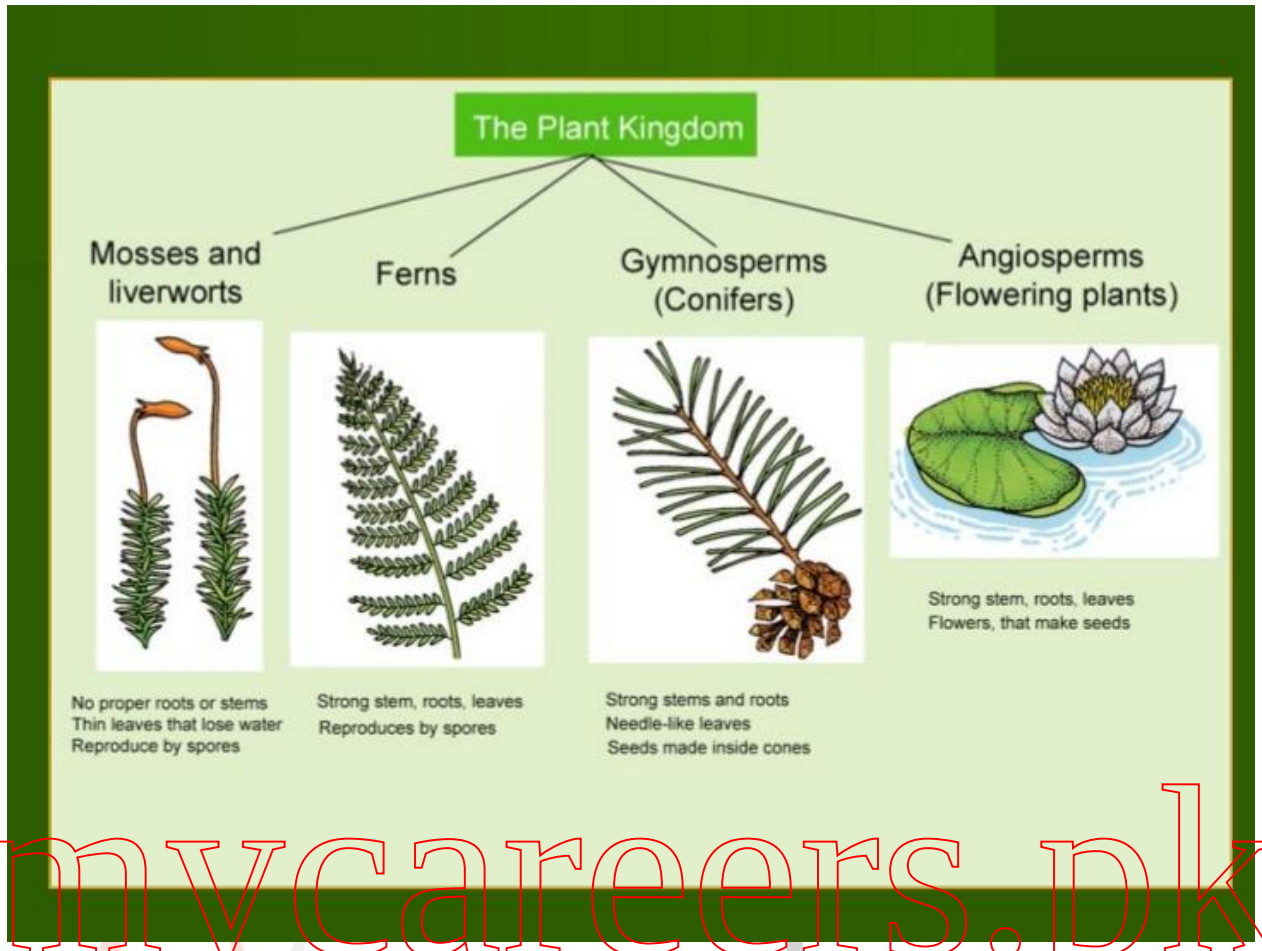
2. Bryophyta : are non-vascular, so they **do not have the right types of tissues to develop roots, stems, or leaves**. There are three main types of bryophytes: **mosses, liverworts, and hornworts.**

3. Pteridophyta : Pteridophytes are vascular plants and have leaves (known as fronds), roots and sometimes true stems, and tree ferns have full trunks. Examples include **ferns, horsetails and club-mosses**. ... **Pteridophytes do not have seeds or flowers either, instead they also reproduce via spores**.

4. Gymnosperms: have no flowers or fruits, and have unenclosed or "naked" seeds on the surface of scales or leaves. Gymnosperm seeds are often configured as cones.

5. Angiosperms: a plant of a large group that comprises those that have flowers and produce seeds enclosed within a carpel (ovary), including herbaceous plants, shrubs, grasses, and most trees.





The Bryophytes (Mosses and liverworts)

Bryophytes are small, non-vascular plants, such as mosses, liverworts and hornworts. They play a vital role in regulating ecosystems because they provide an important buffer system for other plants, which live alongside and benefit from the water and nutrients that bryophytes collect.
Some bryophyte species are amongst the first to colonise open ground. *Bryophytes* are also very good indicators of habitat quality as many plant species in this group are sensitive to levels of moisture in the atmosphere, which are lower in disturbed habitats because there is less shade.
Bryophytes do not have seeds or flowers. Instead they reproduce via spores.
There are around 20,000 species of *Bryophytes*.

Mosses and Liverworts

These are the little ones. The most important feature of mosses and liverworts is that they have **no vascular system**. A vascular system in plants is a series of tubes that can transport water and nutrients over a distance. That vascular system of xylem and phloem allows redwood and sequoia trees to grow to over one hundred feet tall.

Marchantia (Liverworts):

Marchantia is a genus in the family Marchantiaceae of the order Marchantiales, a group of liverworts. The Marchantia shows differentiation into two layers: an upper photosynthetic layer with a well-defined upper epidermis with pores and a lower storage layer. The thallus features tiny cup-like structures called gemma cups, which are used for asexual reproduction. The combination of barrel-shaped pores and the circular shape of the gemma cups are diagnostic of the genus.[1]:22
Multicellular purple colored scales with single cell thickness and unicellular rhizoids are present on the ventral surface of the thallus.

Reproduction: Maechantia:

Marchantia can reproduce both sexually and asexually. Sexual reproduction involves sperm from antheridia on the male plant fertilizing an ovum (egg cell) in the archegonium of a female plant. The antheridia and archegonia are borne atop special gametophore stalks called antheridiophores and archegoniophores, respectively. These are borne on separate thalli; hence, the plants are dioicous. Once fertilized, the ovum is called a zygote and develops into a small sporophyte plant, which remains attached to the larger gametophyte plant. The sporophyte produces sporeswhich develop into free-living male and female gametophyte plants.
Asexual reproduction occurs by means of gemmae, discoid clumps of cells which are genetically identical to the parent and contained in cup-like structures on the upper surface of the plant. These are dispersed when rain splashes into the cups and develop into new plants. Asexual reproduction can also occur when older parts of the plant die and the surviving newer branches develop into separate plants.

Mosses

These are waxy little plants with no leaves and no stem that use each other to stay upright. Their inability to stay up is why you never see one little moss plant; it's always a group. That grouping also helps them retain water in the area. A waxy covering across their bodies helps keep water from evaporating. You will usually find them in moist areas out of the direct sunlight.

DIFFERENCE BETWEEN BRYOPHYTES AND PTERIDOPHYTES

BASIS FOR COMPARISON	BRYOPHYTES	PTERIDOPHYTES
Body definition	Bryophytes has leafy or thalloid plant body.	In pteridophytes plant body in differentiated into roots, stems, and leaves.
Vasculature system	No vasculature system, which means xylem and phloem absent.	Proper vasculature is present which means xylem and phloem is present.
Vascular tissue	Absent	Present
Presence of roots	No roots, instead rhizoids are present helps in anchoring	Roots are present.
Presence of stems or leaves	No true stems or leaves are present.	True stem and leaves are present.
Archegonium and	Common exposure of	Partially embedded

it's formation	archegonium, whose neck is formed of six rows of cells.	archegoninum and it's neck has only four rows of cells.
Antheridium	Stalked.	Sessile.
Dominating part	Gametophyte is dominating.	Sporophyte is dominating.
Cell type	It has haploid cells.	It has diploid cells.
Examples	Mosses, liverworts, hornworts.	Spikemosses, clubmosses, ferns, quillworts.
Sporophytic phase	Depends completely on gametophytic.	Saprophytic phase is an independent autotrophic.

FERNS (Pteridophytes): Life cycle: Gametophyte and sporophyte

Like all plants, the life cycle of ferns is characterized as having an alternation of a gametophyte phase and a sporophyte phase. A typical fern sporophyte is the large, familiar plant seen in nature. Its cells have the unreduced number of chromosomes, usually two sets. Most fern gametophytes are not seen in nature. A typical gametophyte is about 0.4 in (1 cm) in diameter, multicellular, flat, heart-shaped, and green. Its cells have the reduced number of chromosomes, usually one set.

Interestingly, the gametophyte and sporophyte are about equally dominant in the life cycle of ferns. In contrast, the gametophyte is dominant in the more evolutionarily primitive bryophytes (mosses, liverworts, and hornworts), whereas the sporophyte is dominant in the more evolutionarily advanced seed plants.

Gametophyte of ferns:

The gametophyte phase of the fern life cycle begins with a **spore**. A fern spore is a haploid reproductive **cell**, which unlike the seeds of higher plants, does not contain an embryo. Fern spores are often dispersed by the **wind**. Upon **germination**, a spore gives rise to a green, thread-like **tissue**, called a protonema. The protonema develops into a prothallus, a small, green, multicellular tissue that is rarely seen in nature. The prothallus has numerous subterranean rhizoids to anchor it to the substrate and absorb **nutrients**.

Sporophyte of Ferns :

Fusion of the egg and sperm nuclei during fertilization leads to the formation of a zygote, with the unreduced number of chromosomes, usually two sets. The zygote develops into a sporophyte, the most familiar stage of the fern life cycle. As the sporophyte grows, the prothallus to which it is attached eventually decays. Most fern sporophytes in temperate North America are green and terrestrial.

Tracheophytes

Tracheophytes are distinguished from bryophytes by their highly developed vascular systems, which facilitate the transport of water and nutrients to all parts of the plant. This vascularization adaptation has allowed tracheophytes to become more fully terrestrial than bryophytes, which are still dependent upon moist environments for many reproductive and nutritive functions, as discussed in Bryophytes.

Tracheophytes can be broken down into three classes: ferns, gymnosperms, and angiosperms. Ferns are the least evolved of the tracheophytes; they have vascular systems, and specialized leaf and root structures, but are still dependent on moist environments for reproduction. Gymnosperms (coniferous plants) and angiosperms (flowering plants), known together as the seed plants, have evolved reproductive processes that are independent of water. In addition, tracheophyte seed plants all produce embryos that are encased in tough coats. These seed coats prevent desiccation in a terrestrial environment and protect the seed until conditions are favorable for growth. Angiosperms can be further classified as monocots and dicots, depending on their embryonic development and other factors.

Vascular Tissues

Tracheophytes are characterized by the presence of vascular tissue, composed of specialized conductive cells that create "tubes" through which materials can flow throughout the plant body. These vessels are continuous throughout the parts of the plant, allowing for the efficient and controlled distribution of water and nutrients. In addition to this transport function, vascular tissues also provide a measure of support to the plant, contributing to tracheophytes' ability to grow much larger and higher than nonvascularized plants. The two types of vascular tissue are xylem (dead cells) and phloem (living cells). Roots and root hairs, through which the bulk of water and minerals enter the plant body, are also integral to the vascular system of tracheophytes.

Xylem and Phloem

Xylem consists of a "pipeline" of dead cells arranged end to end for water and mineral transport. When the cells that form xylem die at maturity, the nucleus and cytoplasm disintegrate, leaving a hollow tunnel. The leftover cell walls are very thick and provide support for the plant; the cavities inside provide a passage through which fluids can move. The xylem carries water and dissolved minerals upward from the roots through the stem and leaves of the plant. In larger seed plants, xylem cells are specialized into vessel elements and tracheids. Vessel elements are found in flowering plants (angiosperms), and are wider and better at conducting water than the tracheids of conifers (gymnosperms).

DESERT PLANTS

Most desert species have found remarkable ways to survive by evading drought. Desert succulents, such as cacti or rock plants (Lithops) for example, survive dry spells by accumulating moisture in their fleshy tissues. They have an extensive system of shallow roots to capture soil water only a few hours after it has rained. Additionally, many cacti and other stem-succulent plants of hot deserts present columnar growth, with leafless, vertically-erect, green trunks that maximize light interception during the early and late hours of the day, but avoid the midday sun, when excessive heat may damage plant tissues.

One of the most effective drought-survival adaptations for many species is the evolution of an ephemeral life-cycle. An ephemeral life cycle is characterized by a short life and the capacity to leave behind very hardy forms of propagation. This ability is found not only in plants but also in many invertebrates. Desert ephemerals are amazingly rapid growers capable of reproducing at a remarkably high rate during good seasons.

Xerophytes

The term xerophyte refers to a plant species that has evolved over time to survive in dry regions, like deserts, with little water. Xerophytes have adapted to be able to hold onto large amounts of water for a long period of time or limit water loss. Without these capabilities, the plants would die, as their arid environment does not provide enough water to sustain life.

Common Xerophytes

Common examples of xerophytes are aloe vera and pineapples, but there are many more, including:

• Acacia	• Eriogonums
• Adenia glauca	• Esparto grass
• Agave	• Euphorbia
• Antarctic hair grass	• Joshua tree
• Artic willow	• Idria columnaris
• Avonia alstonii	• Kalanchoe
• Barbary fig	• Malosma laurina
• Basal rosette	• Mesquite
• Bursera fagaroides	• Monadenium rubellum
• Cactus family	• Nerium oleander
• Calibanus hookerii	• Pine
• California poppy	• Prickly pear
• Chaparral plants	• Raphinacme
• Cissus tuberose	• Tea plant
• Dudleya brittonii	• Tillandsia
• Dudleya pulverulenta	• Trichodiadema bulbosum

DESERT ANIMALS

Birds and large mammals can escape critical dry spells by migrating along the desert plains or up into the mountains. Smaller animals cannot migrate but regulate their environment by seeking out cool or shady places. In addition to flying to other habitats during the dry season, birds can reduce heat by soaring. Many rodents, invertebrates, and snakes avoid heat by spending the day in caves and burrows searching out food during the night. Animals active in the day reduce their activities by resting in the shade during the hotter hours.

What is Photosynthesis?

The word photosynthesis can be separated to make two smaller words:

“photo” which means light

“synthesis” which means putting together

Plants need food but they do not have to wait on people or animals to provide for them. Most plants are able to make their own food whenever they need it. This is done using light and the process is called photosynthesis.

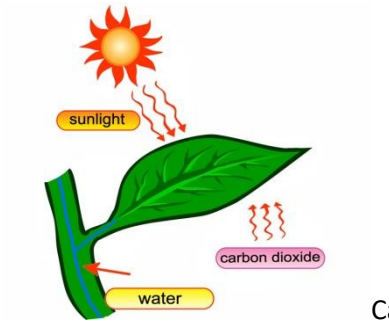
Photosynthesis is the process by which plants make their own food. We will add more details to this definition after making a few things clear as you will see below.

What is needed for Photosynthesis?

To make food, plants need not just one but **all of the following**:

- carbon dioxide
- water
- sunlight

Let's take a look at how these are collected by plants.

- 

Carbon dioxide from the air passes through small pores (holes) in the leaves. These pores are called stomata.
- Water is absorbed by the roots and passes through vessels in the stem on its way to the leaves.
- Sunlight is absorbed by a green chemical in the leaves.

What happens during Photosynthesis?

The photosynthesis process takes place in the leaves of plants. The leaves are made up of very small cells. Inside these cells are tiny structures called **chloroplasts**. Each chloroplast contains a green chemical called **chlorophyll** which gives leaves their green color.

- Chlorophyll absorbs the sun's energy.
- It is this energy that is used to split water molecules into hydrogen and oxygen.
- Oxygen is released from the leaves into the atmosphere.
- Hydrogen and carbon dioxide are used to form glucose or food for plants.

Some of the glucose is used to provide energy for the growth and development of plants while the rest is stored in leaves, roots or fruits for later use by plants.

Here is the process in greater detail:

Photosynthesis occurs in two stages commonly known as Light dependent Reactions and the Calvin Cycle.

Light dependent Reactions

Light dependent reactions occur in the thylakoid membrane of the chloroplasts and take place only when light is available. During these reactions light energy is converted to chemical energy.

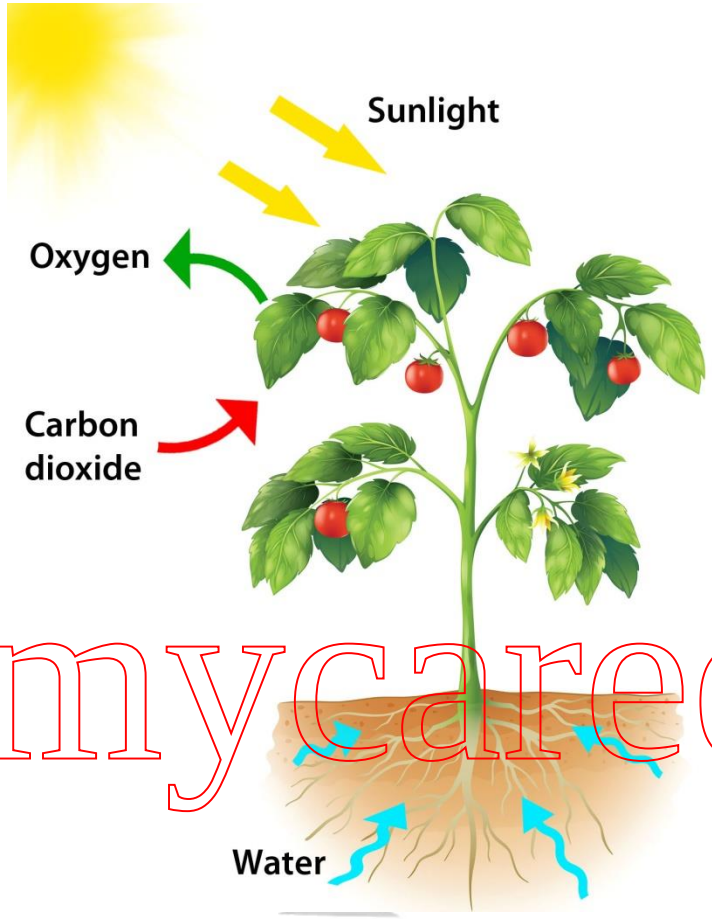
- Chlorophyll and other pigments absorb energy from sunlight. This energy is transferred to the photosystems responsible for photosynthesis.
- Water is used to provide electrons and hydrogen ions but also produces oxygen. Do you remember what happens to the oxygen?
- The electrons and hydrogen ions are used to create ATP and NADPH. ATP is an energy storage molecule. NADPH is an electron carrier/donor molecule. Both ATP and NADPH will be used in the next stage of photosynthesis.

Details about the flow of electrons through Photosystem II, b6-f complex, Photosystem I and NADP reductasehave not been included here but can be found under The Process of Photosynthesis in Plants.

The Calvin Cycle

The Calvin Cycle reactions occur in the stroma of the chloroplasts. Although these reactions can take place without light, the process requires ATP and NADPH which were created using light in the first stage. Carbon dioxide and energy from ATP along with NADPH are used to form glucose.

More details about the formation of sugars can be found under the Process of Photosynthesis in Plants.



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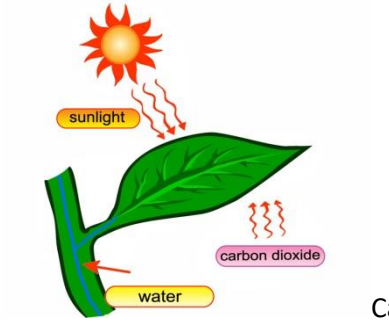

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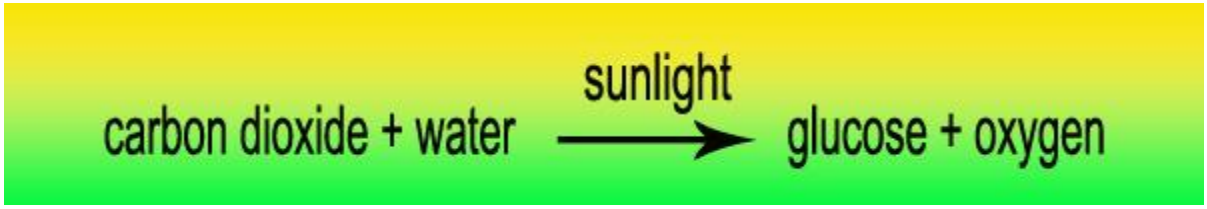
The Calvin Cycle reactions occur in the stroma of the chloroplasts. Although these reactions can take place without light, the process requires ATP and NADPH which were created using light in the first stage. Carbon dioxide and energy from ATP along with NADPH are used to form glucose.

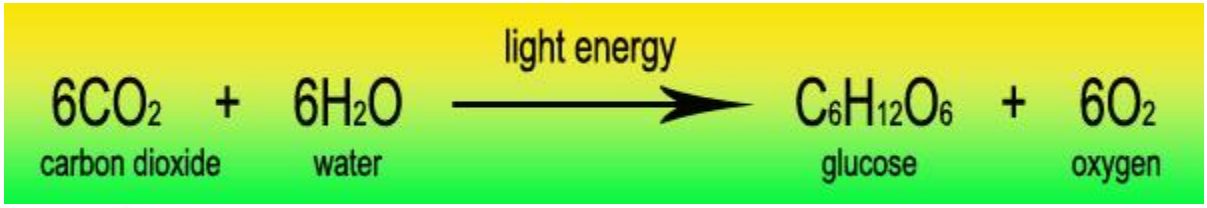
More details about the formation of sugars can be found under the Process of Photosynthesis in Plants.

What have you learned so far?

You already know that plants need carbon dioxide, water and sunlight to make their food. You also know that the food they make is called glucose. In addition to glucose, plants also produce oxygen. This information can be written in a word equation as shown below.



The equation below is the same as the one above but it shows the chemical formula for carbon dioxide, water, glucose and oxygen.



Now back to the definition… Earlier you learned that photosynthesis is the process by which plants make their own food. Now that we know what plants need to make food, we can add that information as shown below.

Photosynthesis is the process by which plants make their own food using carbon dioxide, water and sunlight.

What does Photosynthesis produce?

Photosynthesis is important because it provides two main things:

- food
- oxygen

some of the glucose that plants produce during photosynthesis is stored in fruits and roots. This is why we are able to eat carrots, potatoes, apples, water melons and all the others. These foods provide energy for humans and animals.

Oxygen that is produced during photosynthesis is released into the atmosphere. This oxygen is what we breathe and we cannot live without it.

While it is important that photosynthesis provides food and oxygen, its impact on our daily lives is far more extensive. Photosynthesis is so essential to life on earth that most living organisms, including humans, cannot survive without it.

All of our energy for growth, development and physical activity comes from eating food from plants and animals. Animals obtain energy from eating plants. Plants obtain energy from glucose made during photosynthesis.

Our major sources of energy such as natural gas, coal and oil were made millions of years ago from the remains of dead plants and animals which we already know got their energy from photosynthesis.

Photosynthesis is also responsible for balancing oxygen and carbon dioxide levels in the atmosphere. Plants absorb carbon dioxide from the air and release oxygen during the process of photosynthesis.

NOTES COMPILED BY : TAHIR HABIB

ANIMALIA

The Animal Kingdom

Though there is great diversity in the animal kingdom, animals can be distinguished from the other kingdoms by a set of characteristics. Though other types of life may share some of these characteristics, the set of characteristics as a whole provide a distinction from the other kingdoms. The set of characteristics provided by Audesirk and Audesirk are:

1. Animals are multicellular.
2. Animals are heterotrophic, obtaining their energy by consuming energy-releasing food substances.
3. Animals typically reproduce sexually.
4. Animals are made up of cells that do not have cell walls.
5. Animals are capable of motion in some stage of their lives.
6. Animals are able to respond quickly to external stimuli as a result of nerve cells, muscle or contractile tissue, or both.

The Animal Kingdom is divided into two groups:

- **Invertebrates** – invertebrates are animals with no vertebral column or backbone. Invertebrate animals are very diverse animal forms composing about 98% of the animal kingdom.
- Some examples of invertebrates are snails, sponges, earthworms, squids, sea stars, insects, butterflies, spiders, and jellyfish..
- **Vertebrates** – All animals with back bones are called Invertebrates.

Based on the extent and type of the body design differentiation, Animalia kingdom classified as –

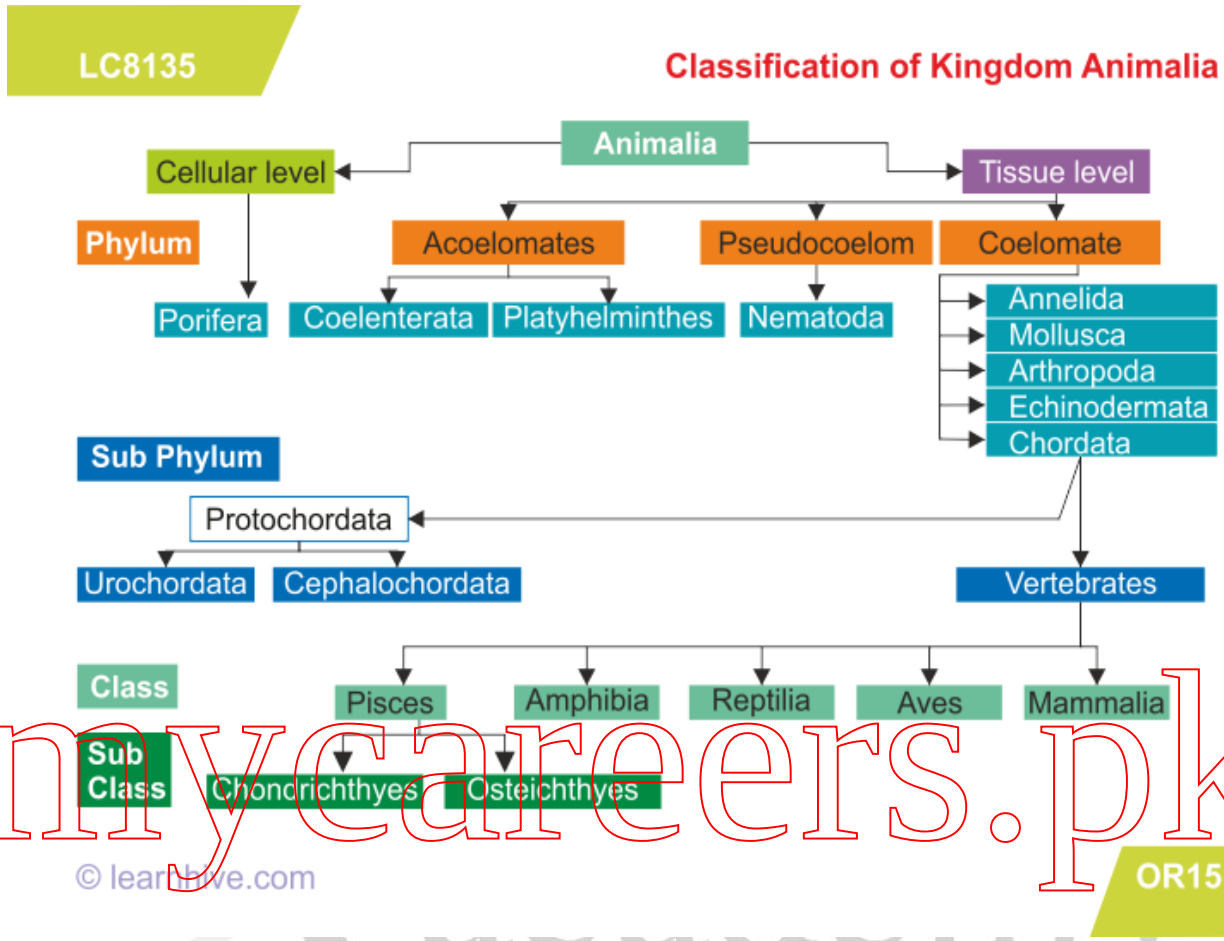
Invertebrata

- **Porifera**
- **Coelenterata**
- **Platyhelminthes**
- **Nematoda**
- **Annelida**
- **Arthropoda**
- **Mollusca**
- **Echinodermata**
- **Protochordata**

Vertebrata

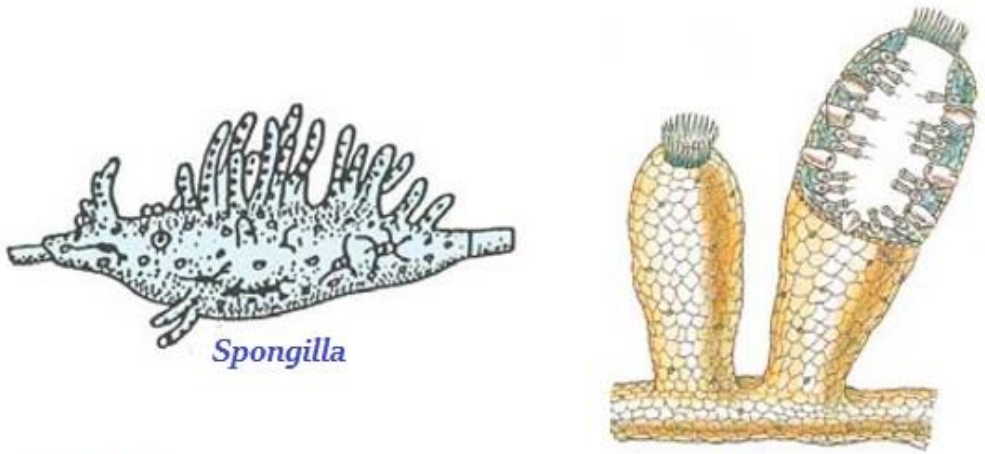
- **Pisces**
- **Amphibia**
- **Reptilia**
- **Aves**

- **Mammalia**



Porifera

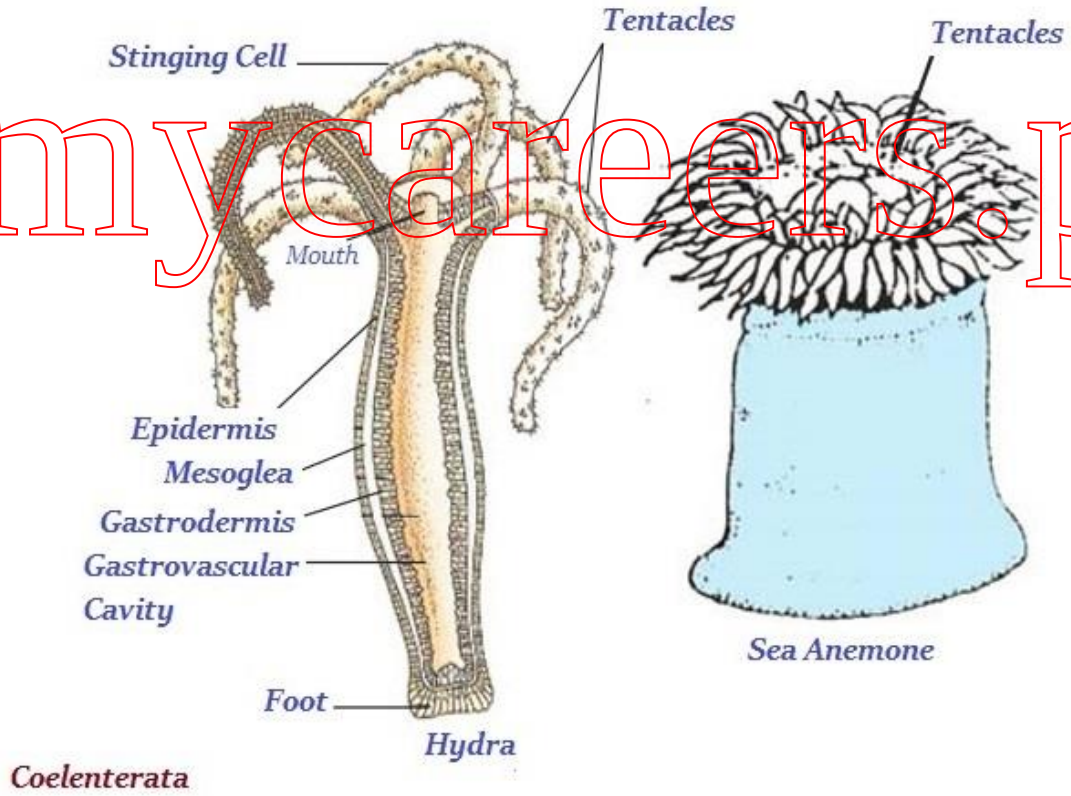
- The literal meaning of 'porifera' is the organisms with holes.
- The organisms of porifera are non-motile and attached to some solid support.



- The examples of this group are Sycon, Spongilla, Euplectelia, etc.

Coelenterata

- Organisms of coelenterata group live in water.
- The organisms of this group have cavity in their bodies.

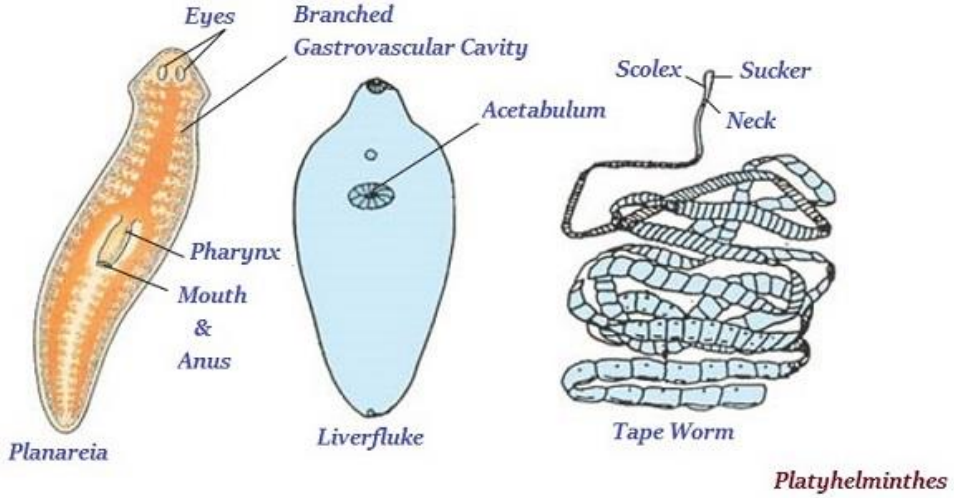


- Hydra and sea anemone are the common example of coelenterate.

Platyhelminthes

- The organisms of this group do not have true internal body cavity or coelom; so, they neither have well-developed organs.

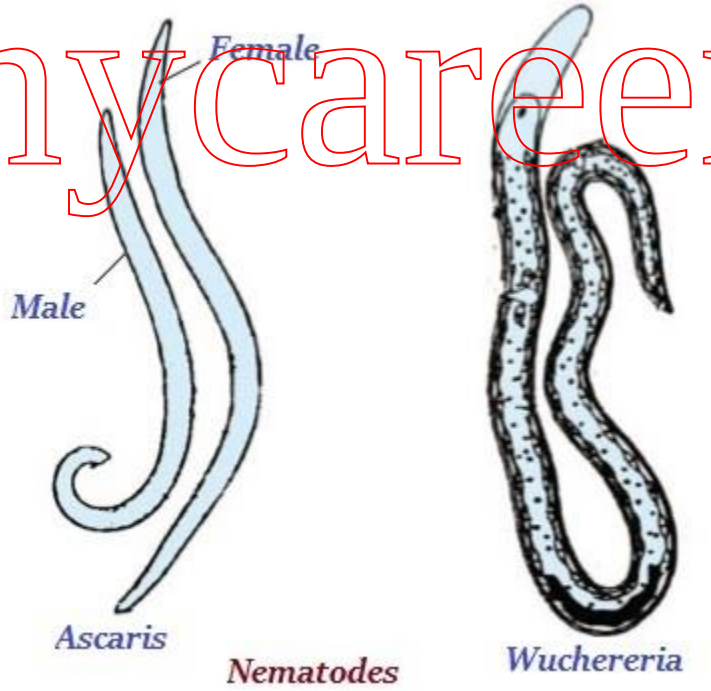
- The bodies of organisms of this group are flattened from top to bottom; therefore, they are also known as **flatworms**.



- Planareia, liverfluke, tape worm, etc., are the typical examples of this group.

Nematoda

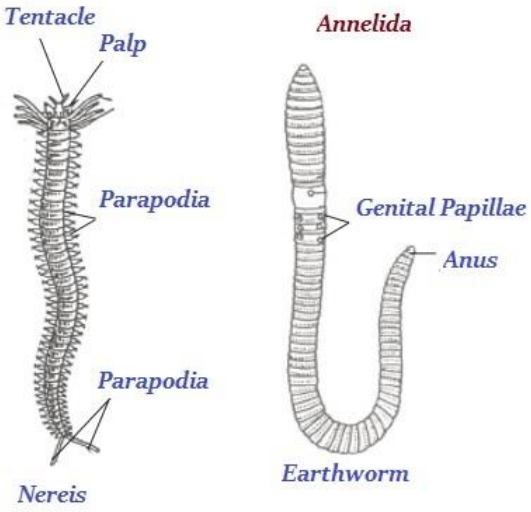
- The organisms of nematode have cylindrical body.
- The organisms have tissue, but as such no well-developed body (i.e. no real organ).



- The filarial worms (causing elephantiasis disease), roundworm in the intestines, etc., are the common examples of nematodes.

Annelida

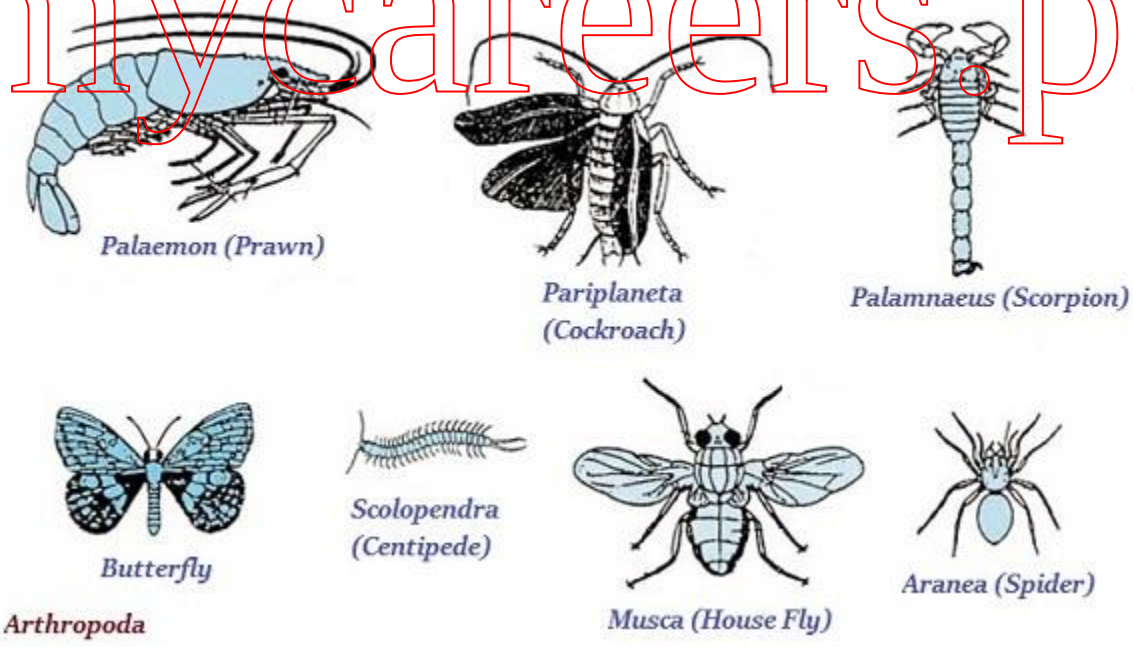
- The organisms of annelida group live almost everywhere including fresh water, marine water as well as on land.



- Earthworms, nereis, and leeches are the familiar examples of annelida.

Arthropoda

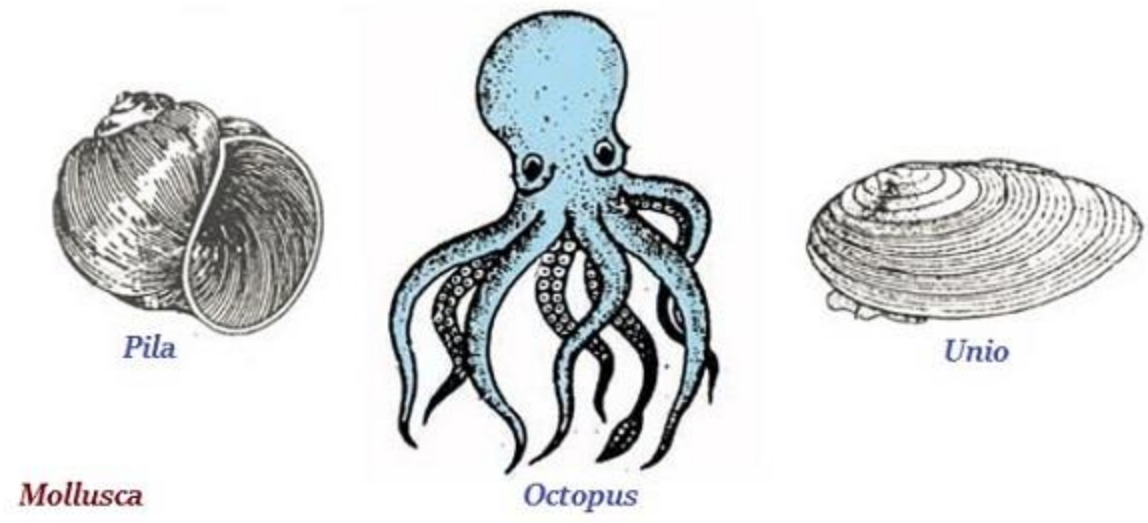
- Arthropoda, probably, is the largest group of animals.
- The animals of this group don't have well defined blood vessels rather there is an open circulatory system.
- The literal meaning of arthropod is jointed legs; so, they have jointed legs.



- Prawns, butterflies, houseflies, spiders, scorpions, etc. are the typical examples of arthropod.

Mollusca

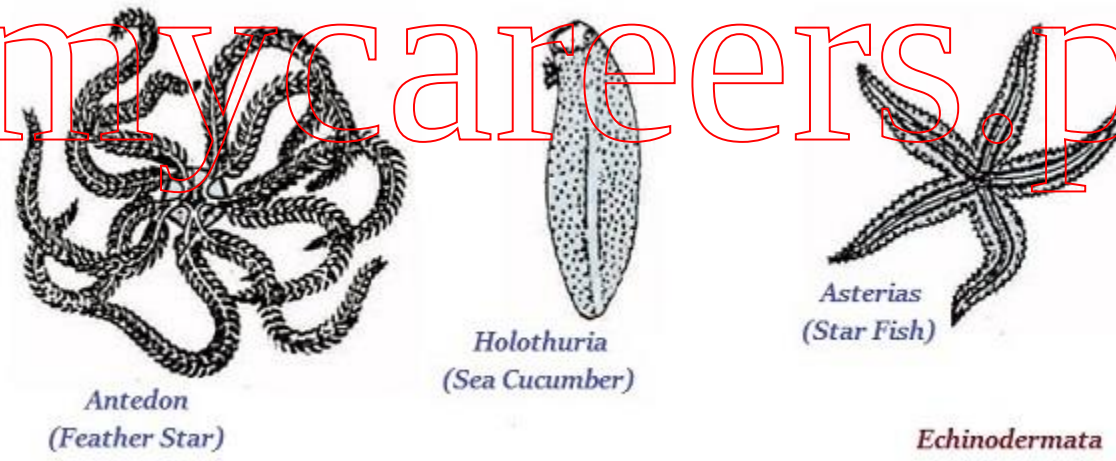
- The organisms of mollusca are invertebrate.
- Most of the organisms of Mollusca group live in water.



- Snails and mussels are the typical example of Mollusca.

Echinodermata

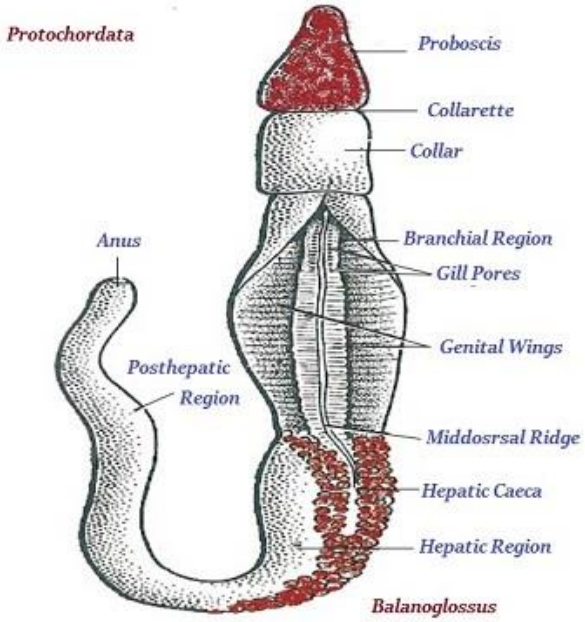
- The organisms of Echinodermata have spiny skinned.
- Echinodermata are free-living marine organisms.



- The examples of echinodermata are starfish, sea urchins, feather star, etc.

Protochordata

- The organisms of protochordata are normally marine. E.g. Balanoglossus, Herdemania, and Amphioxus



- The organisms of protochordata show a typical feature of body design, called as notochord; however, it does present there throughout the life.

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PROTOCHORDATES

Protochordates are an informal category of animals (i.e.; not a proper taxonomic group), named mainly for convenience to describe invertebrate animals that are closely related to vertebrates. This group is composed of the Phylum **Hemichordata**and the Subphyla **Urochordata** and **Cephalochordata**.

The Phylum **Hemichordata** consists of marine worms that share some, but not all of the characteristics of chordates. These animals have pharyngeal gill slits and a dorsal nerve cord, which is usually solid. The three body parts are proboscis, collar and trunk. What was once thought to be a notochord is no longer considered homologous. Acorn worms are examples of hemichordates.

Cephalochordata is represented by the little sand lance, Branchiostoma. This marine animal looks very fish-like with fins, a tail, muscle blocks called myomeres and pharyngeal gill slits for filter feeding. Study their anatomy and note their chordate characteristics. The larva looks like a miniature adult without gonads. This is the one group that retains the Chordate characteristics throughout its life.

Urochordata, sometimes known as the Tunicata, are commonly known as "sea squirts." The body of an adult tunicate is quite simple, being essentially a sack with two siphons through which water enters and exits. Water is filtered inside the sack-shaped body. However, many tunicates have a larva that is free-swimming and exhibits all chordate characteristics: it has a notochord, a dorsal nerve cord, pharyngeal slits, and a post-anal tail. This "tadpole larva" will swim for some time; in many tunicates, it eventually attaches to a hard substrate, it loses its tail and ability to move, and its nervous system

largely disintegrates. Some tunicates are entirely pelagic; known as salps, they typically have barrel-shaped bodies and may be extremely abundant in the open ocean.

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Vertebrates

are animals that have a backbone or spinal column, also called vertebrae. These animals include fish, birds, mammals, amphibians, and reptiles

Introduction

The organisms of this kingdom have a true vertebral column and the internal skeleton structure.

Classification of Vertebrata

- Vertebrates are further classified as –
    - **Pisces**
    - **Amphibia**
    - **Reptilia**
    - **Aves**
    - **Mammalia**

Are there a lot of vertebrate species?

There are currently around 65,000 known species of vertebrate animals. This sounds like a lot, but vertebrates are only around 3% of all the animals on Earth. Most of the animal species are invertebrates.

What are some vertebrate animals?

- Fish - Fish are animals that live in the water. They have gills that allow them to breathe under water. Different species of fish may live in fresh water or salt water. Some examples of fish include the brook trout, the great white shark, lionfish, and the swordfish.
- Birds - Birds are animals that have feathers, wings, and lay eggs. Many, but not all, birds can fly. Some examples of bird species include the bald eagle, the cardinal, the flamingo, ostriches, and the red-tailed hawk.
- Mammals - Mammals are warm-blooded animals that nurse their young with milk and have fur or hair. Some examples of mammals include humans, dolphins, giraffes, horses, and spotted hyenas.
- Amphibians - Amphibians are cold-blooded animals. They start out their lives living in the water with gills just like fish. Later they develop lungs and can move to dry land. Amphibians include frogs, toads, newts, and salamanders.
- Reptiles - Reptiles are cold-blooded animals which lay eggs. Their skin is covered with hard and dry scales. Reptile species include alligators, crocodiles, snakes, lizards, and turtles.

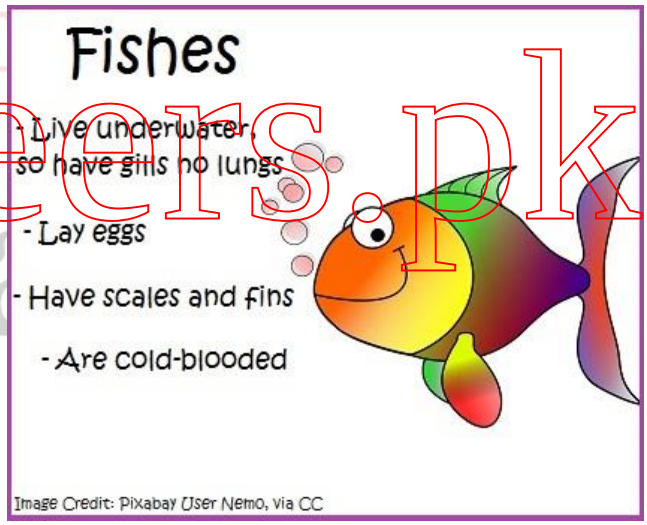
Fun Facts about Vertebrates

- The only mammals that lay eggs are monotremes such as the platypus and spiny anteater.
- There are reptiles that live on every continent except Antarctica.

- Most fish have skeletons made of bone, they are called bony fish. Other fish have skeletons made of cartilage. These include sharks and rays.
- Frogs can breathe through their skin.
- The shortest childhood of any mammal is the hooded seal. They are considered adults when they are just four days old.
- Vertebrates tend to be much more intelligent than invertebrates.

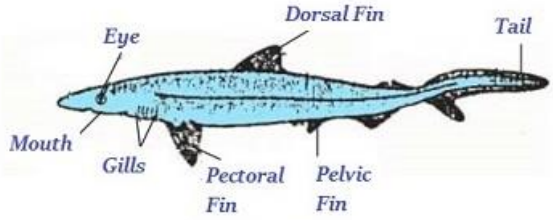
Pisces

- The organisms of this group are typically different types of fishes.
- Fishes can live only in water.
- The skin fish is covered with scales/plates.
- Fish use oxygen dissolved in water by using gills
- The tail of fish helps in their movements.
- Fishes are cold-blooded organisms and their hearts have only two chambers.
- Fishes lay eggs.
- They are the first jawed vertebrates and the study of fish is called **Ichthyology**.
- They are aquatic (may be fresh water or marine).
- Fish are cold blooded animals (**poikilothermic**).
- Their body is spindle shaped or **streamlined** to enable them to move rapidly in water.
- Body is covered with water proof **dermal scales**; which may be of placoid, cycloid, ctenoid or ganoid type.
- **Fins** are the locomotary organs. Pectoral and pelvic fins are paired whereas dorsal and caudal fins are unpaired.
- Eyes are **without eyelids**. External and middle ears are absent; only internal ear is present.
- They consist of **4-7 pairs of gills** for respiration which may be naked or covered with an **operculum**.
- Heart is **two chambered**, known as a **venous heart**. Heart consists of only the impure blood.



- Circulation of blood is **unicircuit** with the presence of **renal** and **hepatic portal**

Pterois Volitans (Lion Fish)

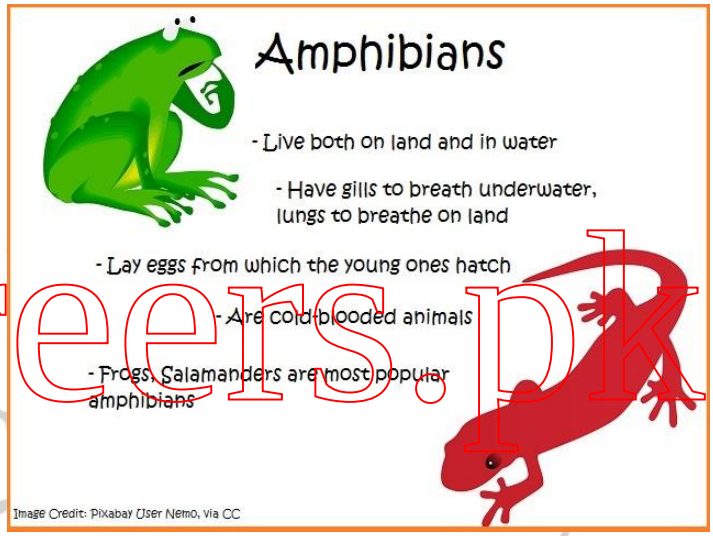


Scoliodon (Dog Fish)

Pisces

Amphibia

- The organisms of amphibia have mucus glands in the skin, and they have three-chambered heart.
- Amphibian can live in water as well as on land.
- The organisms of amphibian respire through either gills or lungs.
- The organisms of amphibia lay eggs.
- Most amphibians are characterized by four well-developed limbs, but some species of salamanders and all caecilians are functionally limbless.
- Amphibians have a moist, permeable skin that is achieved via mucus glands that keep the skin lubricated in order to perform cutaneous respiration.
- All extant adult amphibians are carnivorous; some terrestrial amphibians have a sticky tongue that is used to capture prey.
- Additional characteristics of amphibians include pedicellate teeth, papilla amphibiorum, papilla basilaris, and auricular operculum.
- The tetrapod-like fish, *Tiktaalik roseae*, preceded Acanthostega and lived in a shallow water environment about 375 million years ago.
- All extant adult amphibians are carnivorous, and some terrestrial amphibians have a sticky tongue that is used to capture prey.



Key Terms

- **cutaneous respiration**: exchange of oxygen and carbon dioxide with the environment that takes place through the permeable skin
- **pedicellate teeth**: teeth in which the root and crown are calcified, separated by a zone of noncalcified tissue
- **auricular operculum**: an extra bone in the ear that transmits sounds to the inner ear

Reptilia

Reptiles began to roam the earth about the same time as the dinosaurs. That's a long time to be creeping around, don't you think?

The word **reptile** comes from Latin and means 'one who creeps.' Reptiles are a varied group of a vertebrates (they have a backbone) that includes snakes, lizards, alligators, crocodiles, turtles, worm-lizards and caimans. They live in deserts, forests, freshwater wetlands and the open ocean. Because reptiles are cold-blooded and require less food than birds and mammals, they are the dominate animal in desert environments.

Two characteristics enable reptiles to inhabit land environments to a greater extent than their amphibian ancestors:

1. Scales or scutes
2. The ability to lay hard-shelled or leathery-shelled eggs.

- reptiles have a backbone, which means they are vertebrates.
- All reptiles produce eggs. Most reptiles lay hard-shelled eggs, but a few give birth to live young.
- All reptiles have scales or scutes. **Scales** are small, hard plates that are made from a protein called keratin. **Scutes** are the shells of turtles and the armor of crocodiles and are very similar to scales. Unlike scales, they are bony structures and develop in a deeper skin level than scales. Both scales and scutes provide physical protection and help prevent water loss through the skin.
- Reptiles are **ectothermic** or cold-blooded, which means they cannot control their own body temperature. They must work with their environment to increase or decrease their body temperature. Basking in the sun raises their body temperature, and they move faster when warm. Retreating to shady areas when they get hot lowers their body temperature.
- The organisms of this group are cold bolded.
- The organisms of reptilia lay eggs with tough coverings.

Types

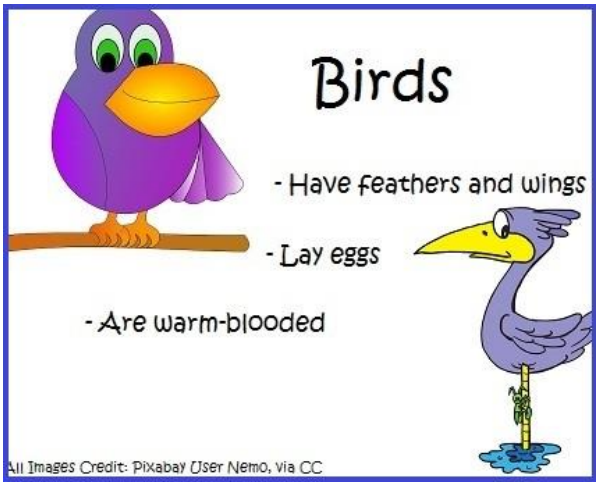
There are four groups or types of reptiles:

1. The turtles
2. The squamata (lizards and snakes)
3. The crocodilians (crocodiles and alligators)
4. The tuatara (lizard-like)

Aves/Birds :

Key Points

- Birds have down feathers that provide insulation and two types of flight feathers found on the wings: thrust-producing primary feathers at the tip of the wing and lift-providing secondary feathers closer to the body.
- Contour feathers found on the body create a smooth, aerodynamic surface.
- The chest muscles of birds are highly developed as they are responsible for the flapping of the entire wing.
- The two clavicles of birds are fused, forming the furcula or wishbone, which is both flexible and strong enough to support to the shoulder girdle during flapping.
- In order to keep body weight low, birds have pneumatic bones, no urinary bladders, and usually only one ovary.
- Birds have developed an efficient respiratory system using air sacs and unidirectional airflow and a cross-current exchange system with the blood.
- The organisms of Aves group are warm-blooded.



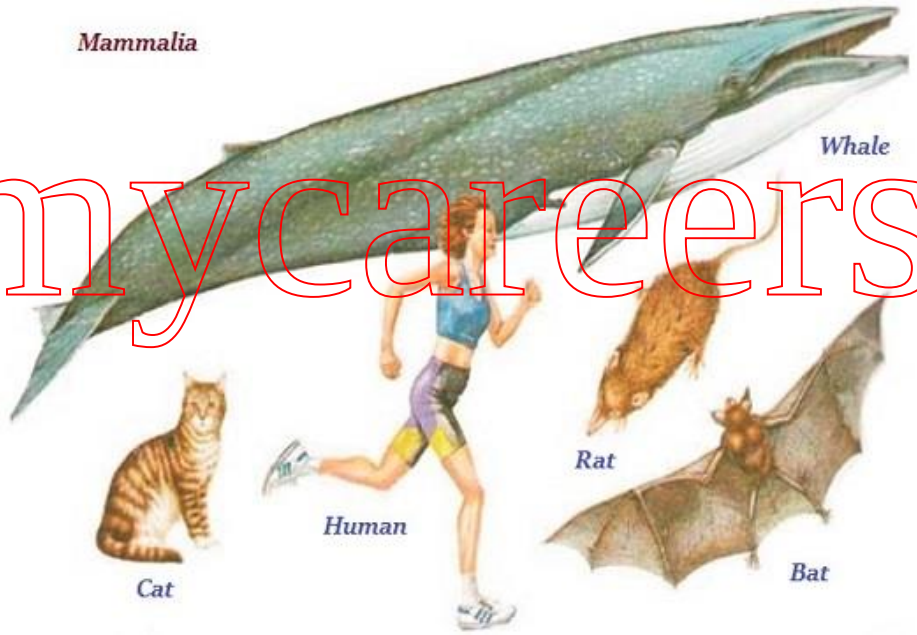
- The organisms of Aves group lay eggs except a few, such as bat.
- Most of the Aves have feathers.

Key Terms

- **pneumatic**: having cavities filled with air
- **endothermic**: an animal whose body temperature is regulated by internal factors
- **furcula**: the forked bone formed by the fusion of the clavicles in birds; the wishbone
- **cloaca**: the common duct in fish, reptiles, birds, and some primitive mammals that serves as the anus as well as the genital opening

Mammalia

- The organisms of Mammalia group are warm-blooded and they have four-chambered hearts.
- Mammalia are typically characterized for their mammary glands.
- Mammary glands produce milk to nourish the young one.
- Most of the mammals produce live baby; however, a few of mammals, such as, the platypus and the echidna lay eggs.



- Mammals' skin has hairs along with sweat and oil glands.

Classification of Mammals

Mammals are the largest class in the animal world. Mammals are of different types and can be distinguished up into marine mammals, smaller mammals and larger mammals. Mammals belong to the class mammalia.

Since mammals are of different types they are classified into three subclass based on their reproduction. They are Eutheria, Metatheria and Prototheria.

Eutheria
Mammals that give birth to their young ones directly belong to the subclass Eutheria. The young ones form as an embryo in the mother stomach and grow there for a certain period of time. This subclass consists of 19 orders. Best example and well known of this class are humans, dogs and cats.

Metatheria
Mammals that belong to this subclass also give birth to their young ones but the young ones are born immature. So they jump into their mother pouch and stay their till they are mature. Metatheria subclass contains seven orders with 250 species

- Didelphimorphia (New World opossums)
- Paucituberculata (South American rat opossums)
- Microbiotheria (colocolo)
- Kangaroos

Prototheria
Prototheria consists of egg laying animals and are also known as monotremes. This subclass consists of six species all in one order.

- Monotremata (platypus and echidna)

Although mammals are classified in to class, subclass, and order the scientist have classified on the general basis. This general classification makes it easy to learn about the mammals class and their distinguished features.

Locomotion in Invertebrates
Locomotion is a characteristic and fundamental attribute of all forms of animals. Unicellular animals swim by cilia or flagella, crawl about with pseudopodia, make withdrawal movements on a stalk that coils up like a stretched spring, or glide along without apparent deformation in shape. Multicellular animals are characterized by the development of muscles—the specialized contractile tissues unique to the animal world.

In general, these different types of motility may be grouped into three broad categories:
(1) Protoplasmic or cytoplasmic movement—the most universal and probably oldest, phylogenetically;
(2) Ciliary or flagellar movement; and
(3) Muscular contraction. At the molecular level, all motile systems depend on a relatively small group of protein molecules, actin and myosin, that polymerize to form elongated microtubules or delicate microfilaments. These two categories of cell organelle are basic to animal movement at all levels in phylogeny.
The survival and success of multicellular organisms depend on the versatility of the muscular system. During evolution, the contractile machinery of muscle system has been adopted to an almost infinite range of movements the sudden withdrawal of the startled tube dwelling worm, the jet propulsion of the squid, the gentle movement of star fish, the rapid oscillation of wings and so on.
All these diverse mode of movement depend on very similar biochemical mechanisms.

However, it was found that muscular tissue alone is not sufficient in most metazoan animals to bring about effective movement of the body. The reason is that the contraction of muscle fibre is an active process whereas their relaxation is not. So the contracted fibres must be restored to their original length by some force, if the form of the body is to be maintained.
In higher animals (vertebrates), the force is external and applied through the jointed skeleton and attached muscles. In order to achieve this force, soft-bodied animals have developed a special type of skeletal system known as hydrostatic skeleton. Its function depends upon the musculature being so arranged that it surrounds an enclosed volume of fluid.

The contraction of any one part of the musculature system sets up a pressure in the fluid which is then transmitted in all directions to the rest of the body and thus making its movement possible. With the advancement in the organization of body structure, coelomates evolved.
In coelomates the coelom or body cavity with its contained fluid provides more highly organized structural basis for the hydrostatic skeleton than that of the acoelomate animals like coelenterates and platyhelminthes.

Coelomates viz., annelids, echinoderms and many other small groups move upon hydrostatic principles but they show a greatly increased flexibility and speed of response.
Along with the coelom, another innovation in the structural organization is the development of metamerism—a plan of structure in which the body is differentiated along long axis into a series of units, each of which contains elements of some chief organ systems like appendages, nerve ganglia, excretory organs etc.

In some metameric annelids, the locomotion depends upon the segmental partitioning of coelomic fluid as well as the refinement of integration exerted by the metamerically segmented nervous system.

So the precision of various movements depend on the architecture of muscular system and concomitant specialization in associated tissues, hydrostatic skeletal system, metamerism and nervous integration. Here we shall discuss how various type of movements are performed by animals belonging to different phyla in different habitats.

Gas Exchange

In order to see how gas exchange occurs we need to look further into the lungs. Firstly we know that air enters the body through the mouth or nose, from here it moves to the pharynx (throat), passes through the larynx (voice box) and enters the **trachea**. The trachea splits into two branches, the left and right **bronchus**, each bronchus divides many times into smaller branches called **bronchioles**. Each bronchiole finally leads to a bunch of tiny air sacs, called **alveoli**, which inflate during inhalation, and deflate during exhalation.
It is at the alveoli where **gas exchange** takes place.
Gas exchange is the delivery of oxygen from the lungs to the bloodstream, and the elimination of carbon dioxide from the bloodstream to the lungs and out of the body.

Air enters the body through the mouth and nose, from here it moves to the pharynx (throat), passes through the larynx (voice box) and enters the trachea.

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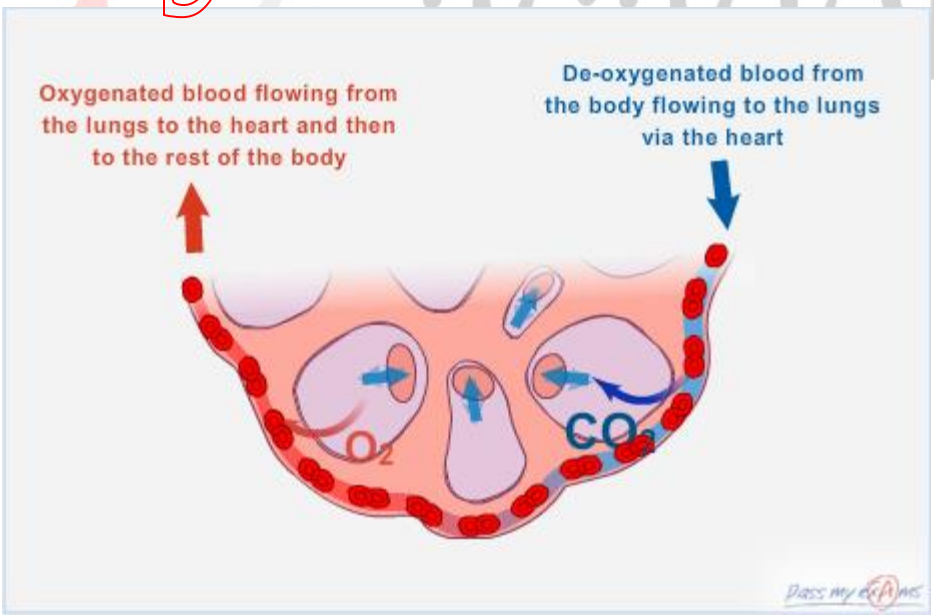
Each bronchiole finally leads to a bunch of tiny air sacs, called alveoli, which inflate during inhalation, and deflate during exhalation.

Gas exchange is the delivery of oxygen from the lungs to the bloodstream, and the elimination of carbon dioxide from the bloodstream to the lungs and out of the body. It takes place in the alveoli.



The walls of the alveoli are surrounded by a network of blood capillaries. In fact the alveoli walls share a membrane with the capillaries which allows for oxygen to diffuse through the alveoli wall and enter the bloodstream and then travel to the heart. At the same time it allows for carbon dioxide to diffuse from

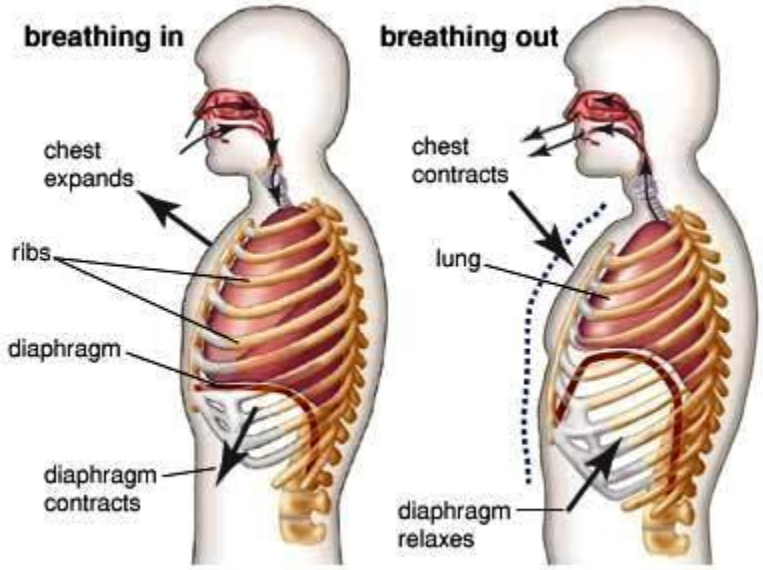
the bloodstream into the alveoli and exhaled out of the body. Both oxygen and carbon dioxide move from areas of high concentration to areas of lower concentration.

Breathing	Gaseous exchange at lungs level	Gas transport by blood	Gaseous exchange at tissue level	Cellular Respiration
Air movement into and out of lungs	Exchange of gases between alveoli and blood	Transport of oxygen from blood capillaries of alveoli to body cells and return of carbon dioxide	Exchanging of oxygen from blood into the cells and carbon dioxide from cells into the blood	Using oxygen in cell processes to produce carbon dioxide and water, releasing energy to be used for life processes

NOTES COMPILED BY TAHIR HABIB

Exchange of gases:

(a) **Exchange of gases in lungs:** It is also called external respiration. In this gaseous exchange oxygen passes from alveoli to pulmonary capillary blood and CO_2. Comes to alveoli from pulmonary capillary.



(2) **Release of CO_2 by the blood:** The P_{CO2} (partial pressure of carbon dioxide) of blood reaching the alveolar capillaries is higher than the P_{CO2} of alveolar air. Therefore, carbon dioxide diffuses from the blood of alveolar capillaries into the alveolar air.
(b) **Exchange of gases in tissues:** In the tissues, exchange of gases occurs between the blood and the tissue cells. This exchange occurs via tissue fluid that bathes the tissue cells. The blood reaching the tissue capillaries has P_{O2} higher than that in the tissue cells and P_{CO2} lower than that in the tissue cells.
(iii) **Transport of gases:** Blood carries O2 from respiratory organs to the tissue cells for oxidation and CO2 from tissue cells to respiratory organs for elimination. Blood should be slightly alkaline to help the transport of O2 and CO2 properly.

Partial pressures of respiratory gases in mm Hg

Gas	Inspired air	Alveolar air	Venous blood	Arterial blood	Expired air	Tissue cells
Oxygen	158	100 – 105	40	95 – 100	116	20 – 40
Carbon dioxide	0.3	40	46	40	32	45 – 52
Nitrogen	596	573	573	573	565	–

Composition of three samples of air

Gases	Inspired air	Expired air	Alveolar air	Gain / loss %
Oxygen	20.84%	15.70%	13.6%	Gain 5.14%
Carbon dioxide	0.04%	4.00%	5.3%	Loss 3.96%
Nitrogen	78.62%	74.50%	74.9%	Gain 4.12%
Water	0.5%	6.2%	6.2%	Loss 5.7%

Aerobic respiration	Anaerobic respiration
1) It takes place in the presence of oxygen.	1) It takes place in the absence of oxygen.
2) In aerobic respiration, complete oxidation of glucose takes place.	2) In anaerobic respiration, the glucose molecule is incompletely oxidised.
3) End products are CO_2 and water.	3) End products are either ethyl alcohol or lactic acid and CO_2.
4) Lot of energy is liberated (38 ATP).	4) Relatively small energy is liberated (2 ATP).
5) It occurs in plant's and animal's cells.	5) Occurs in many anaerobic bacteria and human muscle cells.
6) $C_6H_{12}O_6 + 6O_2 \rightarrow 6\,CO_2 + 6H_2O + 686$ K.cal	6) $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2 + 56$ K.cal

Gas exchange in plants

Plants respire all the time, but photosynthesis only happens during the day. This means that the net gas exchange from a leaf depends on the light intensity.

The leaf

The structure of the leaf is adapted for gas exchange. The cells in the spongy mesophyll (lower layer) are loosely packed, and covered by a thin film of water. There are tiny pores, called stomata, in the surface of the leaf. Most of these are in the lower epidermis, away from the brightest sunlight.

The role of stomata

The stomata control gas exchange in the leaf. Each **stoma** can be open or closed, depending on how turgid its guard cells are.

In the light, the guard cells absorb water by osmosis, become turgid and the stoma opens.

In the dark, the guard cells lose water, become flaccid and the stoma closes.

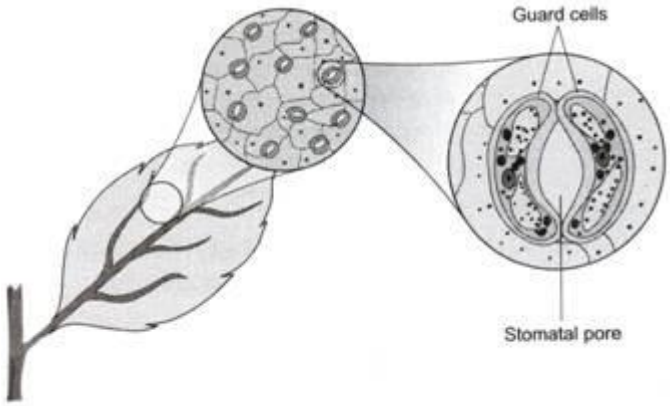
Diffusion of carbon dioxide, oxygen and water vapour into (or out of) the leaf is greatest when the stomata are open.

Exchange of Gases in Plants!

In plants, oxygen and carbon dioxide diffuse through the stomata and the intercellular spaces of the leaves, and the lenticels of the bark.

In woody plants, the stem is covered with bark.

Lenticels are small openings in the pits of the bark. The exchange of gases takes place through the lenticels also, apart from the exchange through the openings in the leaves.



Stomata

The direction of exchange of gases between a plant and its surroundings depends upon the time of the day and the usage of the gases by the plant. Plants respire throughout the day, while photosynthesis takes place only in the presence of sunlight. In daytime, carbon dioxide produced in respiration by the plants is used by them in photosynthesis. So, carbon dioxide is not released into the environment.

TRANSPORT OF MATERIALS IN LIVING THINGS

To stay alive all living organisms need to transport materials like food, water and oxygen to various parts of the body. Food and oxygen are transported to all cells in the body for respiration and growth. Waste products are transported from the cells to organs that excrete them.

All plants need water. The wilted leaves recover when water is added to the soil, which means that water has been conducted upward into the leaves. You have also learnt that the leaves for photosynthesis need water. Likewise, the food produced in the leaves has to be transported to other parts of the plant including the stem, the roots flowers and fruits etc. All this transportation is the function of conducting tissues.

Similarly, in animals, the food absorbed by the gut has to be carried to all the body parts, oxygen absorbed in the lungs has to be transported to every cell of the body, the carbon dioxide produced in the cells has to be carried to the lungs for elimination, and the poisonous body wastes like urea has to be transported to the kidneys for elimination in urine, and so on. All such functions are the outcome of a transport system.

WAYS OF TRANSPORTATION OF MATERIALS

Molecules move in and out of a cell through the cell membrane, which forms the boundary of each cell. The cell membrane is selectively permeable to substances, which means that it permits entry and exit of certain molecules only. There are various methods by which materials are transported in plants and animals. The movement of molecules takes place by passive transport (simple diffusion, facilitated diffusion, osmosis, and mass flow) and active transport.

1. PASSIVE TRANSPORT

Passive transport is a movement of ions and other atomic or molecular substances across cell membranes without need
of energy input. Passive transport is naturally occurring phenomenon and does not require the cell to expend energy to accomplish the movement.

2. ACTIVE TRANSPORT

In active transport, molecules have to move (against concentration gradient) i.e., from a region of their lower concentration to a region of their higher concentration. Energy is required in active transport.

The four main kinds of passive transport are simple diffusion, facilitated diffusion, osmosis, and mass flow.

A) DIFFUSION

Diffusion is a passive process of transport in which substances tend to move out from their region of higher concentration to the region of lower concentration until concentration is equal across the space. For example, during respiration, oxygen-laden air in lungs being at a higher concentration moves into blood capillaries having lower concentration of oxygen in them. Such movement of particles or molecules from a region of their higher concentration to a region of their lower concentration is termed diffusion.

Factors that affect the rate of diffusion

i) Extent of the concentration gradient: the greater the difference in concentration, the more rapid the diffusion. The closer the distribution of materials gets to equilibrium, the slower the rate of diffusion becomes.

ii) Mass of the molecules diffusing: more massive molecules move more slowly, because it is more difficult for them to move between the molecules of the substance they are moving through; therefore, they diffuse more slowly.

iii) Size of the molecule: the smaller the molecule such as gas, the faster the rate of diffusion while the larger the molecule (liquid) the slower the rate of diffusion.

iv) Temperature: higher temperatures increase the energy and therefore the movement of the molecules, increasing the rate of diffusion.

v) State of matter: diffusion in gas molecules is faster than the diffusion in liquids and it is not possible in solids.

B) FACILITATED DIFFUSION

In facilitated transport also called facilitated diffusion, material moves across the plasma membrane with the assistance
of transmembrane proteins down a concentration gradient (from high to low concentration) without expenditure of cellular energy.

C) OSMOSIS

Osmosis is the movement of water molecules from a region having more water molecules to a region having less water molecules when separated by a semi permeable membrane. Semi permeable membrane means a membrane, which allows some molecules (e.g. water molecules) to pass through it but not some other larger molecules. No energy is spent during osmosis.

Whereas diffusion transports material across membranes and within cells, osmosis transports *only water* across a membrane and the membrane limits the diffusion of solutes in the water.
When water moves across a semi permeable membrane by osmosis into another solution, a pressure builds up to stop the flow of pure water into the solution. This pressure is called **osmotic pressure** .Thus water moves from a region of high osmotic pressure to a region of low osmotic pressure.

Terms used in connection with osmosis
i. Hypotonic solution: This is used to describe a solution containing less solute and more water molecules compared to another. A hypotonic solution has lower osmotic pressure and is generally termed as less concentrate.
ii. Isotonic solution: These are solutions with same concentration of solute and water i.e. solutions with same osmotic pressure.
iii. Hypertonic solution: This is used to describe a solution with more solutes and less water molecules than another .A hypertonic solution has a higher osmotic pressure and is generally termed as more concentrated solution.
iv. Haemolysis: refers to the destruction of red blood cells (RBCs), which is broadly defined as a reduction in the life span below 100 days (normal 110-120 days).
v. Crenation is the contraction (shrinkage) of a cell after exposure to a hypertonic solution, due to the loss of water through osmosis.
vi. Plasmolysis is when plant cells lose water after being placed in a solution that has a higher concentration of solutes than the cell does. This is known as a hypertonic solution. Water flows out of the cells and into the surrounding fluid due to osmosis. This causes the protoplasm, all the material on the inside of the cell, to shrink away from the cell wall.
vii. Turgidity is the fully expanded condition of a cell with its wall stretched due to excessive accumulation of water. The outward pressure exerted by the cell fluid on the cell wall is called **turgor pressure**. The inward pressure exerted on the cell contents by the stretched cell wall is called **wall pressure**.

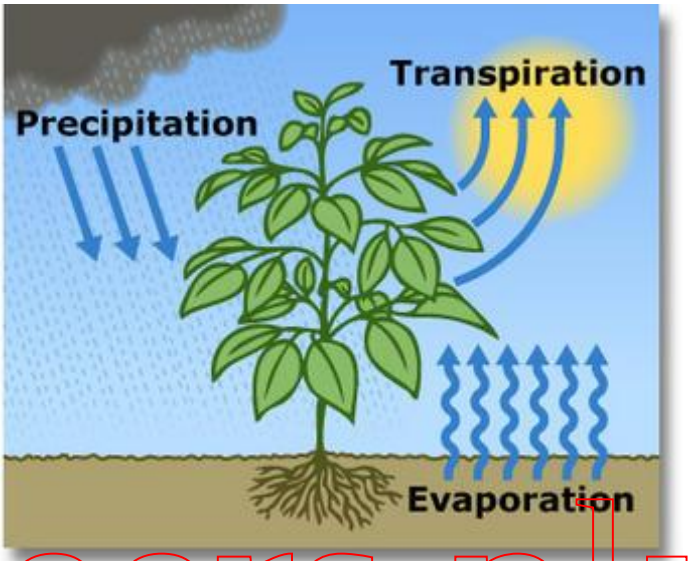
D) MASS FLOW
Mass flow refers to the movement of substance in bulk from one point to another as a result of pressure differences between the two points.
In living organisms this usually means the bulk movement of water (the solvent) together with all its dissolved solutes and suspended objects. So mass flow is like a river carrying everything with it. Mass flow always requires a source of energy to pump the fluid, but it has the advantage of being much faster than diffusion, especially over large distances. Mass flow is completely independent of concentration differences. Examples of mass flow include: circulatory systems in animals, xylem and phloem systems in plants, filter feeder currents, and ventilation.

Evapotranspiration can be defined as the sum of all forms of evaporation plus transpiration, but here at the Water Science School, we'll be defining it as the sum of evaporation from the land surface plus transpiration from plants.

What is evapotranspiration?

Evapo transpiration is the sum of evaporation from the land surface plus transpiration from plants.

The typical plant, including any found in a landscape, absorbs water from the soil through its roots. That water is then used for metabolic and physiologic functions. The water eventually is released to the atmosphere as vapor via the plant's stomata — tiny, closeable, pore-like structures on the surfaces of leaves. Overall, this uptake of water at the roots, transport of water through plant tissues, and release of vapor by leaves is known as transpiration.



Water also evaporates directly into the atmosphere from soil in the vicinity of the plant. Any dew or droplets of water present on stems and leaves of the plant eventually evaporates as well. Scientists refer to the combination of evaporation and transpiration as evapo transpiration,

If you search for the definition of evapo transpiration, you will find that it varies. In general, evapo transpiration is the sum of evaporation and transpiration. Some definitions include evaporation from surface-water bodies, even the oceans. But, since we have a Web page just about evaporation, our definition of evapo transpiration will not include evaporation from surface water.

CIRCULATORY SYSTEM

The circulatory system consists of three independent systems that work together: the heart (cardiovascular), lungs (pulmonary), and arteries, veins, coronary and portal vessels (systemic). The system is responsible for the flow of blood, nutrients, oxygen and other gases, and as well as hormones to and from cells.

An average adult has 5 to 6 quarts (4.7 to 5.6 liters) of blood, which is made up of plasma, red blood cells, white blood cells and platelets.

The heart is a muscular organ with four chambers. Located just behind and slightly left of the breastbone, it pumps blood through the network of arteries and veins called the cardiovas- cular system.

The systemic circulation is a major portion of the circulatory system. The network of veins, arteries and blood vessels transports oxygenated blood from the heart, delivers oxygen and nutrients to the body's cells and then returns deoxygenated blood back to the heart.

The system of blood vessels in the human body measure about 60,000 miles (96,560 kilometers).

Arteries carry oxygen-rich blood from the heart through the body. Veins carry oxygen-poor blood back to the heart.

The superior vena cava carries oxygen-poor blood into the heart. The aorta carries oxygenated blood from the heart to organs and tissues.

Blood Basics

Blood is a specialized body fluid. It has four main components: plasma, red blood cells, white blood cells, and platelets. Blood has many different functions, including:

- transporting oxygen and nutrients to the lungs and tissues
- forming blood clots to prevent excess blood loss
- carrying cells and antibodies that fight infection
- bringing waste products to the kidneys and liver, which filter and clean the blood
- regulating body temperature

The blood that runs through the veins, arteries, and capillaries is known as whole blood, a mixture of about 55 percent plasma and 45 percent blood cells. About 7 to 8 percent of your total body weight is blood. An average-sized man has about 12 pints of blood in his body, and an average-sized woman has about nine pints.

Plasma

The liquid component of blood is called plasma, a mixture of water, sugar, fat, protein, and salts. The main job of the plasma is to transport blood cells throughout your body along with nutrients, waste products, antibodies, clotting proteins, chemical messengers such as hormones, and proteins that help maintain the body's fluid balance.

Red Blood Cells (also called erythrocytes or RBCs)

Known for their bright red color, red cells are the most abundant cell in the blood, accounting for about 40 to 45 percent of its volume. The shape of a red blood cell is a biconcave disk with a flattened center - in other words, both faces of the disc have shallow bowl-like indentations (a red blood cell looks like a donut).

Production of red blood cells is controlled by erythropoietin, a hormone produced primarily by the kidneys. Red blood cells start as immature cells in the bone marrow and after approximately seven days of maturation are released into the bloodstream. Unlike many other cells, red blood cells have no nucleus and can easily change shape, helping them fit through the various blood vessels in your body. However, while the lack of a nucleus makes a red blood cell more flexible, it also limits the life of the cell as it travels through the smallest blood vessels, damaging the cell's membranes and depleting its energy supplies. The red blood cell survives on average only 120 days.

Red cells contain a special protein called hemoglobin, which helps carry oxygen from the lungs to the rest of the body and then returns carbon dioxide from the body to the lungs so it can be exhaled. Blood appears red because of the large number of red blood cells, which get their color from the hemoglobin. The percentage of whole blood volume that is made up of red blood cells is called the hematocrit and is a common measure of red blood cell levels.

White Blood Cells (also called leukocytes)

White blood cells protect the body from infection. They are much fewer in number than red blood cells, accounting for about 1 percent of your blood.

The most common type of white blood cell is the neutrophil, which is the "immediate response" cell and accounts for 55 to 70 percent of the total white blood cell count. Each neutrophil lives less than a day, so your bone marrow must constantly make new neutrophils to maintain protection against infection. Transfusion of neutrophils is generally not effective since they do not remain in the body for very long.

The other major type of white blood cell is a lymphocyte. There are two main populations of these cells. T lymphocytes help regulate the function of other immune cells and directly attack various infected cells and tumors. B lymphocytes make antibodies, which are proteins that specifically target bacteria, viruses, and other foreign materials.

Platelets (also called thrombocytes)

Unlike red and white blood cells, platelets are not actually cells but rather small fragments of cells. Platelets help the blood clotting process (or coagulation) by gathering at the site of an injury, sticking to the lining of the injured blood vessel, and forming a platform on which blood coagulation can occur. This results in the formation of a fibrin clot, which covers the wound and prevents blood from leaking out. Fibrin also forms the initial scaffolding upon which new tissue forms, thus promoting healing.

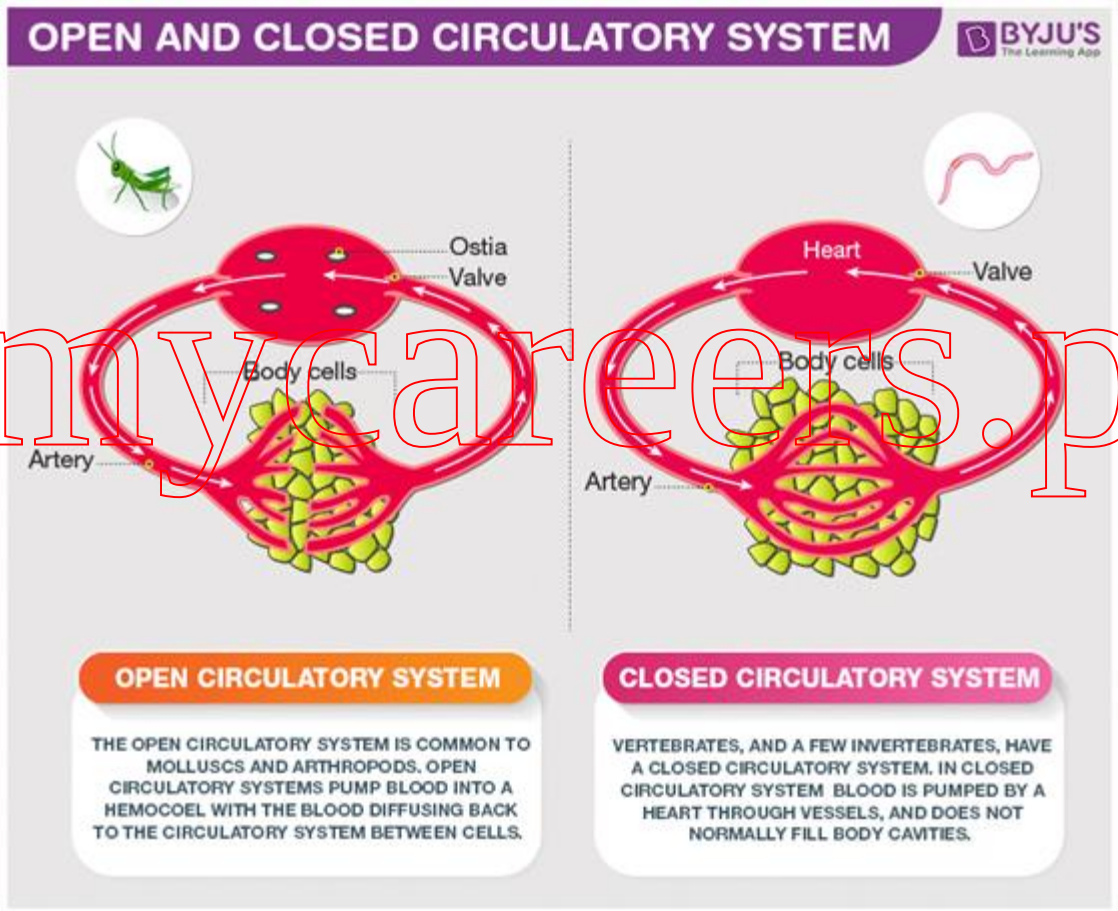
A higher than normal number of platelets can cause unnecessary clotting, which can lead to strokes and heart attacks; however, thanks to advances made in antiplatelet therapies, there are treatments available to help prevent these potentially fatal events. Conversely, lower than normal counts can lead to extensive bleeding.

Difference Between Open and Closed Circulatory System

Vertebrates and few invertebrates have a closed circulatory system. The open circulatory system on the other hand is most commonly seen in invertebrates such as cockroaches and crabs. The other major difference between Open and Closed Circulatory System are summarized below:

Difference Between Open and Closed Circulatory System	
Open Circulatory System (OCS)	**Closed Circulatory System (CCS)**
Blood flows through open spaces	Blood flows through closed spaces
The open spaces are called sinuses and lacunae	Closed spaces involve arteries and veins
The velocity at which blood flows is slow	Blood flows at a comparatively higher velocity

Organisms that have OCS have haemocoel	CCS organisms don't have haemocoel
The time it takes to circulate nutrients and eliminate wastes are high	The time it takes to circulate nutrients and eliminate wastes are low
Blood flow cannot be regulated	Blood flow can be regulated
Organs come in direct contact with blood	Organs are not in direct contact of blood
Organisms with OCS: Snails, clams, cockroaches and spiders	Organisms with CCS: Humans, squids, Cats, earthworms



Excretion In Plants And Transpiration

Living organisms carry out their life based on certain life processes. These life processes help to regulate their daily activities. Excretion is one among them. The metabolism takes place in the cells of living organisms resulting in both useful and toxic products. The accumulation of toxins may harm the organism. Thus the living organisms remove all these metabolic wastes from their body and this process

is called excretion. Different organisms follow different modes of excretion. Let's have a glance at excretion in plants and how excretion in plants is different from that of animals.

Excretion in Plants

Elimination of toxic and waste products from the body is called excretion. Organisms like animals have an advanced and specialized system for excretion. But plants lack a well-developed excretory system like that in animals. They do not have special organs for excretion. Thus excretion in plants is not so complex.

Excretory products

The cellular respiration, photosynthesis, and other metabolic reactions produce a lot of excretory products in plants. Carbon dioxide, excess water produced during respiration and nitrogenous compounds produced during protein metabolism are the major excretory products in plants.

Plants produce two gaseous waste products i.e. oxygen during photosynthesis and carbon dioxide during respiration. Excretion of gaseous waste in plants takes place through stomatal pores on leaves. Oxygen released during photosynthesis is used for respiration while carbon dioxide released during respiration is used for photosynthesis.

Excess of water is also excreted from the plant body through the stomatal pores and from the surfaces of fruits and stems. The process of elimination of water is called transpiration.

KIDNEY

What are kidneys?

Your kidneys are two of the most important organs in your body. They filter your blood and help get rid of waste products from your body.

Each kidney is about the size of a mobile phone. They have an unusual shape - kidney beans are named after them because they have the same shape.

They are found just under your back ribs, but you can't feel them with your hands.

What kidneys do

The kidneys do several important jobs which help to keep your body working well.

- They get rid of waste products carried in the blood.
  The kidneys are part of the waste disposal team. They check out the minerals, vitamins and other nutrients that you get from your food and send off into urine anything that is not needed. They make urine (wee), send it down to the bladder through tubes called the ureters (say yoo-ree-ters), and when the bladder feels full enough the brain sends you off to the toilet to get rid of the urine. Have a look at 'Your waste disposal system' if you would like to know more about this.

- **They balance the volume of fluid in the body.**
  Adults have around 7 to 8 litres of blood in their body (kids have a smaller amount, depending on how big they are). All of this gets filtered through the kidneys many times a day. If the volume of fluid in your body goes down (maybe you are sweating out a lot of fluid through your skin or maybe you are not drinking enough water), the kidneys will not make much urine until the amount of fluid in your body goes up.
- **They can change blood pressure.**
  The kidneys make a hormone that can constrict (make narrower) the arteries in the body. This causes blood pressure to rise when a higher pressure is needed to make sure that blood gets to all parts of your body.
- **They help in making red blood cells.**
  The kidneys make a hormone that tells the body when to make more red blood cells.
- **They produce active vitamin D.**
  Vitamin D helps the body to absorb calcium from dairy products and some other foods that you eat. Calcium is needed to make strong bones and teeth.

CONTROL & COORDINATION

➢ **Coordination-**The working together of various organs of the body of an organism in a proper manner to produce appropriate reaction to a stimulus is called coordination.

➢ **Stimulus-** The changes in the environment to which an organism responds and reacts is called Stimulus

➢ **Control & coordination in animals-** takes place by (i) Nervous system & (ii) Endocrine system

➢ **Nervous system**

Stimulus → Receptor organ → Sensory nerve → Brain/Spinal cord
↓ Response ← Effector organ ← Motor nerve

➢ **Endocrine system**

Stimulus → Endocrine organ → Secrete hormone → Hormone in blood ↓
Response ← Target organ

➢ **Parts of the Nervous system –**

(i) Brain (ii) Spinal cord (iii) Nerves (Neurons)

➢ A Neuron is the structural & functional unit of Nervous system

➢ **Parts of a neuron-**

(i) Dendrites (ii) Cell body (iii) Axon

➢ **Synapse-** Space/junction between two adjacent nerves is called Synapse.

➢ **Passing of information takes place –**

(i) By Electric impulse (inside the neuron) and
(ii) In the form of chemicals (At synapse)

➢ **Reflex action-** Spontaneous, involuntary and automatic response to a stimulus to protect us from harmful situations. Eg. On touching a hot object unknowingly we instantly withdraw our hand.

➢ **Reflex arc-** The pathway of the reflex action is called Reflex arc.

Stimulus → Receptor organ → Sensory nerve → Spinal cord →Effector organ→ Response

➢ **Nervous system-**

(1) Central Nervous system (CNS)

(2) Peripheral Nervous system(PNS)

(i) Brain (i) Autonomic Nervous system

(ii) Spinal cord (ii) Voluntary Nervous system

➢ Brain

(i) Centre of coordination of all activities

(ii) Thinking is involved

(iii) Complex process

➢ **Parts of brain-**

Refer to figure 7.3 page no. 118 of N.C.E.R.T Text book

Fore brain	Mid brain	Hind brain
(i) Cerebrum (ii) Thalamus (iii) Hypothallamus	----------	(i) Cerebellum (ii) Pons (iii) Medulla oblongata

➢ **Fore brain Cerebrum-**

(i) Main thinking and largest part of the brain.

(ii) It has 3 main areas-

a) Sensory area- to receive impulses from sense organs via Receptors

b) Motor area- control voluntary movements.

c) Association areas- Reasoning, learning & intelligence. Thalamus – It relays sensory information to the Cerebrum

Hypothallamus- It forms the link between Nervous system & Endocrine system

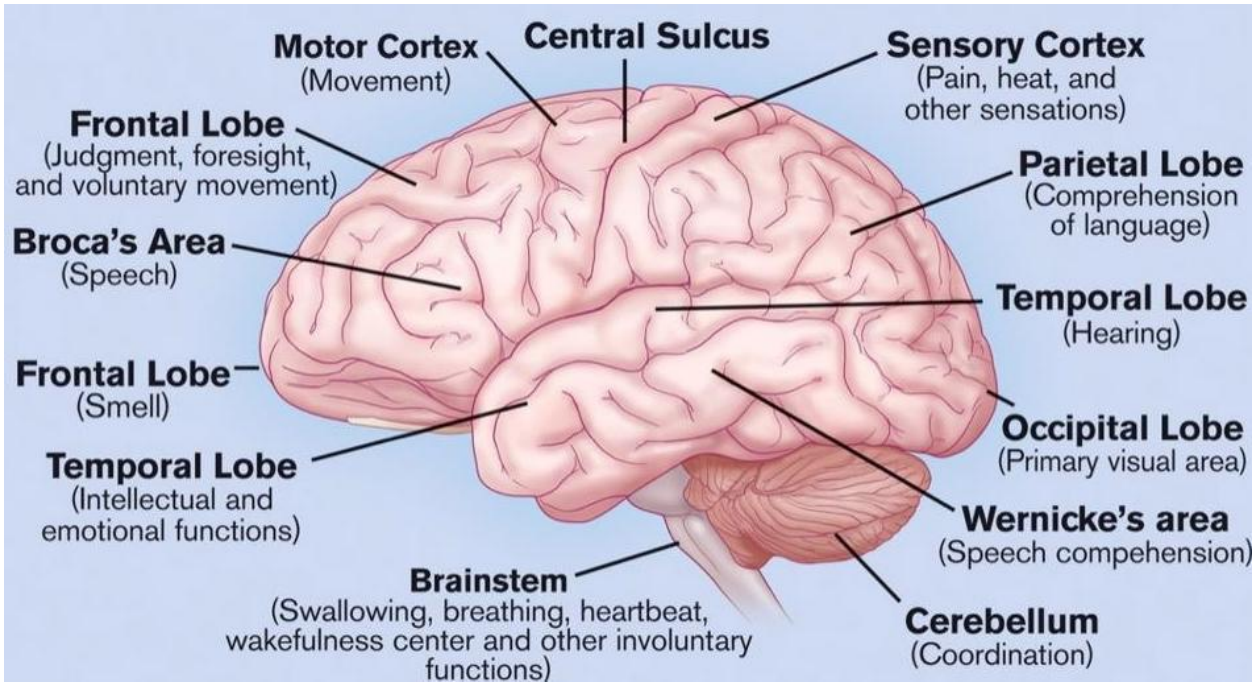
➢ **Mid brain-** It connects Fore brain and Hind brain. Controls reflex of eyes & ears

➢ **Hind brain-** Connects the Fore brain & Hind brain

Cerebellum – Controls & coordinates muscular movements, maintaining body posture and equilibrium.

Pons- Acts as a bridge between brain & spinal cord

Medulla oblongata- Controls involuntary actions like blood pressure, salivation, vomiting, etc.



➢ **Spinal cord-** Cylindrical or tubular structure extending downwards from the Medulla oblongata.

➢ **Protection of the brain & the spinal cord-**

(i) Bony outer covering: skull for the brain & vertebral column for the spinal cord.

(ii) Cerebrospinal fluid present in between the three membranes.

➢ **Action caused by Nervous tissue**

Information → Nervous tissue → Brain Muscles → Causes action

➢ **Path or action-**

Nerve impulse → Muscle cell → Changes shape due to special proteins

↓

Action caused ← Shorter form of muscles ← Change shape & arrangement of cell

➢ **Chemical communication by hormones- (advantages)**

(i) Electrical impulses have their limitations because they reach only those cells connected to the nervous tissue.

(ii) Also the nerve cells cannot generate & transmit impulses continuously.

iii)Electrical communication is slower.

➢ **Hormones-**

(i) are chemical messengers secreted by endocrine glands

(ii) Are secreted in small amounts & may act in nearby places or distant places.

(iii) Do not take part in the reaction & are destroyed immediately.

➢ **Hormones are secreted by- Endocrine glands & Exocrine glands**

S. No.	Endocrine glands	Exocrine glands
1.	Ducts absent	Ducts present

2.	Secrete hormones	Secrete enzymes
3.	Secreted in blood	Secreted in ducts of glands
4.	Situated away from the site of action	Situated near the site of action

Some glands which act as both endocrine & exocrine

Gland	Endocrine function	Exocrine function
Pancreas	Produces insulin & Glucagon hormone.	Produces digestive enzyme. (pancreatic amylase)
Testes	Produces hormone Testosterone	Produces male gametes (reproductive cells)
Ovaries	Produces hormone Oestrogen	Produces female gametes (reproductive cells)

➢ **Important Endocrine glands, the hormone they secrete & their function**

Endocrine gland	Hormone	Function
Pituitary gland	Growth hormone	Body growth, development of bones & muscles (If excess- Gigantism) (If less- Dwarfism)
Thyroid gland	Thyroxine	Regulates carbohydrate, protein & fat metabolism
Pancreas	Produces insulin & Glucagon hormone	Regulates blood sugar levels (if less diabetes is caused)
Testes in males	Produces hormone Testosterone	Development of secondary male characters like deep voice, beard, etc.
Ovaries in females	Produces hormone Oestrogen	Development of secondary female characters like mammary glands, menstrual cycle, maintenance of pregnancy.

➢ **Coordination in plants-** Only chemical coordination is present in plants.

➢ **Tropic movements-** The movements of plants in the direction of stimulus (positive) or away from it (negative) are called tropic movements. E.g. Phototropism, Geotropism. Chemotropism.

Nastic movements -The movements of plants independent of stimuli are called nastic movements. E.g.- Touch me not plant leaves close when touched.

➢ **Plant hormones (Phytohormones) Examples-**

1. Auxins- Help in growth of root & shoot tips.
2. Gibberellins- Help in vegetative growth
3. Cytokinins- Promote cell division
4. Abscissic acid - Inhibits growth & causes wilting (falling) of leaves

➢ **Important diagrams-**

1. Structure of neuron (nerve cell)
2. Reflex arc
3. Human brain
4. Endocrine glands .

THE ENDOCRINE SYSTEM

The endocrine system is a set of hormone secreting glands within the body of an animal. The function of the endocrine system is homeostasis, communication and response to stimuli. The endocrine system regulates the internal environment of the animal for growth, survival and reproduction as well as allowing it to respond to changes in its external environment.

The endocrine system's glands secrete chemical messages we call hormones. These signals are passed through the blood to arrive at a **target organ**, which has cells possessing the appropriate **receptor**.

Exocrine glands (not part of the endocrine system) secrete products that are passed outside the body. Sweat glands, salivary glands, and digestive glands are examples of exocrine glands.

The other communication method in the body is the nervous system. Although there are differences between them, they complement each other in many responses, e.g., response to danger.

The difference between nervous and endocrine control are as follows:

1. Nervous response is faster.
2. Nervous response is shorter in duration.
3. Nervous response stops quicker.
4. Nervous response is much more local.
5. Nerve ‗messages' are conducted electrically; endocrine ‗messages' are carried chemically.

Hormones:

Most hormones are made of protein. They are called peptides. Peptides are short chains of amino acids; most hormones are peptides. They are secreted by the pituitary, parathyroid, heart, stomach, liver, and kidneys.

Some hormones are steroid based. Steroids are lipids derived from cholesterol. Testosterone is the male sex hormone. Estradiol, similar in structure to testosterone, is responsible for many female sex characteristics. Steroid hormones are secreted by the gonads, adrenal cortex, and placenta.

Hormones are usually slow to act but, once they act,

THE PITUITARY GLAND

The pituitary gland is often called **the master gland**. That is because the pituitary gland produces hormones that regulate other endocrine glands. Some hormones produced by the pituitary gland are:

1. **Follicle Stimulating Hormone (FSH):** Follicle-stimulating hormone is a gonadotropin, a glycoprotein polypeptide hormone. FSH is synthesized and secreted by the gonadotropic cells

of the anterior pituitary gland, and regulates the development, growth, pubertal maturation, and reproductive processes of the body.

2. **Luteinising Hormone (LH):** Luteinizing hormone is a hormone produced by gonadotropic cells in the anterior pituitary gland. In females, an acute rise of LH triggers ovulation and development of the corpus luteum. In males, where LH had also been called interstitial cell–stimulating hormone, it stimulates Leydig cell production of testosterone.

3. **Growth Hormone (GH):** Causes body cells to absorb amino acids and form protein for growth. The main function is to cause the elongation of bones.

4. **Prolactin:** stimulates milk formation by the breast after the birth of the baby.

5. **Oxytocin:** stimulates muscle contraction of uterus during birth, stimulates muscle contraction in the milk ducts during breast-feeding.

6. **Antidiuretic Hormone (ADH):** causes increased water reabsorption by kidneys.

7. **Thyroid Stimulating Hormone (TSH)**: Combines with iodine at the thyroid gland to produce thyroxine. Overproduction of GH causes gigantism and underproduction causes dwarfism.

NOTES COMPILED BY TAHIR HABIB

THE HYPOTHALAMUS

The hypothalamus **links** the **nervous system** with **the endocrine system**. It produces hormones that control the pituitary gland's responses to messages from the brain and other hormones. Some these hormones, called **releasing hormones**, stimulate the pituitary gland to make other hormones. Others, called **release inhibiting hormones,** prevent the production of pituitary hormones.

An example is **growth hormone releasing factor**. This causes the production of **growth hormone (GH)** by the pituitary gland.

THE THYROID GLAND

The thyroid gland produces the hormone called **thyroxin**. Thyroxin controls the rate of all the body's internal reactions. In other words, thyroxin controls the rate of the body's **metabolism**.

Physical conditions related to abnormal thyroid function are:

Hypothyroidism- Under Production of Thyroxine

1. **Cretinism**- **Under production** of thyroxin in **young children**. This results in low metabolic rates and results in retarded physical and mental development.

2. **Myxoedema- Under production** of thyroxin in **adults**. Characteristics are tiredness, lack of energy, slow mental and physical activity, and weight gain.

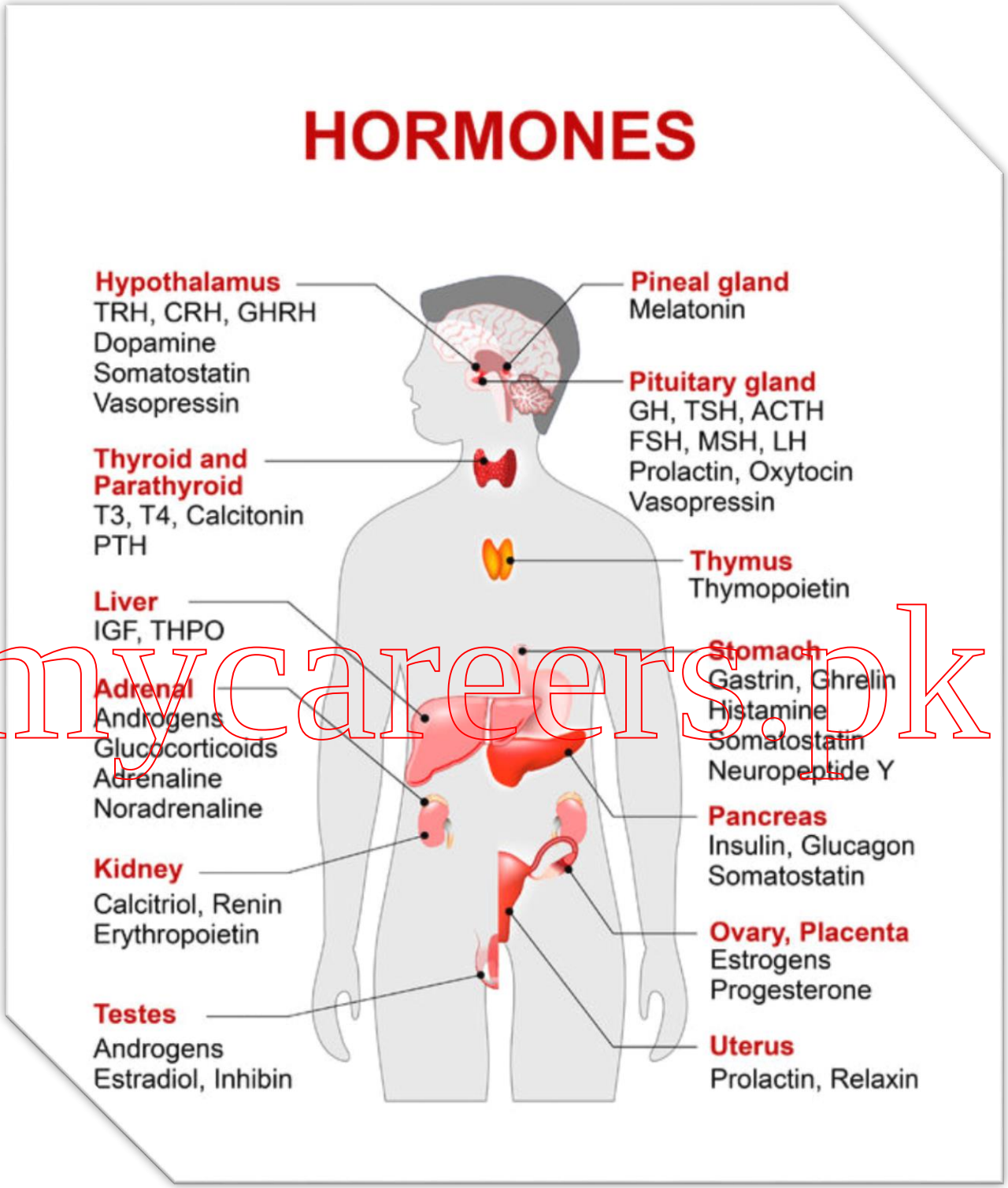
3. Goitre- Swelling of the thyroid caused by myxoedema.

Thyroxine Excess (Hyperthyroidism)

Thyroxine secretion is above normal. This causes a raised level of metabolism. Symptoms of over production of thyroxin are bulging eyes, weight loss heat production, nervousness, irritability, and anxiety. This condition is called **Grave's Disease.** Corrective measures for Grave's Disease are:

1. Drugs to suppress thyroid activity
2. Surgically remove part of the gland
3. Use radioactive iodine to destroy some of the gland.

HORMONES



THE PARATHYROIDS

There are 4 parathyroid glands. They are located **within the thyroid gland**. The hormone they produce is called **parathormone.** This hormone stimulates the release of calcium from the bones. That is why we must continue to include calcium in our diet even when our bones are fully grown.

ADRENAL GLAND ESSENTIALS

The adrenal glands are two glands that sit on top of your kidneys that are made up of two distinct parts.
The adrenal cortex—the outer part of the gland—produces hormones that are vital to life, such as cortisol (which helps regulate metabolism and helps your body respond to stress) and aldosterone (which helps control blood pressure).
The adrenal medulla—the inner part of the gland—produces nonessential (that is, you don't need them to live) hormones, such as adrenaline (which helps your body react to stress).

HORMONES OF THE ADRENAL GLANDS

The adrenal cortex and the adrenal medulla have very different functions. One of the main distinctions between them is that the hormones released by the adrenal cortex are necessary for life; those secreted by the adrenal medulla are not.

ADRENAL CORTEX HORMONES

The adrenal cortex produces two main groups of corticosteroid hormones—glucocorticoids and mineralcorticoids. The release of glucocorticoids is triggered by the hypothalamus and pituitary gland. Mineralcorticoids are mediated by signals triggered by the kidney.
When the hypothalamus produces corticotrophin-releasing hormone (CRH), it stimulates the pituitary gland to release adrenal corticotrophic hormone (ACTH). These hormones, in turn, alert the adrenal glands to produce corticosteroid hormones.
Glucocorticoids released by the adrenal cortex include:
Hydrocortisone: Commonly known as cortisol, it regulates how the body converts fats, proteins, and carbohydrates to energy. It also helps regulate blood pressure and cardiovascular function.
Corticosterone: This hormone works with hydrocortisone to regulate immune response and suppress inflammatory reactions.

The principle mineralcorticoid is **aldosterone**, which maintains the right balance of salt and water while helping control blood pressure.
There is a third class of hormone released by the adrenal cortex, known as sex steroids or sex hormones. The adrenal cortex releases small amounts of male and female sex hormones. However, their impact is usually overshadowed by the greater amounts of hormones (such as estrogen and testosterone) released by the ovaries or testes.

ADRENAL MEDULLA HORMONES

Unlike the adrenal cortex, the adrenal medulla does not perform any vital functions. That is, you don't need it to live. But that hardly means the adrenal medulla is useless. The hormones of the adrenal medulla are released after the sympathetic nervous system is stimulated, which occurs when you're stressed. As such, the adrenal medulla helps you deal with physical and emotional stress. You can learn more by reading a Spine Universe article about the sympathetic nervous system.

You may be familiar with the fight-or-flight response—a process initiated by the sympathetic nervous system when your body encounters a threatening (stressful) situation. The hormones of the adrenal medulla contribute to this response.

Hormones secreted by the adrenal medulla are:
 Epinephrine: Most people know epinephrine by its other name—adrenaline. This hormone rapidly responds to stress by increasing your heart rate and rushing blood to the muscles and brain. It also spikes your blood sugar level by helping convert glycogen to glucose in the liver. (Glycogen is the liver's storage form of glucose.)

 Norepinephrine: Also known as noradrenaline, this hormone works with epinephrine in responding to stress. However, it can cause vasoconstriction (the narrowing of blood vessels). This results in high blood pressure.

PANCREAS:
In addition, the pancreas produces the hormone called **insulin.** This hormone is produced in groups of cells called **Islets of Langerhans** Insulin is needed because it reduces blood glucose levels in the blood. It causes cells, especially fat and muscle cells, to absorb glucose from the blood. The glucose is needed for cellular respiration or converted into glycogen. The glycogen is stored in the liver or the muscles for future use in cellular respiration.

Pancreas
• A triangular gland, which has both exocrine and endocrine cells, located behind the stomach
• Acinar cells produce an enzyme-rich juice used for digestion (exocrine product)
• Pancreatic islets (islets of Langerhans) produce hormones (endocrine products)
• The islets contain two major cell types: 1: Alpha cells 2:Beta cells

Glucagon
• A 29-amino-acid polypeptide hormone that is a potent hyperglycemic agent
• Its major target is the liver, where it promotes:
• Glycogenolysis – the breakdown of glycogen to glucose
• Gluconeogenesis – synthesis of glucose from lactic acid and noncarbohydrates
• Releases glucose to the blood from liver cells

Insulin
• A 51-amino-acid protein consisting of two amino acid chains linked by disulfide bonds
• Synthesized as part of proinsulin and then excised by enzymes, releasing functional insulin
• Insulin:
• Lowers blood glucose levels
• Enhances transport of glucose into body cells
• Counters metabolic activity that would enhance blood glucose levels

Diabetes is a serious condition that results from 1 of 2 causes. In **type 1 diabetes**, the **pancreas** no longer makes **insulin** and therefore blood glucose cannot enter the cells to be used for energy. In **type 2 diabetes**, either the pancreas does not make enough insulin or the body is unable to use insulin correctly. Symptoms of diabetes are high glucose levels in the blood and urine, the production of large amounts of urine, severe thirst, loss of weight, and tiredness.

Injections of insulin, which are taken daily, the control of carbohydrate intake, exercise, and weight control treat diabetes.

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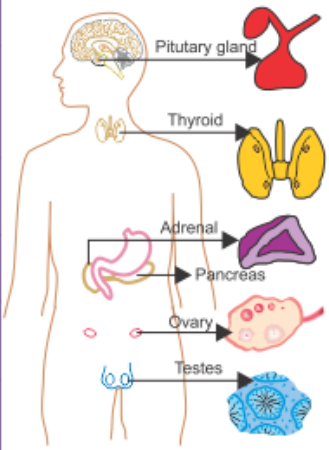
The Endocrine System in Humans

Glands	Location	Hormones	Functions
Pituitary	Brain	Growth hormone	• Regulates growth • Controls the functioning of endocrine glands
Thyroid	Throat	Thyroxine	• Controls the metabolism rate • It also brings about balanced growth
Parathyroid	Near thyroid gland	Parathormone	• Controls calcium balance of the body
Adrenal	Attached to kidneys	Adrenaline	• Prepares body for emergency
Pancreas	Abdomen	Insulin	• Controls glucose level of the blood
Testes	Scrotum	Testosterone	• Controls growth and development of male reproductive system
Ovaries	Lower abdomen	Oestrogen, progesterone	• Controls growth and development of female reproductive system



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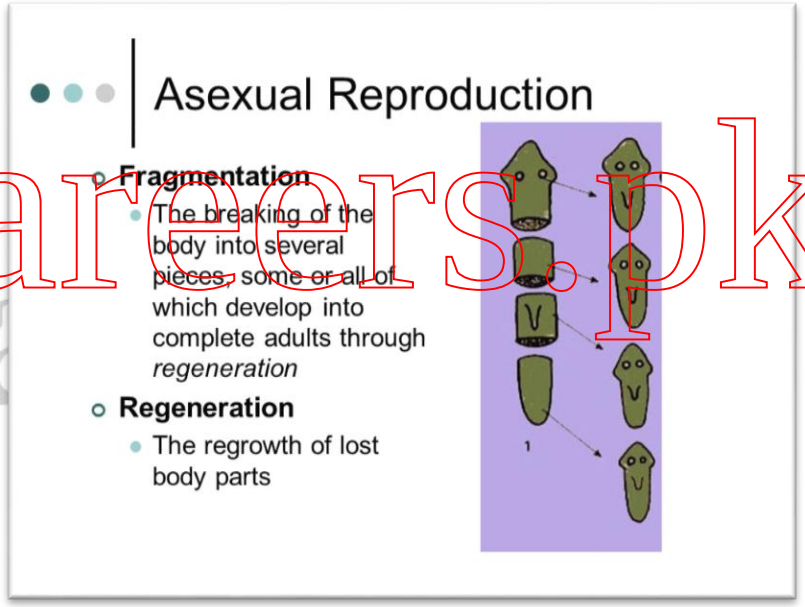
REPRODUCTION IN PLANTS AND ANIMALS

Reproduction is the biological process by which new individual organisms – "offspring" – are produced from their "parents". Reproduction is a fundamental feature of all known life; each individual organism exists as the result of reproduction. There are two forms of reproduction: asexual and sexual.

Asexual Reproduction

Asexual reproduction occurs in prokaryotic microorganisms (bacteria) and in some eukaryotic single-celled and multi-celled organisms. **Asexual reproduction** produces offspring that are genetically identical to the parent because the offspring are all clones of the original parent. A single individual can produce offspring asexually and large numbers of offspring can be produced quickly.

In a stable or predictable environment, asexual reproduction is an effective means of reproduction because all the offspring will be adapted to that environment. In an unstable or unpredictable environment asexually-reproducing species may be at a disadvantage because all the offspring are genetically identical and may not have the genetic variation to survive in new or different conditions. On the other hand, the rapid rates of asexual reproduction may allow for a speedy response to environmental changes if individuals have mutations. An additional advantage of asexual reproduction is that colonization of new habitats may be easier when an individual does not need to find a mate to reproduce. There are a number of ways that animals reproduce asexually.



Fission

Fission, also called binary fission, occurs in prokaryotic microorganisms and in some invertebrate, multi-celled organisms. After a period of growth, an organism splits into two separate organisms. Some unicellular eukaryotic organisms undergo binary fission by mitosis. In other organisms, part of the individual separates and forms a second individual. This process occurs, for example, in many asteroid echinoderms through splitting of the central disk. Some sea anemones and some coral polyps (Figure 1a) also reproduce through fission.

Budding

Budding is a form of asexual reproduction that results from the outgrowth of a part of a cell or body region leading to a separation from the original organism into two individuals. Budding occurs commonly in some invertebrate animals such as corals and hydras. In hydras, a bud forms that develops into an adult and breaks away from the main body, as illustrated in Figure 1b, whereas in coral budding, the bud does not detach and multiplies as part of a new colony.

Fragmentation is the breaking of the body into two parts with subsequent regeneration. If the animal is capable of fragmentation, and the part is big enough, a separate individual will regrow.
For example, in many sea stars, asexual reproduction is accomplished by fragmentation.

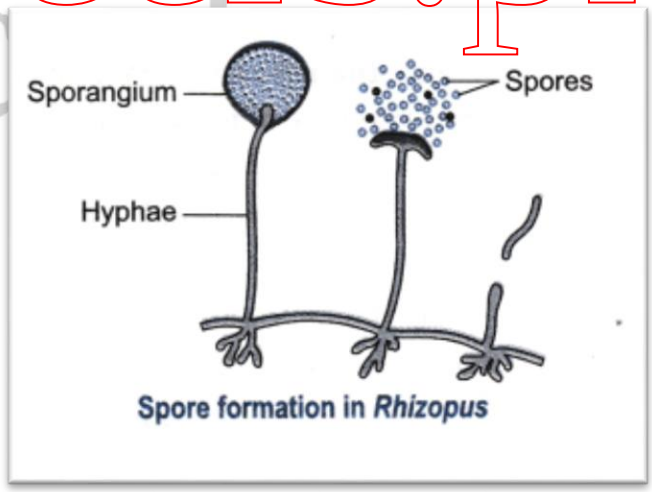
Parthenogenesis

Parthenogenesis is a form of asexual reproduction where an egg develops into a complete individual without being fertilized. The resulting offspring can be either haploid or diploid, depending on the process and the species. Parthenogenesis occurs in invertebrates such as water flees, rotifers, aphids, stick insects, some ants, wasps, and bees. Bees use parthenogenesis to produce haploid males (drones) and diploid females (workers). If an egg is fertilized, a queen is produced. The queen bee controls the reproduction of the hive bees to regulate the type of bee produced.
Some vertebrate animals—such as certain reptiles, amphibians, and fish—also reproduce through parthenogenesis. Although more common in plants, parthenogenesis has been observed in animal species that were segregated by sex in terrestrial or marine zoos. Two female Komodo dragons, a hammerhead shark, and a blacktop shark have produced parthenogenic young when the females have been isolated from males.

Spore Formation

This may look similar to seed formation in flowering plants, but spore production only occurs in non-flowing plants and in other microscopic organisms. Examples of such organisms include fungi, green algae, moulds, protozoa, and ferns.

Scientists believe that the ability for bacteria to sporulate (produce spores) make them thrive in diverse ecosystems and also make them survive adverse conditions and environmental fluctuations.
The term **sporulation** is often used to mean the production of spores by bacteria when conditions are harsh. Such spores can remain dormant until conditions are favorable.
An example of bacteria that **sporulates** up to about 9 endospores is Metabacterium polyspora. In this bacteria, the cell produces spores at the poles. The spores divide to produce more spores, elongate and develop into mature endospores.



Spore formation in *Rhizopus*

Vegetative Propagation

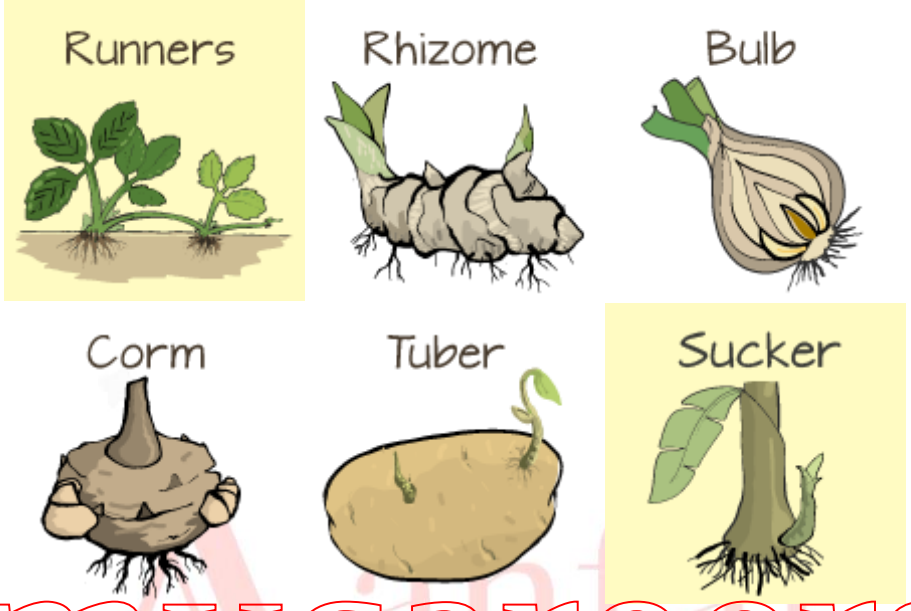
New plants can be produced from vegetative structures such as the roots, stems, and leaves of some plants. The process can be natural or artificial.
Roots:
Some roots, such as those of sweet potato, begonia and dahlia, have swollen roots that serve as storage

structures. Tubers can develop into new plants that have identical genetic makeup as the parents. Tubers with buds at the base of the stems can also be separated and new plants produced from them.

Stems:

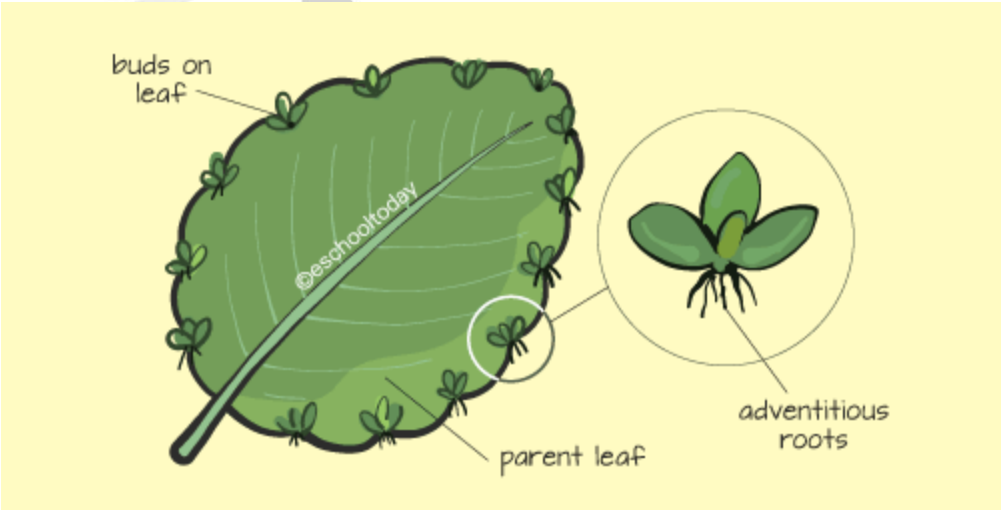
In many plants, the stems have buds on them. Onions, daffodils, and strawberries have stems that can start new offsprings. Types of stems that can reproduce include

- Runners
- Bulbs
- Rhizomes
- Corms
- Tubers
- Suckers



Leaves:

Some leaves, such as those of Bigonia, have buds on their margins. These buds have adventitious roots. Usually, when such leaves touch the ground, new plants develop that grow into independent plants. They can slo be cut and planted into new plants.

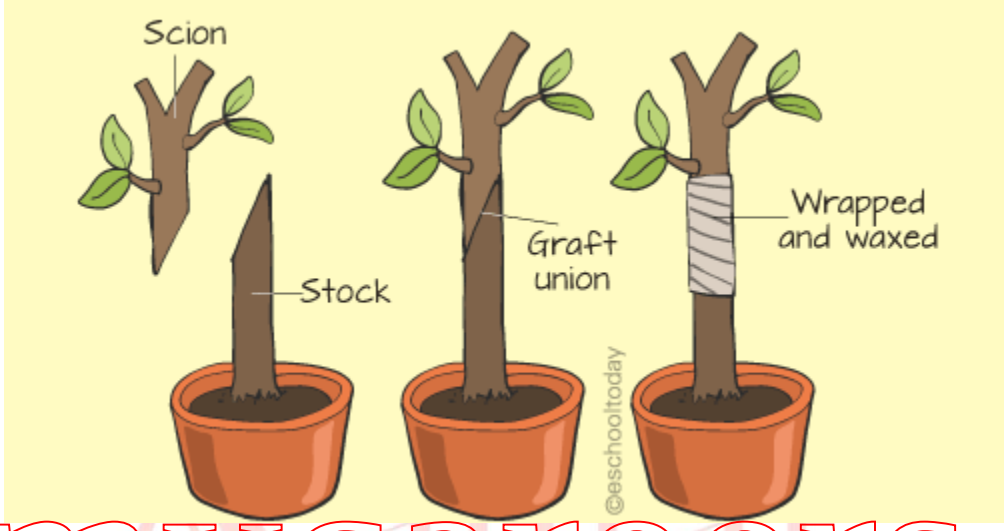


ARTIFICIAL VEGETATIVE PROPAGATION

Artificial propagation of plants include these four main processes:

Grafting:

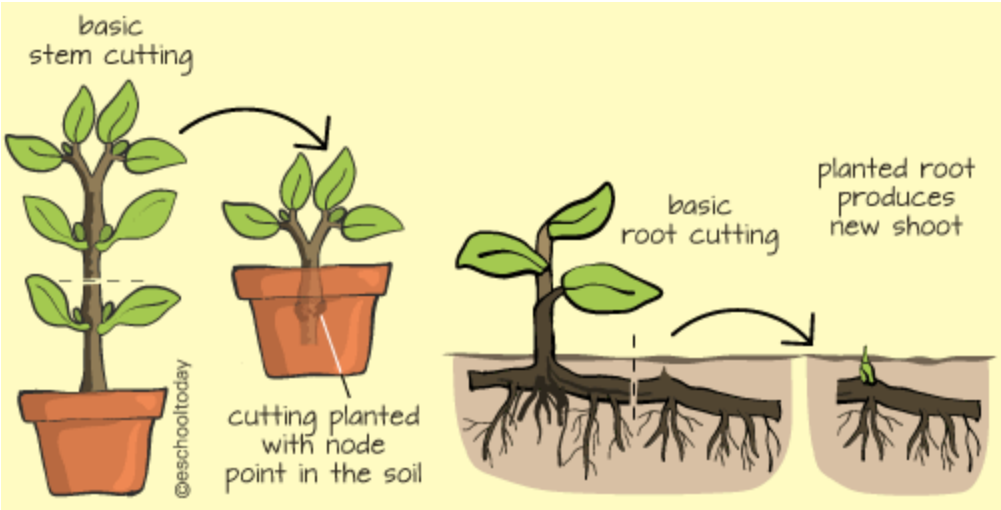
This process involves joining the shoot system of a plant (known as scion) to the root system of another plant (known as the stock). The two are joined where the sizes (diameter) of the scion and stock are very close. They are both cut diagonally and placed facing each other. They are then taped and left to heal with time.



Cutting:

Plants such as roses and sugarcane can be cut at the points of nodes and internodes. These points are then placed in moist soils. After some time, adventitious roots develop at the points and new plants begin to grow.

Thee are many types of cutting techniques, grouped into three categories: Stem, leaf and root cutting. Stem cuttings include hardwood, semi-hardwood, and softwood cutting. Leaf-cutting include leaf blade cutting, leaf vein cutting, leaf bud cutting and leaf edge cutting. The third category is root cutting.



Layering:
In some plants like raspberries, the stem can be bent and buried in the soils around the plant. After some time, adventitious roots develop off the stem. This part of the stem is known as the layer. The stem can then develop into a new plant.
Tissue Culture:
In this modern technique, tissue scrapped from the parent plant is placed in a special growing medium and under certain conditions. The tissue is nourished from the nutrients in the medium until new plants are produced. Orchids, Chrysanthemum and Asparagus are examples of plants cultivated with tissue culture.

Advantages of Asexual Reproduction.

More offsprings
Within a short period, more individuals can be produced from a single parent.
Identical Offsprings
The individual organisms have the same genetic makeup as the parent. Good genetic traits are preserved.
Less time and energy
There is no need for the parent to find a mate for reproduction. Additionally, no parental care is needed as the offsprings are well-developed individuals. There is no baby stage.
Easy dispersal
Offsprings can be easily moved to other locations to start new colonies. No need for male and female movement.

Disadvantages of Asexual Reproduction

Less Resistant
Changes in environmental conditions can be catastrophic to the organisms as there are no variations in their genes. A disease can easily wipe out the entire colony of that organism.

SEXUAL REPRODUCTION

REPRODUCTION
Sexual Reproduction and Variations:
As discussed earlier, sexual reproduction involves two parents and gamete formation. Gametes are special cells which are formed after meiosis. There are two types of gametes, viz. male and female gametes. The number of chromosomes is haploid in the gametes. When gametes fuse during fertilization, the number of chromosomes becomes diploid. This is important for maintaining the unique identity of a particular species which reproduces by sexual method.
In sexual reproduction, the offspring gets sets of genes from two different individuals. This leads to subtle variation through subsequent generations. These variations accumulate over thousand of

generations and finally may give rise to a new species. That is how all complex organisms have evolved from a common ancestor.

Sexual Reproduction in Flowering Plants:

Flower is a modified leaf which bears special organs and plays the role of the reproductive system in plant.

Structure of a typical Flower:

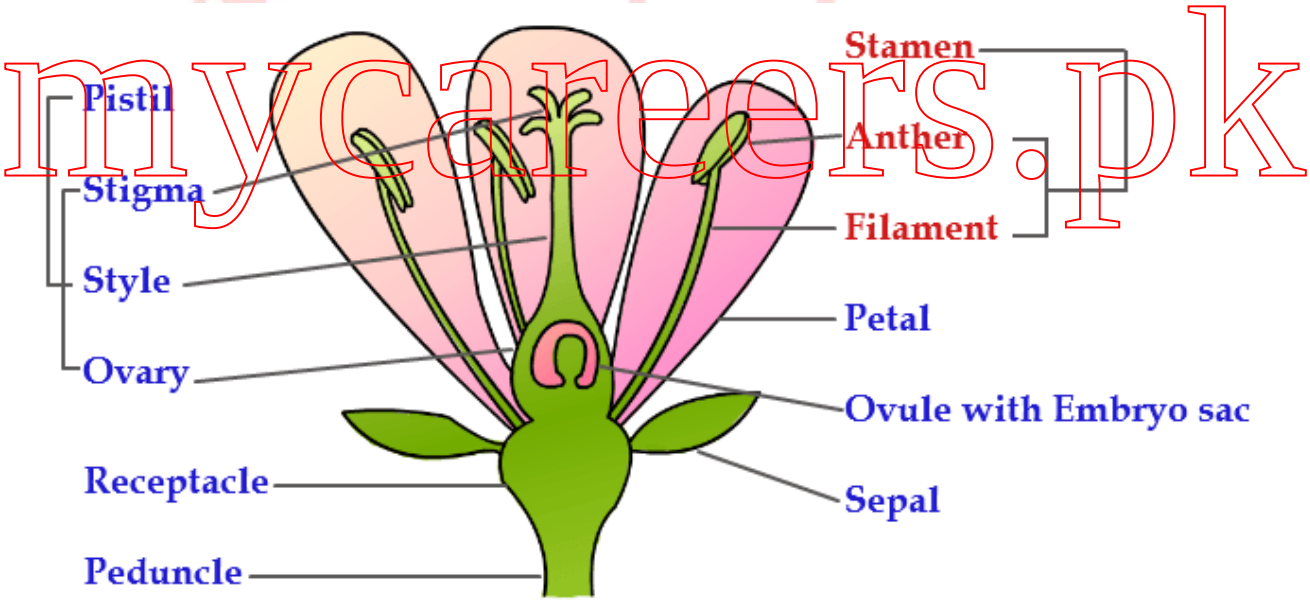
A typical flower is composed of four distinct whorls, viz. calyx, corolla, androecium and gynoecium.

Calyx: The outermost whorl of the flower is called calyx. It is composed of green leaf-like structures; called sepals.

Corolla: The second whorl of the flower is called corolla. It is composed of colourful leaf-like structures; called petals. Petals are colourful so that insects and birds can be attracted; to assist the flower in pollination.

Androecium: This is the third whorl in the flower. It is composed of stamens. Stamen is made of a slender stalk and anthers on top. Anthers produce the pollen-grains. Pollen grains are the male gametes.

Gynoecium: This whorl is at the centre of the flower. It is composed of a swollen base; called ovary. A slender style stands upright on the ovary. It has a flat top; called stigma. Ovules are inside the ovary. Ovules are the female gametes.



Pollination: The pollen grains need to be transferred to the stigma so that fertilization can take place. The transfer of pollen grains from anther to the stigma is called pollination. If the pollen grains from the same flower or the same plant are transferred to the stigma; it is called self pollination. If pollen grains from a different plant are transferred to the stigma; it is called cross-pollination. Cross pollination is better; from the perspective of variations. Many agents help plants in cross pollination, e.g. insects, animals, air, water, etc. Insects are the main pollinators for the plant kingdom.

Fertilisation:

The fusion of male and female gametes is called fertilization. The product of fertilization is called zygote. Zygote undergoes several rounds of mitosis and develops into an embryo. Subsequently, the embryo develops into a new individual.

Fertilisation

Fusion of nuclei of male and female gametes is called syngamy or fertilization. Fertilization results in the formation of a diploid zygote.

Parthenogenesis: The female gamete in some organisms develops to form a new organism without fertilization. This phenomenon is called parthenogenesis, e.g. some lizards, rotifers, honeybees and some birds (turkey).

External Fertilisation: In most of the aquatic organisms, fertilization occurs in external medium (water), i.e. outside the body of the organism. When fertilization occurs outside the body of the organism, it is called external fertilization. Organisms which exhibit external fertilization show great synchrony between the sexes while releasing a large number of gametes in water. Release of a large number of gametes in the external medium enhances the chances of syngamy. As a result, a large number of offspring are produced. But such offspring are extremely vulnerable to predators, and majority of them do not survive up to adulthood.

Fertilization in flowering plant:

After landing at the stigma, pollen grains absorb moisture and germinate. A pollen grain develops a pollen tube; which penetrates through the tissue of the style and reaches the ovule. Pollen nuclei are transferred through the pollen tube. After fertilization, zygote is formed; which finally develops into the embryo.

Changes in flower; After Fertilization: The calyx and corolla wither and fall off and so do the stamens. The ovary turns into the fruit. The embryo turns into seed. Once the seed becomes mature, fruit dries up so that dispersal of seeds can take place.

Structure of Seed: A seed contains an embryo, some reserve food and is enclosed by a protective covering; called seed coat. The reserve food is stored in the cotyledons. The embryo has two pointed parts. The upper part is called plumule which gives rise to the shoot system. The lower part is called radicle which gives rise to the root system. Cotyledons supply food when the embryo needs it during germination. Seed germination is the process by which the embryo in the seed kick-starts a new life.

REPRODUCTION IN HUMAN BEINGS

Male Reproductive System:

The male reproductive system in human beings is composed of following parts:

Testis: There is a pair of testes; which lie in a skin pouch; called scrotum. Scrotum is suspended outside the body; below the abdominal cavity. This helps in maintaining the temperature of testes below the body temperature. This is necessary for optimum sperm production. Testis primarily serves the function of sperm production. Sperms are the male gametes. Apart from that, testis also produces testosterone. Testosterone is also called the male hormone, as it is responsible for developing certain secondary sexual characters in boys.

Vas Deferens: Vas deferens is the tube which carries sperms to the seminal vesicle.

Seminal Vesicle: This is the place where sperms are stored. Secretions from the seminal vesicle and prostate gland add up to make the semen.
Penis: It is a muscular organ which serves the genitor-urinary functions. The urethra works as the common passage for urine as well as for sperms.

Female Reproductive System:

The female reproductive system in human beings is composed of following parts:
Uterus: This is pear-shaped hollow muscular organ. Uterus is the place where the embryo gets implanted and develops into a newborn baby. The wall of the uterus provides safety and nutrition to the growing foetus.
Fallopian Tubes: One fallopian tube comes out from each side at the top of the uterus. The fallopian tubes end in finger-like structures; called flimbriae. Fertilization happens in the fallopian tube.
Ovary: There are two ovaries; one near each fallopian tube. Ovary produces the eggs or the female gametes. All the eggs are produces by the ovary when the female child is still in the womb. One egg matures in each ovulation cycle and is released from the ovary. The egg is caught by the flimbriae and transferred to the fallopian tube.
Vagina: The cervix (mouth of the uterus) opens into the vagina. Vagina is a muscular tube-like organs; which serves as the passage for the sperms and also as the canal during the child birth.
Puberty
Human beings are complex animals and hence there is a distinct phase in their life cycle which marks the onset and attainment of sexual maturity. This period is called puberty. It usually starts at around 10 – 11 years of age in girls and at around 12 – 13 years of age in boys. It usually ends at around 18th year of age in girls and at around 19th year of age in boys. Since the years during puberty end in 'teens'; hence this phase is also called teenage.
Changes in Boys during Puberty: The boys suddenly grow in height dramatically. Voice becomes deep and the Adam's apple becomes prominent. Shoulders become broad and body becomes muscular. Facial hairs begin to grow. Hairs also grow under the armpit and in the pubic region.
Changes in Girls during Puberty: The voice becomes thin. Shoulders and hip become rounded. Breasts get enlarged. Hairs grow under the armpit and in the pubic region.

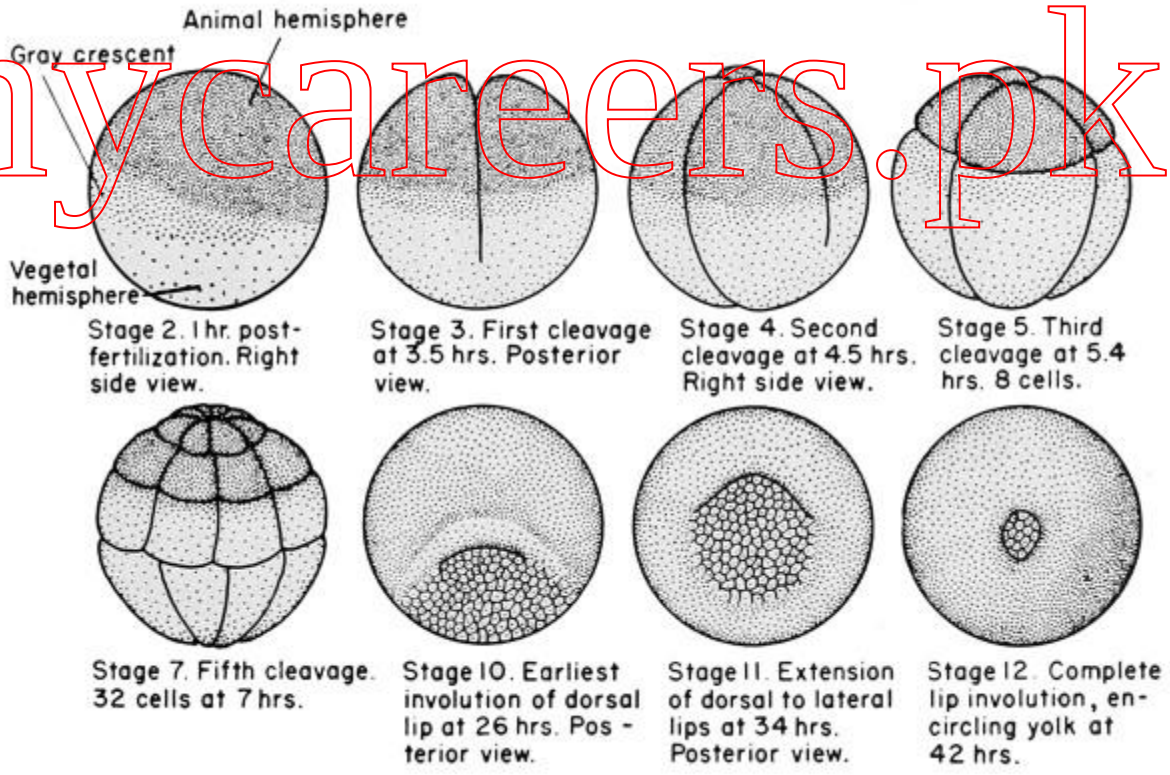
Internal Fertilisation: In most of the terrestrial organisms; fertilization occurs inside the body of the organism. This type of fertilization is called internal fertilization. Example: some fungi, reptiles, birds, mammals, bryophytes, pteridophytes, gymnosperms and angiosperms. In organisms which exhibit internal fertilization, number of sperms is very large but there is significant reduction in number of eggs produced.
Post-fertilisation Events: These events take place after the formation of zygote.
The Zygote
Further development of the zygote depends on the type of life cycle of the organism and the environment it is exposed to. In fungi and algae, zygote develops a thick wall which is resistant to dessication and damage. It undergoes a period of rest before germination.
In organisms with haplontic life cycle, zygote undergoes meiosis to form haploid spores. The spores then grow into haploid individuals.

Sexual Dimorphism: The physical dissimilarities in the male and female of a species which give them different appearances is called sexual dimorphism.
Secondary Sexual Characters: Features which highlight sexual dimorphism are called secondary sexual characters.
Menstruation: Menstruation is a trait which is unique to humans and some primates. During each ovulation cycle, the uterus prepares itself in anticipation of a possible pregnancy. The uterine wall develops an additional lining. When the egg is not fertilized, it gets disintegrated and so does the additional lining in the uterine wall. The fragments of disintegrated tissues are shed; along with blood. This is observed in the form of bleeding through the vagina which can last from 3 to 7 days. The whole sequence of events during an ovulation cycle is called menstrual cycle. The bleeding which occurs for few days is called menstruation. The first menstrual flow is called menarche and the last menstrual flow (which happens in the late 40s) is called menopause.

Development of Frog-Embryonic Development

- When sperm fertilize the egg, streaming movements are set up in the egg and these results in distribution of materials. So that three regions can be seen, the upper animal hemisphere (pole) which is pigmented and lower white vegetal pole. Between the two hemispheres, there is a small are with no pigment called grey crescent.

Cleavage or Segmentation:



- 2-3 hours after fertilization, the zygote begins to divide. The repeated division in the successive fashion is known as **cleavage or segmentation.**
- Division is mitotic

- The cleavage begins as a small depression at animal pole and gradually extends surrounding the zygote, dividing into two cell.
- The divisions are **holoblastic** and complete
- First cleavage is vertical; two celled stage
- Second cleavage is also vertical but right angle to the first one; forms 4 celled stage
- The cells are known as blastomere
- Third cleavage is horizontal but above the equatorial line forming unequal size cells. The upper 4 cells toward animal pole are small and pigmented known as micromeres or epiblast. The lower 4 large yolk laden cells are known as megameres or hypoblat.
- Fourth and fifth cleavage are also vertical forming 16 celled zygote. These division is followed by two horizontal cleacage, one toward animal pole and other toward vegetal pole, resulting in 32 celled stage.

Morula (mulberry shape stage):

- As the result of repeated and irregular cleavage, ball of cells is formed known as morula stage.
- One hemisphere of morula is composed of large number of small black and yolkless cells known as **micromeres** and other hemisphere is composed of fewer number of large white and yolk laden cells known as **megameres.**

Blastula:

- The micromeres dives more rapidly than megameres which results in formation of small fluid filled cavity known as **Blastocoel or segmentation cavity.**
- Blastocoel bearing stage is called **Blastula**
- The floor of blastocoel is composed of layer of yolk laden megameres while the roof is composed of micromeres.
- In this stage early Presumptive areas can be differentiated by staining technique.
- The entire animal pole of blastula represents the presumptive ectoderm, which is further divided into presumptive epidermis and presumptive neural plate
- A small area near vegetal pole is presumptive notocord
- Close to presumptive norocord there is a grey crescent region which is the presumptive mesoderm
- The remaining vegetal region is presumptive endoderm

Gastrula:

- Gastrula is the two layered embryo stage formed by migration and rearrangement of cells of blastula. The process of formation of gastrula is called **gastrulation.**
- Gastrulation involves some critical changes in the blastula such as- differentiation of cells, transformation from monoblastic to **diploblastic layer**, formation of **three primary germ layers.**
- Gastrulation completes in following steps.

1. **Epiboly: (Gastrula stage)**

- In this step, micromeres at animal pole dives more repeatedly and rapidly enclosing the megameres except in the region of yolk plug. This overgrowth or spreading of micromere cells is known as Epibloy.

2. Emboly or Intucking (Invagination): (Gastrula stage)

- In this step, small groove appears due to invagination of megameres near grey crescent region. The invagination gradually grows inward causing migration of cells.
- This stage is also known as Yolk plug stage.

- The narrowing of blastopore exerts pressure on underlying yolk laden megameres, result in protruding of some megameres cells as yolk plug.
- Contraction of lips of blastopore: contraction of lips from all side occurs so that blastopore become smaller and narrower.
- As invagination progresses archenteron increases in size and the blastocoel become reduced and finally obliterated.
- This groove is the beginning of archenteron and its anterior opening is called blastopore. The blastopore is guided by anterior margin called dorsal lip and backward projecting lateral lip.

3. Involution: (Step in Gastrula)

- due to increase in size of archenteron as well as formation of yolk plug, there is rapid migration of presumptive areas within the embryo occurs. This movement of the presumptive areas is known as involution.
- Rotation of gastrula: gastrulation causes shift in the center of gravity of the embryo. In the blastula stage, embryo floats with animal pole upward. But formation of archenteron causes the embryo to rotate within the vitelline membrane so that blastopore comes near the vegetal pole.
- Gastrulation causes following changes-
- i) blastopore is presumptive gut
- ii) roof of archenteron is chordamesoderm
- iii) floor of archenteron is endoderm

4. Formation of three germ layer: (Step in Gastrula)

- The three layers are ectoderm, mesoderm and endoderm are known as primary germ layer. They are also called as germinal layers because entire organs and body are derived from these layer.

Fate of germ layers

1. **Ectoderm:** epidermis, cutaneous glands, eye lens, cornea, retina, conjunctiva, central nervous system (brain and spinal cord), pineal gland, pituitary gland, enamel of teeth etc are derived from primary ectoderm layer.
2. **Mesoderm**: notochord, pericardium, peritoneum, muscles, skeleton, connective tissues-blood, lymph, adipose tissue, dermis of skin, visceral organs, are derived from primary mesoderm layer.
3. **Endoderm:** epithelium of digestive tract, respiratory tracts, Eustachian tubes, gastric and intestinal glands, liver, pancreas, bile and pancreatic ducts, lining of urinary bladder are derived from primary endoderm layer.

Neurulation:

- It is the process of formation of neural tube or nerve cord.
- At the end of gastrulation the prospective neural plate comes to lie along the length of mid-dorsal region. Neural plate later forms central nervous system including brain and spinal cord.
- A pair of longitudinal ridges called neural folds appears along the edges of neural plate, which meet in a semicircle anteriorly.
- The neural folds increase in height and comes closer together the median line where they fuse to form neural tube, enclosing the neural canal.
- The closure of neural tube begins just in front of mid-region and proceeds both anteriorly and posteriorly

- At the front end neural tube remains open for short time through neuropore. But posteriorly it communicates for some time with archenteron by neurenteric canal.
- Finally closed tubular neural tube is formed which later form brain and spinal cord.

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Notogenesis:

- It is the process of formation of notochord
- The meso-endodermal cell lying in mid dorsal region of roof of archenteron separates from mesoderm layer
- These cells become solid cylinder rod like structure along the median line and parallel to and just below the neural tube lies called notochord.
- Later, notochordal sheath develop around the notochord
- In adult notochord is replaced by vertebral column.

Formation of coelom:

- Coelom is the body cavity and it is mesodermal in origin
- Mesodermal layer split into two thin layers-outer somatic or (parietal) layer and inner visceral or (splanchnic) layer.
- Between these two layers a cavity is formed called splanchnocoel, which extend downward and continues to the outside below the gut
- Outer somatic layer combines with ectoderm to form body wall (somatopleure)
- Inner visceral layer unites with endoderm to form gut wall (splanchnopleure)
- Splanchnocoel continues to form coelom or body cavity between gut wall and body wall.
- The coelom is known as Schizocoel coelom.

EVOLUTION

Evolution is change in the heritable characteristics of **biological** populations over successive generations. ... It is this process of **evolution** that has given rise to biodiversity at every level of **biological** organisation, including the levels of species, individual organisms and molecules.

Evolution is a theory, an idea with lots of evidence. It explains why animals and plants are so good at surviving in their environments, the places where they live. What it means is that a species changes over time and can even split in two new **species**.
The theory of evolution was developed by **Charles Darwin** back in 1859. He said that evolution worked through **natural selection**. Natural selection means that some individuals in a species are better at surviving than others and will have more children.

Lamarckism

Lamarckism is the first theory of evolution, which was proposed by Jean Baptiste de Lamarck (1744-1829), a French biologist. Although the outline of the theory was brought to notice in 1801, but his famous book "Philo-sophic Zoologies" was published in 1809, in which he discussed his theory in detail. Lamarck coined the terms "invertebrates" and "Annelida". The term "Biology" was given by Lamarck and Treviranus (1802).

Lamarck's Propositions:
Lamarckism includes four main propo-sitions.

(i) Internal Vital Force:
All the living things and their component parts are continually increased due to internal vital force. Lamarck.
(ii) Effect of Environment and New Needs:
Environment influences all types of organisms. A change in environment brings about changes in organ-isms. It gives rise to new needs. New needs or desires produce new structures and change habits of the organisms. Doctrine of desires is called appetency.
iii) Use and Disuse of Organs:
If an organ is constantly used it would be better developed whereas disuse of organ results in its degeneration.
(iv) Inheritance of Acquired Characters:
Whatever an individual acquires (to pos-sess) characters in its life time due to internal vital force, effect of environment, new needs and use and disuse of organs, they are inherited (transmitted) to the next generations. The process continues. After several generations, the variations are accumulated upto such extent that they give rise to new species.

(Darwin)

Survival of the fittest (Darwin)

Rabbit live all over, and have dark fur. But in a place where it snows a lot, white fur would be an advantage. A white furred rabbit would be harder to see and is more likely to survive and have children. These children will inherit its mum or dad's white fur. Eventually all the rabbits living in the cold place will have white fur.
This is called **'survival of the fittest'** because animals which are best able to survive also fit better in their homes, like a white rabbit fits better in a cold country.

Darwinism (Natural Selection)	*Neo–Darwinism*
1. It is the original theory given by Charles Darwin (1859) to explain the origin of new species.	1. Neo–Darwin is a modification of the original theory of Darwin to remove its short–comings.
2. According to this theory accumulation of continuous variations causes changes in individuals to form new species.	2. Instead of continuos variations, mutations are believed to help form new species.
3. It believes in the selection of individuals on the basis of accumulation of variation.	3. Variations accumulate in the gene pool and not in the individuals.
4. Darwinism does not believe in isolation.	4. Neo–Darwinism incorporates isolation as an essential component of evolution.
5. It can explain the origin of new characters.	5. The theory can explain the occurrence of unchanged forms over millions of years.
6. Darwinism cannot explain the persistence of certain forms in the unchanged condition.	6. Normally only those modification are transferred to next generation which influence germ cells or where somatic cells give rise to germ cells.

Speciation :
Evolution also explains how one species can become two, like with the rabbits. We call this **Speciation**. The white rabbits are better fits where it snows but dark brown rabbits fit better where it snows less. With time, the different rabbits will become different species, both living in their own, separate environment.

Darwin

Charles Darwin (1809–1882) wrote his *On the Origin of Species* in 1859. In this book, he put forward much evidence that evolution had occurred. He also proposed natural selection as the way evolution had taken place. But Darwin did not understand about genetics and how traits were actually passed on. He could not accurately explain what made children look like their parents.

Nevertheless, Darwin's explanation of evolution was fundamentally correct. In contrast to Lamarck, Darwin's idea was that the giraffe's neck became longer because *those with longer necks survived better*.[p177/8] These survivors passed their genes on, and in time the whole race got longer necks.

Summary of Darwin's Theory of Evolution

A species is a population of organisms that interbreeds and has fertile offspring.

Living organisms have descended with modifications from species that lived before them.

Natural selection explains how this evolution has happened:
More organisms are produced than can survive because of limited resources.
Organisms struggle for the necessities of life; there is competition for resources.

Individuals within a population vary in their traits; some of these traits are heritable -- passed on to offspring.

Some variants are better adapted to survive and reproduce under local conditions than others.

Better-adapted individuals (the "fit enough") are more likely to survive and reproduce, thereby passing on copies of their genes to the next generation.

Species whose individuals are best adapted survive; others become extinct.

Natural selection

Natural selection is one of the basic mechanisms of evolution, along with mutation, migration, and genetic drift.
Darwin's grand idea of evolution by natural selection is relatively simple but often misunderstood. To find out how it works, imagine a population of beetles:

There is variation in traits.
For example, some beetles are green and some are brown.
There is differential reproduction.
Since the environment can't support unlimited population growth, not all individuals get to reproduce to their full potential. In this example, green beetles tend to get eaten by birds and survive to reproduce less often than brown beetles do.
There is heredity.
The surviving brown beetles have brown baby beetles because this trait has a genetic basis.
End result:
The more advantageous trait, brown coloration, which allows the beetle to have more offspring, becomes more common in the population. If this process continues, eventually, all individuals in the population will be brown.

INHERITANCE AND GENETIC CROSSES

Definitions:

- **Genetics**: study of inheritance.
- **Inheritance**: passing on of traits from one generation to the next.
- **Traits**: physical/chemical characteristics that a living organism possesses.
- **Gamete**: haploid sex cell.
- **Fertilisation**: fusion of two haploid gametes to produce a diploid zygote.
- **Allele**: alternative form of the same gene where a number of different types of the same gene exist.
- **Locus**: position of an allele or gene on a chromosome.
- **Homozygous**: two alleles are the same.
- **Heterozygous**: two alleles are different.
- **Dominance**: one allele masks the effects of another allele.
- **Recessive**: allele's effect is only expressed in the homozygous condition.
- **Genotype**: genetic make-up of an individual.
- **Phenotype**: physical make-up of an individual.

Alleles/Homozygous/Heterozygous/Dominance/Recessive

There can be a number of different **alleles** controlling the same characteristics; e.g. eye colour in humans: blue, green, brown, hazel are some of the common colours. Each organism has a maximum of two alleles for each characteristic; e.g. a person with brown eyes could have two brown eye alleles or one brown eye allele and one blue eye allele. Alleles are usually assigned letters with a capital letter signifying a **dominant** allele and a lower-case letter signifying a **recessive** allele. B (brown eyes), b (blue eyes), etc.

- BB is described as homozygous dominant.
- Bb is described as heterozygous.
- bb is described as homozygous recessive.

Genetic crosses:

Genetic cross: diagram or table showing how characteristics are inherited.

Monohybrid cross: genetic mating between two organisms where one gene is studied.

Examples of characteristics that can be studied using monohybrid crosses:

- Ability to tongue roll (dominant) versus inability to tongue roll (recessive).
- Cleft chin (dominant) versus non-cleft chin (recessive).
- Dimples (dominant) versus no dimples (recessive).
- Free ear lobes (dominant) versus attached ear lobes (recessive).
- Long second toe (dominant) versus short second toe (recessive).
- Widow's peak (dominant) versus no widow's peak (recessive).
- Straight thumb (dominant) versus curved thumb (recessive).

Study of the inheritance of single traits to the first filial generation involving homozygous parents.

Study of the inheritance of single traits to the first filial generation involving heterozygous parents.

Genetics of sex determination:

Sex determination in other species

In some species XX are male and XY are female! Examples include: some birds, some reptiles, moths and butterflies. In man XY is Male while XX is female.

Incomplete dominance

- **Incomplete dominance**: neither allele of an allelic pair is dominant or recessive with respect to each other – they are equally expressed and the resulting phenotype is a mixture, or blend, of the two.

An example of incomplete dominance is flower colour in the snapdragon plant. A red-flowered snapdragon plant (RR) crossed with a white-flowered snapdragon plant (rr) produces pink-flowered offspring (see below).

If the offspring are crossed the following second filial generation phenotypes are possible:

Another example of incomplete dominance is in cattle coat colour. A red-coated bull (RR) crossed with a white-coated cow (rr) produces road-coated offspring (see below).

If the offspring are crossed the following second filial generation phenotypes are possible:

Origin of Genetics

Work of Gregor Mendel

Mendel was an Augustinian monk, known as the father of modern genetics. Mendel carried out genetics studies on pea plants. He studied seven characteristics:

1. Flower colour (purple versus white)
2. Flower position (axial versus terminal)
3. Pea colour (yellow versus green)
4. Pea shape (round versus wrinkled)
5. Pod colour (green versus yellow)
6. Pod shape (inflated versus constricted)
7. Height (tall versus short)

As a result of his work, Mendel came up with his two Laws of Genetics:

- **First Law of Segregation:**

Each cell contains two factors for each trait. These factors separate at gamete formation, so that each gamete contains only one factor from each pair of factors. At fertilisation, the new organism will have two factors for each trait, one from each parent.

- **Second Law of Independent Assortment:**

Members of one pair of factors separate independently of another pair of factors during gamete formation.

Explanation of Mendel's First Law of Segregation: Chromosomes are arranged into homologous pairs. During meiosis, half of the gametes receive one of the homologous chromosomes with the other half of gametes receiving the other homologous chromosome.

Explanation of Mendel's Second Law of Independent Assortment: Mendel's second law applies to crosses involving more than one gene, that is, two pairs of alleles. Each allele of a pair can combine completely randomly with either member of another pair

Sex linkage

Sex linkage applies to genes that are located on the sex chromosomes. These genes are considered sex-linked because their expression and inheritance patterns differ between males and females. While sex linkage is not the same as genetic linkage, sex-linked genes can be genetically linked

- **Sex linkage**: genes are located on the X chromosome.

In humans, female are 'XX' whereas males possess a 'y' chromosome and are therefore 'XY'.
The 'X' chromosome is longer than the 'Y' chromosome.
This means that many genes that are present on the 'X' chromosome are not present on the 'Y'chromosome.
Males therefore only have one copy of many sex-linked genes rather than the usual two.
Two examples of sex-linked characteristics in humans that you must learn about are:

- Red-green colour vision
- Blood-clotting

Both of these characteristics are controlled by genes present only on the 'X' chromosome. There is no corresponding gene for these characteristics on the 'Y' chromosome. This is represented in genetic crosses as 'Y_'.
As a result of males having only one copy of these genes they are much more likely to suffer from the corresponding genetic conditions should they inherit an 'X' chromosome with a mutated gene from their mother.
The corresponding conditions are:

- Red-green colour blindness
- Haemophilia

If they inherit a normal gene from their mother, this is represented by 'XN'. If they receive a mutated gene from their mother, this is represented as 'Xn'.

The structure of DNA

DNA

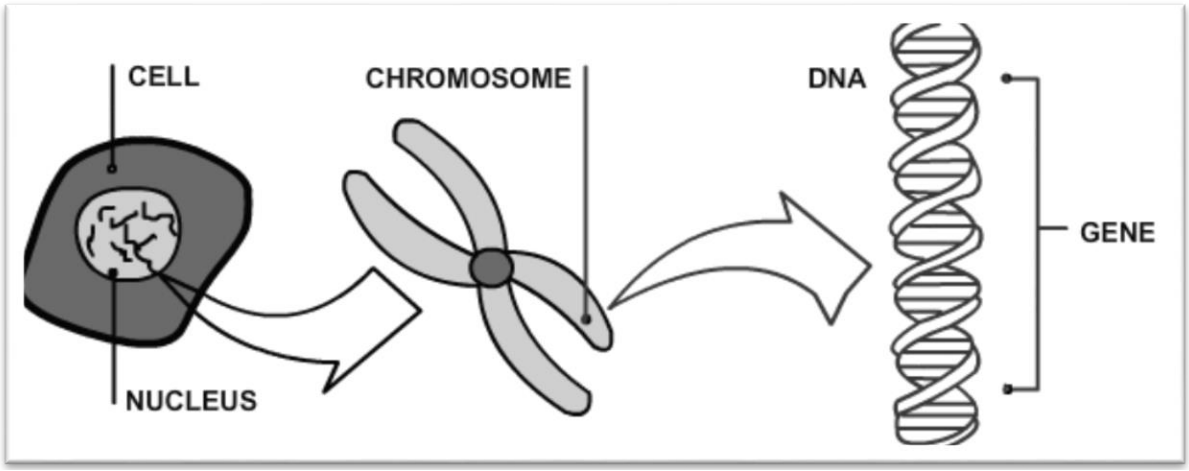
DNA molecules are large and complex. They carry the genetic code that determines the characteristics of a living organism.

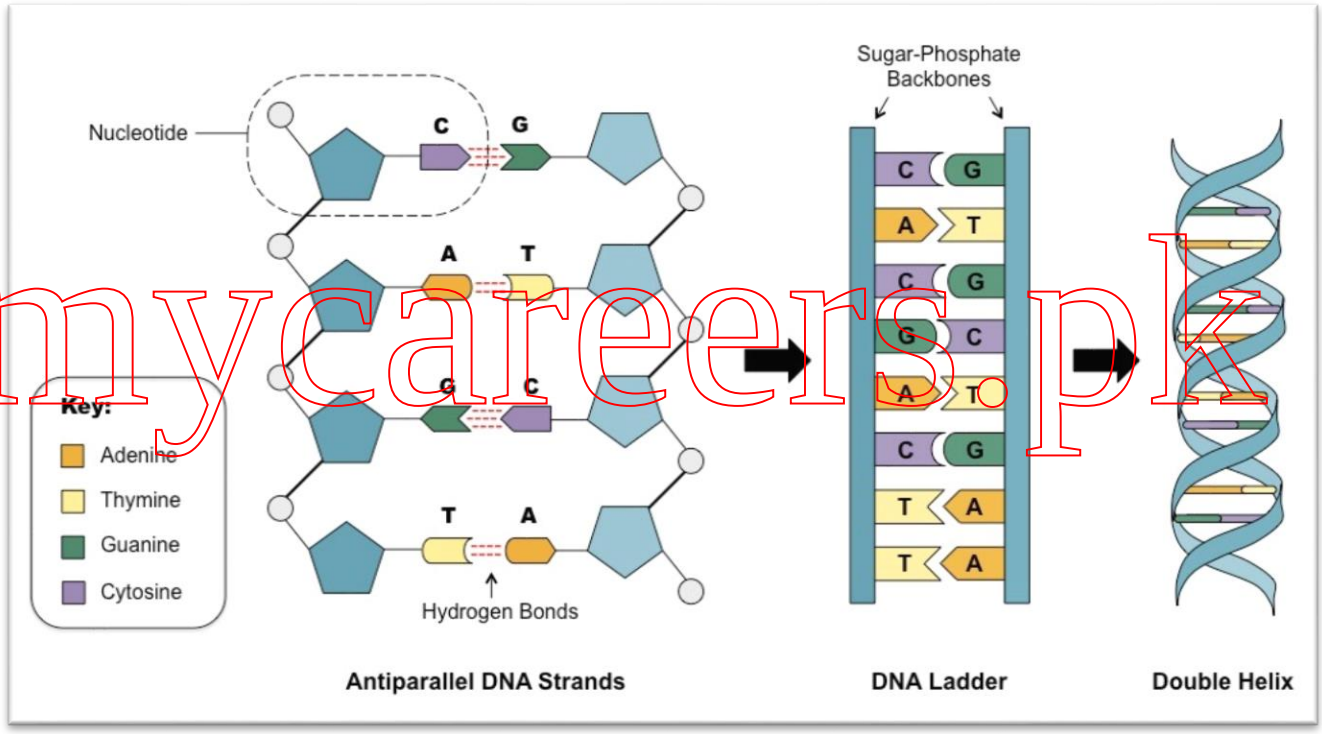
Genes

A gene is a section of DNA that codes for a specific protein. It is the unit of heredity, and may be copied and passed on to the next generation.

Chromosomes

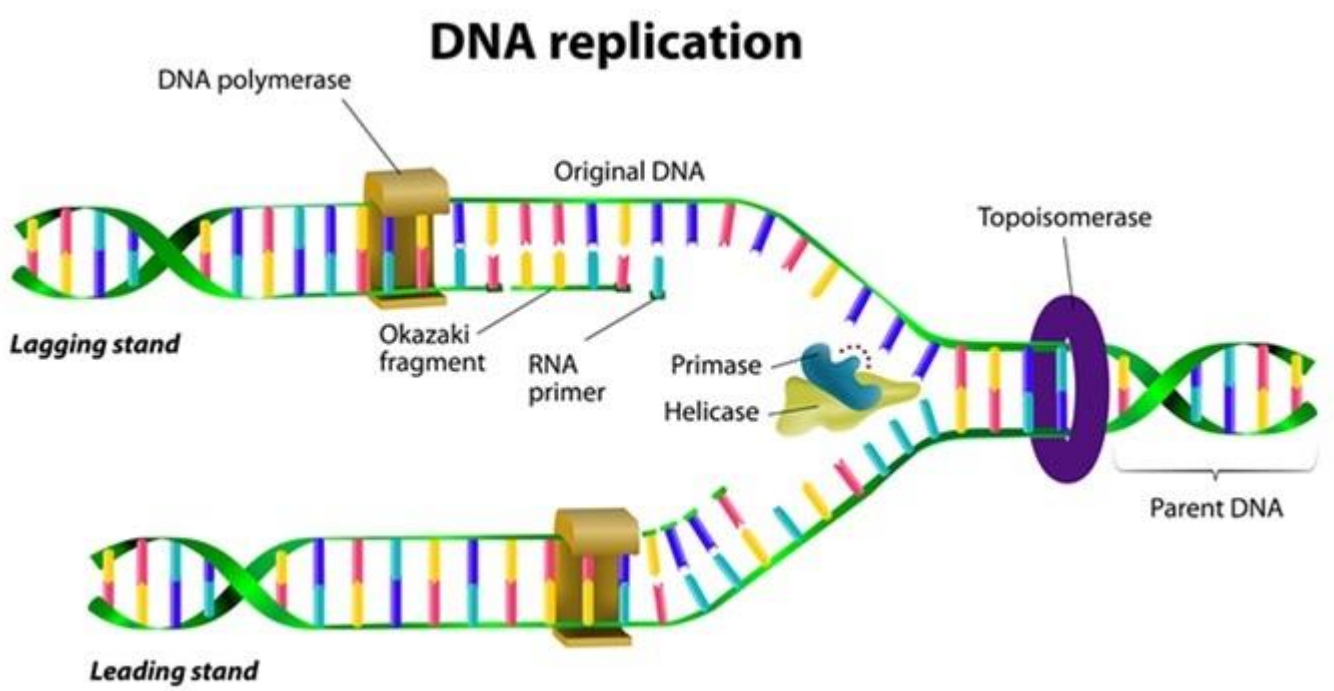
The nucleus of the cell contains chromosomes. These are long threads of DNA, each made up of many genes.
The diagram shows the relationship between the cell, its nucleus, the chromosomes in the nucleus, and genes.





DNA Replication

A DNA strand can act as a template for synthesis of a new nucleic acid strand in which each base forms a hydrogen-bonded pair with one on the template strand (G with C, A with T, or A with U for RNA molecules). The new sequence is thus complementary to the template strand. The copying of DNA molecules to produce more DNA is known as **DNA Replication.**



DNA replication takes place at a Y-shaped structure called a replication fork. A self-correcting DNA polymerase enzyme catalyzes nucleotide polymerization in a 5′-to-3′ direction, copying a DNA template strand with remarkable fidelity. Since the two strands of a DNA double helix are antiparallel, this 5′-to-3′ DNA synthesis can take place continuously on only one of the strands at a replication fork (the leading strand).

On the lagging strand, short DNA fragments must be made by a "backstitching" process. Because the self-correcting DNA polymerase cannot start a new chain, these lagging-strand DNA fragments are primed by short RNA primer molecules that are subsequently erased and replaced with DNA.

DNA replication requires the cooperation of many proteins. These include

1. DNA polymerase and DNA primase to catalyze nucleoside triphosphate polymerization;
2. DNA helicases and single-strand DNA-binding (SSB) proteins to help in opening up the DNA helix so that it can be copied;
3. DNA ligase and an enzyme that degrades RNA primers to seal together the discontinuously synthesized laggingstrand DNA fragments;
4. DNA topoisomerases to help to relieve helical winding and DNA tangling problems. Many of these proteins associate with each other at a replication fork to form a highly efficient "replication machine," through which the activities and spatial movements of the individual components are coordinated.

Major steps involved in DNA replication are as follows:

1. Each strand in a parental duplex DNA acts as a template for synthesis of a daughter strand and remains basepaired to the new strand, forming a daughter duplex (semiconservative mechanism).
2. New strands are formed in the 5′ to 3′ direction.
3. Replication begins at a sequence called an origin.
4. Each eukaryotic chromosomal DNA molecule contains multiple replication origins.
5. DNA polymerases, unlike RNA polymerases, cannot unwind the strands of duplex DNA and cannot initiate synthesis of new strands complementary to the template strands.
6. Helicases use energy from ATP hydrolysis to separate the parental (template) DNA strands.

7. Primase synthesizes a short RNA primer, which remains base-paired to the template DNA.
8. This initially is extended at the 3' end by DNA polymerase α (Pol α), resulting in a short (5')RNA-(3')DNA daughter strand.
9. Most of the DNA in eukaryotic cells is synthesized by Pol δ, which takes over from Pol α and continues elongation of the daughter strand in the 5' to 3'direction.
10. Pol δ remains stably associated with the template by binding to Rfc protein, which in turn binds to PCNA, a trimeric protein that
encircles the daughter duplex DNA.
11. DNA replication generally occurs by a bidirectional mechanism in which two replication forks form at an origin and move in opposite directions, with both template strands being copied at each fork.
12. Synthesis of eukaryotic DNA in vivo is regulated by controlling the activity of the MCM helicases that initiate DNA replication at multiple origins spaced along chromosomal DNA.
13. At a replication fork, one daughter strand (the leading strand) is elongated continuously.
14. The other daughter strand (the lagging strand) is formed as a series of discontinuous Okazaki fragments from primers synthesized every few hundred nucleotides.
15. The ribonucleotides at the 5' end of each Okazaki fragment are removed and replaced by elongation of the 3' end of the next Okazaki fragment.
16. Finally, adjacent Okazaki fragments are joined by DNA ligase.

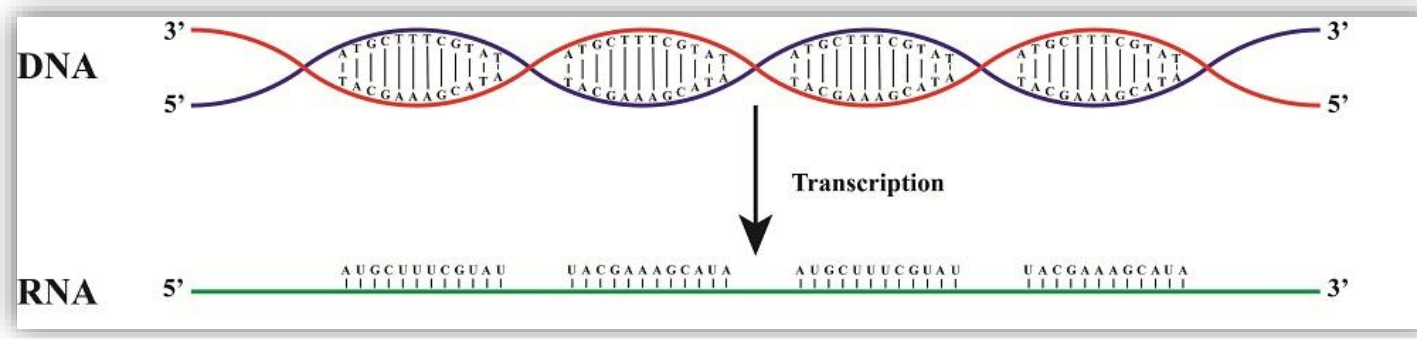
NOTES COMPILED BY TAHIR HABIB

Transcription

Definition: Transcription is the first step of DNA based gene expression, in which a particular segment of DNA is copied into RNA by the enzyme RNA polymerase. Both DNA and RNA are nucleic acids, which use base pairs of nucleotides as a complementary language.

The first step is the conversion of the information into messenger RNA (mRNA).
Transcription is carried out by RNA polymerase. As with DNA synthesis, the RNA strand is made in the 5' to 3' direction.
Firstly, only a comparatively short molecule is produced, and secondly, only one of the DNA strands is transcribed. Since only a single strand is made, it can be produced continuously using a single enzyme; there is no need for lagging strand synthesis.
In addition the production of relatively short single-stranded RNA causes fewer topological problems: the enzyme and the RNA product can essentially rotate around the helix, so there is no need for the helicases and topo isomerases that are essential for replication.
Furthermore, RNA polymerase can start synthesis from scratch – no primer is needed. Transcription is therefore considerably simpler than replication.

In *E. coli*, depending on growth conditions, 2000–5000 copies of RNA polymerase may be engaged on mRNA synthesis at any time.



The transcription reaction can be divided into the three stages: **initiation**, in which the promoter is recognized, a bubble is created, and RNA synthesis begins; **elongation**, in which the bubble moves along the DNA as the RNA transcript is synthesized; and **termination**, in which the RNA transcript is released and the bubble closes.

Initiation

Initiation itself can be divided into multiple steps.

Template recognition begins with the binding of RNA polymerase to the double-stranded DNA at a DNA sequence called the **promoter**. The enzyme first forms a closed complex in which the DNA remains double-stranded. Next the enzyme locally unwinds the section of promoter DNA that includes the transcription start site to form the open complex.

Separation of the DNA double strands makes the template strand available for base pairing with incoming ribonucleotides and synthesis of the first nucleotide bonds in RNA. The initiation phase can be protracted by the occurrence of abortive events, in which the enzyme makes short transcripts, typically shorter than around 10 nucleotides (nt), while still bound at the promoter. The enzyme often makes successive rounds of abortive transcripts by releasing them and starting RNA synthesis again. The initiation phase ends when the enzyme finally succeeds in extending the chain and clearing the promoter.

Elongation

Elongation involves processive movement of the enzyme by disruption of base pairing in double-stranded DNA, exposing the template strand for nucleotide addition and translocation of the transcription bubble downstream. As the enzyme moves, the template strand of the transiently unwound region is paired with the nascent RNA at the point of growth. Nucleotides are added covalently to the 3 ‘ end of the growing RNA chain, forming an RNA-DNA hybrid within the unwound region . Behind the unwound region, the DNA template strand pairs with its original partner to reform the double helix, and the growing strand of RNA emerges from the enzyme.

The traditional view of elongation as a monotonic process, in which the enzyme moves forward along the DNA at a steady pace corresponding to nucleotide addition, has been revised in recent years. RNA polymerase pauses or even arrests at certain sequences. Displacement of the 3 ‘ end of the RNA from the active site can cause the polymerase to “backtrack” and remove a few nucleotides from the growing RNA chain before restarting. Pausing can also be programmed to occur by the use of a coded RNA hairpin structure or sequence context-caused misalignment of the incoming nucleotide with its complementary base.

Termination

Termination involves recognition of sequences that signal the enzyme to halt further nucleotide addition to the RNA chain. In addition, long pauses can lead to termination. The transcription bubble collapses as the RNA-DNA hybrid is disrupted and the DNA reforms a duplex, phosphodiester bond formation ceases, and the transcription complex dissociates into its component parts: RNA polymerase, DNA, and RNA transcript. The sequence of DNA that directs the end of transcription is called the terminator.

Translation (Protein Synthesis)

Definition: Translation is a step in protein biosynthesis wherein the genetic code carried by mRNA is decoded to produce the specific sequence of amino acids in a polypeptide chain. The process follows transcription in which the DNA sequence is copied (or transcribed) into an mRNA.

In bacteria, translation starts when ribosomes bind to a specific site (the ribosome binding site, RBS), which is adjacent to the start codon.
In eukaryotes, the mechanism is much more complicated. Instead of binding just upstream of the initiation codon, the ribosome binds to the cap at the 5' end of the mRNA, and reads along the 5' untranslated region (UTR) until it reaches an initiation codon.
The site of protein synthesis is the ribosome. Ribosomes are interesting structures in that they are a combination of RNA and protein. The form of RNA that is found in a ribosome is ribosomal RNA, or rRNA.

Translation occurs in three major steps: (1) initiation. (2) elongation, and (3) termination.
Initiation

1. During initiation, a group of proteins called initiation factors assist in assembling the ribosome around the mRNA.
2. The initiation factors temporarily recognize specific sequences in the mRNA.
3. The small ribosomal subunit then recognizes the initiation factors, followed by the large ribosomal subunit.
4. The ribosome is assembled around the mRNA, much like a series of toy plastic blocks.
5. Near the beginning of the mRNA is a codon called the start codon (AUG). This codes for an amino acid called methionine.
6. Three regions are important as the ribosome is assembled around the mRNA. They are commonly called the A, P, and E sites.
7. Each site will fit a single tRNA.
8. The only tRNA that can effectively enter the site is the one whose anticodon complements the codon of the mRNA revealed within the site.
9. In initiation, the assembly of the ribosome occurs with the AUG start codon within the P site. This
ends the initiation stage.

Elongation

1. The elongation stage involves the assembly of specified amino acids into a polypeptide chain.
2. The key to elongation are the E, P, and A sites within the ribosome.
3. Following initiation, the first tRNA (for methionine) is located within the P site.
4. A second codon in the mRNA is exposed in the A site.

5. Only a tRNA with an anticodon complementary to the mRNA codon exposed in the A site will correctly fit.
6. At this point there are two tRNAs in the ribosome.
7. By an enzymatic reaction, the amino acids between the P and A chains are joined together by a peptide bond.
8. As the peptide bond forms, the amino acid is released from the tRNA in the P site. The ribosome then moves one codon down the mRNA (in the 3' direction).
9. As it does so, the tRNA that was in the P site enters into the E site and leaves the ribosome.
10. The tRNA that was in the A site, which still has the polypeptide chain attached, moves into the P site.
11. A new mRNA codon is then revealed in the A site.
12. A tRNA with an anticodon complementary to the exposed mRNA codon then enters the A site, and the process repeats itself.
13. The rate at which this reaction occurs is amazing.
14. In eukaryotic systems, the ribosome may read up to six codons per second.

Termination

1. The process of termination begins once the end of the mRNA is reached by the ribosome.
2. In place of tRNAs, proteins called release factors enter into the A site.
3. Since the release factors do not contain amino acids, the process of translation is stopped at this point.
4. The release factors also promote the disassembly of the ribosome and its interaction with the mRNA.
5. The end result of translation is a polypeptide chain. This polypeptide chain must undergo a series of folds in order to produce a functional protein.

ENVIRONMENT SCIENCE

What is the environment?
The environment is everything around us. All our surroundings including the air, soil, water, plants, and animals make up the environment.
Biomes and Ecosystems
Plants and animals need a healthy environment to survive. An ecosystem is an area where living organisms interact in a specific way with the local environment to survive. When ecosystems are damaged by man, then some living organisms may not be able to survive. A biome is a large group of similar ecosystems like the desert, savanna, and rainforest.

What is environmental science?

Definition : Environmental science is defined as a branch of biology focused on the study of the relationships of the natural world and the relationships between organisms and their environments. An example of **environmental science** is the study of the natural world and how it relates to recycling and mulching.

Environmental science studies the environment and how the earth works. Environmental scientists often study how humans have impacted the Earth's environment and how we can reduce the impact that humans have on the environment.

Environmental scientists study things like the atmosphere, the oceans, geology, habitats, and ecology.

What is an ecosystem?

Each individual plant and animal could not exist by itself on planet Earth. All living organisms need millions of other living organisms to survive. How these organisms interact with the sun, soil, water, air and each other in a specific area is called an ecosystem.

An ecosystem describes a specific area where the organisms work together as a unit. It could be any size from a tiny pool of water to hundreds of square miles of desert. Each ecosystem is different and each has established a balance over time that is important to every form of life within the ecosystem.

Components of Ecosystem

There are two main components of an ecosystem which are in constant communication with each other. They are the biotic components and the abiotic components.

Biotic Components of Ecosystem

The living components of an ecosystem are called the biotic components. Some of these factors include plants, animals, as well as fungi and bacteria. These biotic components can be further classified, based on the energy requirement source. Producers, consumers, and decomposers are the three broad categories of biotic components.

- ***Producers*** are the plants in the ecosystem, which can generate their own energy requirement through photosynthesis, in the presence of sunlight and chlorophyll. All other living beings are dependent on plants for their energy requirement of food as well as oxygen.

- ***Consumers*** include herbivores, carnivores, and omnivores. The herbivores are the living organisms that feed on plants. Carnivores eat other living organisms. Omnivores are animals that can eat both plant and animal tissue.
- ***Decomposers*** are the fungi and bacteria, which are the saprophytes. They feed on the decaying organic matter and convert this matter into nitrogen and carbon dioxide. The saprophytes play a vital role in recycling the nutrients so that the producers i.e. plants can use them once again.

Abiotic Components of Ecosystem

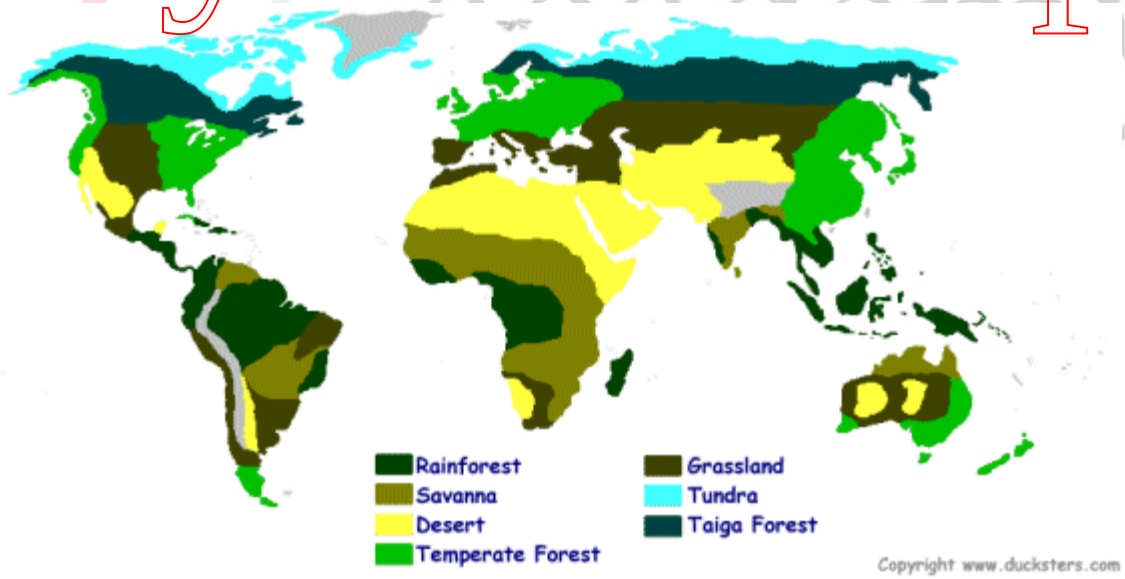
Abiotic components are the physical and/or the chemical factors that act on the living organisms at any part of their life. These are also called as the ecological factors. The physical and chemical factors are characteristic of the environment. Light, air, soil, and nutrients, etc. form the abiotic components of an ecosystem.

The abiotic factors vary from ecosystem to ecosystem. In an aquatic ecosystem, the abiotic factors may include water pH, sunlight, turbidity, water depth, salinity, available nutrients and dissolved oxygen. Similarly, abiotic factors in terrestrial ecosystems can include soil, soil types, temperature, rain, altitude, wind, nutrients, sunlight etc.

Here, the sun is the energy source. Producers/plants use this energy to synthesize food in the presence of carbon dioxide and chlorophyll. The energy from the sun, through several chemical reactions, turns into chemical energy.

What is a biome?

A biome is way to describe a large group of similar ecosystems. Biomes have similar weather, rainfall, animals, and plants. There are a number of biomes on planet Earth. See the map of the world biomes below.



Map of the world biomes - Click on the map to see a larger picture

Land Biomes

- Desert
- Grasslands

- Savanna
- Tundra
- Tropical Rainforest
- Temperate Forest
- Taiga Forest

Aquatic Biomes

- Marine
- Freshwater
- Coral Reef

The Balance of the Ecosystem

Ecosystems maintain important balances in order that all the organisms within the ecosystem can survive. These balances involve food, water, oxygen, nitrogen, and carbon.

The sun provides the energy needed by ecosystems. Plants take this energy and use photosynthesis to create sugar which they can use for energy. Nutrients in the soil, the air, and water also play a part in keeping an ecosystem thriving and in balance.

Some important cycles that occur in ecosystems to help maintain proper balance include:

- Food Chain and Food Web (Energy Cycle)
- Carbon Cycle
- Oxygen Cycle
- Water Cycle
- Nitrogen Cycle

Humans and the Ecosystem

Humans have adversely affected many ecosystems and biomes throughout the world. Cutting down trees, developing land, growing crops, burning fossil fuels, overfishing, and overhunting are just some of the ways that we have upset the balance of nature.

Nutrient Cycles

The Earth's environment is constantly recycling nutrients so they can be used by different parts of the environment. These cycles are important for the existence of living organisms. Some important cycles include the water cycle, the nitrogen cycle, the carbon cycle, the oxygen cycle, and the food chain.

1. Food Chain and Web
2. Carbon Cycle
3. Oxygen Cycle
4. Water Cycle
5. Nitrogen Cycle

Food Chain and Food Web

Every living plant and animal must have energy to survive. Plants rely on the soil, water, and the sun for energy. Animals rely on plants as well as other animals for energy.

In an ecosystem, plants and animals all rely on each other to live. Scientists sometimes describe this dependence using a food chain or a food web.

Food Chain

A food chain describes how different organisms eat each other, starting out with a plant and ending with an animal. For example, you could write the food chain for a lion like this:

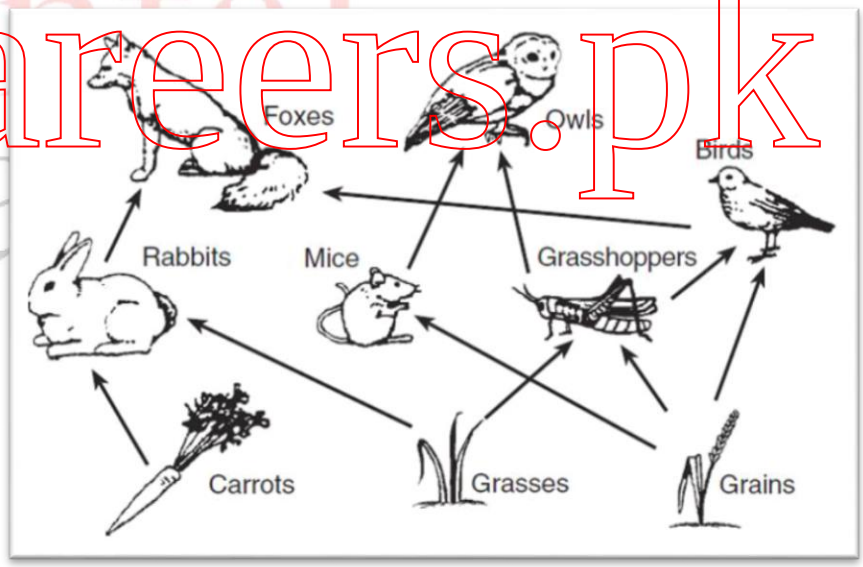
grass ---> zebra ---> lion

The lion eats the zebra, which eats the grass. Here is another example in picture form:

The grasshopper eats grass, the frog eats the grasshopper, the snake eats the frog, and the eagle eats the snake.

Links of the Chain

There are names to help describe each link of the food chain. The names depend mostly on what the organism eats and how it contributes to the energy of the ecosystem.



- Producers - Plants are producers. This is because they produce energy for the ecosystem. They do this because they absorb energy from sunlight through photosynthesis. They also need water and nutrients from the soil, but plants are the only place where new energy is made.
- Consumers - Animals are consumers. This is because they don't produce energy, they just use it up. Animals that eat plants are called primary consumers or herbivores. Animals that eat other animals are called secondary consumers or carnivores. If a carnivore eats another carnivore, it is called a tertiary consumer. Some animals play both roles, eating both plants and animals. They are called omnivores.
- Decomposers - Decomposers eat decaying matter (like dead plants and animals). They help put nutrients back into the soil for plants to eat. Examples of decomposers are worms, bacteria, and fungi.

grass ---> zebra ---> lion

- grass = producer
- zebra = primary consumer
- lion = secondary consumer

Energy is Lost

Like we said above, all the energy made in the food chain comes from the producers, or plants, converting sunlight into energy with photosynthesis. The rest of the food chain just uses energy. So as you move through the food chain there is less and less energy available. For this reason, there are less and less organisms the further along the food chain you get.

In our example above, there is more grass than zebras, and more zebras than lions. The zebras and lions use up energy doing stuff like running, hunting, and breathing.

Each Link is Important

Links higher up in the food chain rely on the lower links. Even though lions don't eat grass, they wouldn't last long if there wasn't any grass because then the zebras wouldn't have anything to eat.

Food Web

In any ecosystem there are many food chains and, generally, most plants and animals are part of several chains. When you draw all the chains together you end up with a food web.

Trophic Levels

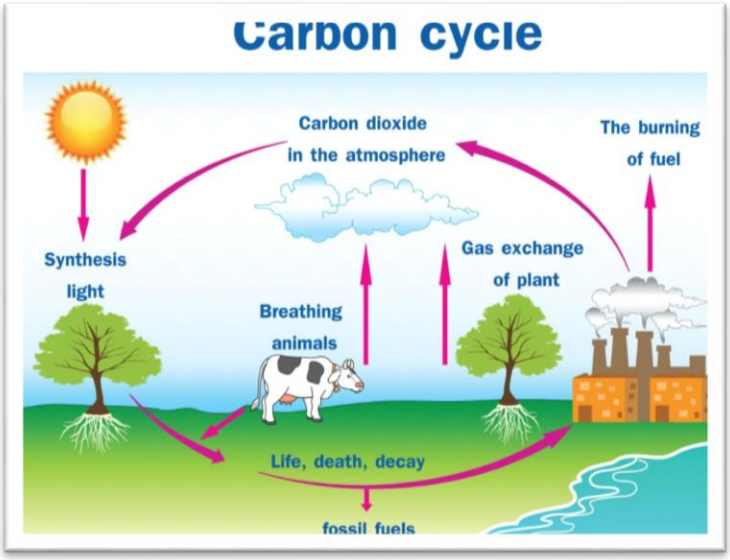
Sometimes scientists describe each level in a food web with a trophic level. Here are the five trophic levels:

- Level 1: Plants (producers)
- Level 2: Animals that eat plants or herbivores (primary consumers)
- Level 3: Animals that eat herbivores (secondary consumers, carnivores)
- Level 4: Animals that eat carnivores (tertiary consumers, carnivores)
- Level 5: Animals at the top of the food chain are called apex predators. Nothing eats these animals.

CARBON CYCLE

Definition:

The carbon cycle is the biogeochemical cycle by which carbon is exchanged among the biosphere, e, geosphere, hydrosphere, and atmosphere of the Earth. Carbon is the main component of biological compounds as well as a major component of many minerals such as limestone.



The key processes in the carbon cycle are:

- carbon dioxide from the atmosphere is converted into plant material in the biosphere by photosynthesis
- organisms in the biosphere obtain energy by respiration and so

release carbon dioxide that was originally trapped by photosynthesis

- some organisms do not decay so the carbon is stored as wood, soil carbon, sediments or even eventually converted to fossil fuels. The carbon becomes part of the lithosphere
- carbon dioxide dissolves in the waters of the Earth, particularly in cold water. This makes the water more acidic. Carbon is stored in the hydrosphere
- increasing levels of carbon dioxide in the atmosphere as a result of combustion of fossil fuels traps the Earth's radiant heat, resulting in an increase in average global temperatures and anthropogenic climate change.

Changes in the carbon cycle resulting from increases in greenhouse gases, such as carbon dioxide and methane, have contributed to global warming.

NITROGEN CYCLE

The nitrogen cycle describes how nitrogen moves between plants, animals, bacteria, the atmosphere (the air), and soil in the ground. Nitrogen is an important element to all life on Earth.

Different Nitrogen States

For Nitrogen to be used by different life forms on Earth, it must change into different states. Nitrogen in the atmosphere, or air, is N_2. Other important states of nitrogen include Nitrates ($N0_3$), Nitrites (NO_2), and Ammonium (NH_4).

Nitrogen Cycle

This picture shows the flow of the nitrogen cycle. The most important part of the cycle is bacteria. Bacteria help the nitrogen change between states so it can be used. When nitrogen is absorbed by the soil, different bacteria help it to change states so it can be absorbed by plants. Animals then get their nitrogen from the plants.

Processes in the Nitrogen Cycle

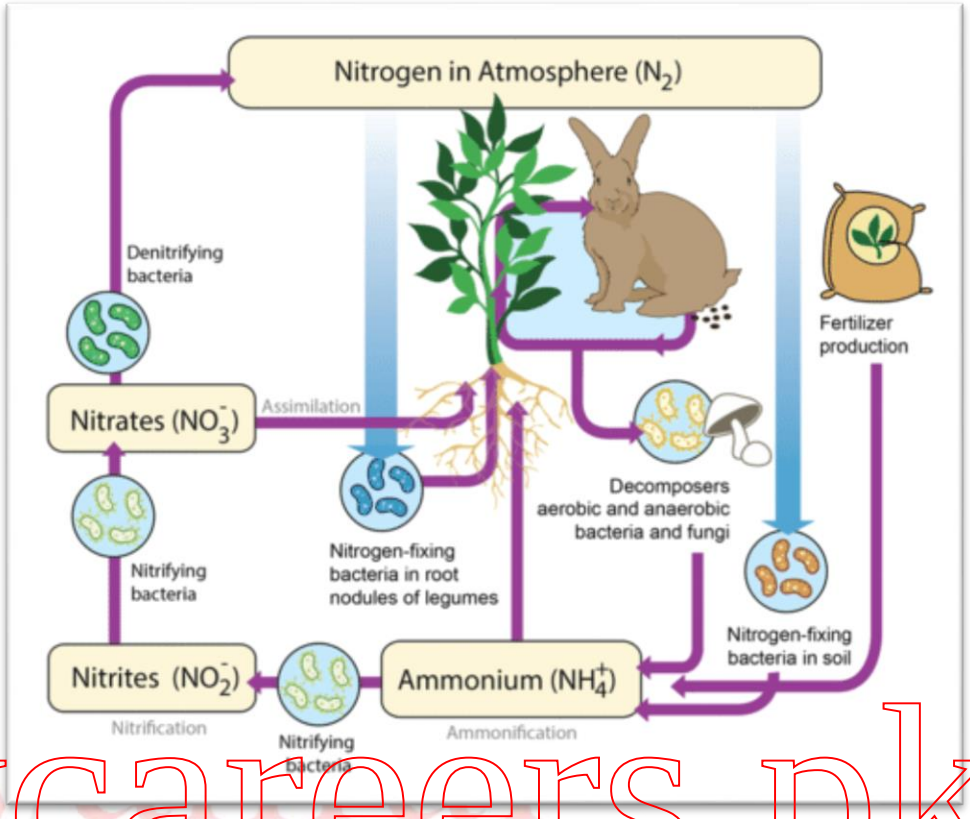
- Fixation - Fixation is the first step in the process of making nitrogen usable by plants. Here bacteria change nitrogen into ammonium.
- Nitrification - This is the process by which ammonium gets changed into nitrates by bacteria. Nitrates are what the plants can then absorb.
- Assimilation - This is how plants get nitrogen. They absorb nitrates from the soil into their roots. Then the nitrogen gets used in amino acids, nucleic acids, and chlorophyll.
- Ammonification - This is part of the decaying process. When a plant or animal dies, decomposers like fungi and bacteria turn the nitrogen back into ammonium so it can reenter the nitrogen cycle.
- Denitrification - Extra nitrogen in the soil gets put back out into the air. There are special bacteria that perform this task as well.

Why is nitrogen important to life?

Plants and animals could not live without nitrogen. It is an important part of many cells and processes such as amino acids, proteins, and even our DNA. It is also needed to make chlorophyll in plants, which plants use in photosynthesis to make their food and energy.

How have humans altered the nitrogen cycle?

Unfortunately, human activity has altered the cycle. We do this by adding nitrogen into the soil with fertilizer as well as other activities that put more nitrous oxide gas into the atmosphere. This adds in more nitrogen than is needed by normal cycle and upsets the cycle's balance.



Fun Facts

- Around 78% of the atmosphere is nitrogen. However, this is mostly not usable by animals and plants.
- Nitrogen is used in fertilizer to help plants grow faster.
- Nitrous oxide is a greenhouse gas. Too much of it can also cause acid rain.
- Nitrogen has no color, odor, or taste.
- It is used in many explosives.
- About 3% of your body weight is nitrogen.

WHAT IS THE WATER CYCLE?

The water cycle is a way that water moves all around the Earth. It never stops and doesn't really have a beginning or an end. It's like a big circle. We'll describe it by starting with water that's on land. For example, water that resides in the ocean or in a lake. Some water on the surface of the ocean will evaporate due to heat from the sun. When it evaporates it turns into vapor water and goes up into the atmosphere. This vapor water gets together with a lot of other vapor water and turns into clouds. Clouds move about the earth with the weather and once they are so full of water they drop the water to Earth in some form of precipitation. It could be rain, snow, sleet, or hail. When the water hits the earth it may fall right back into the ocean or feed a flower or be snow on the top of a mountain. Eventually this water will evaporate and start the whole cycle again.

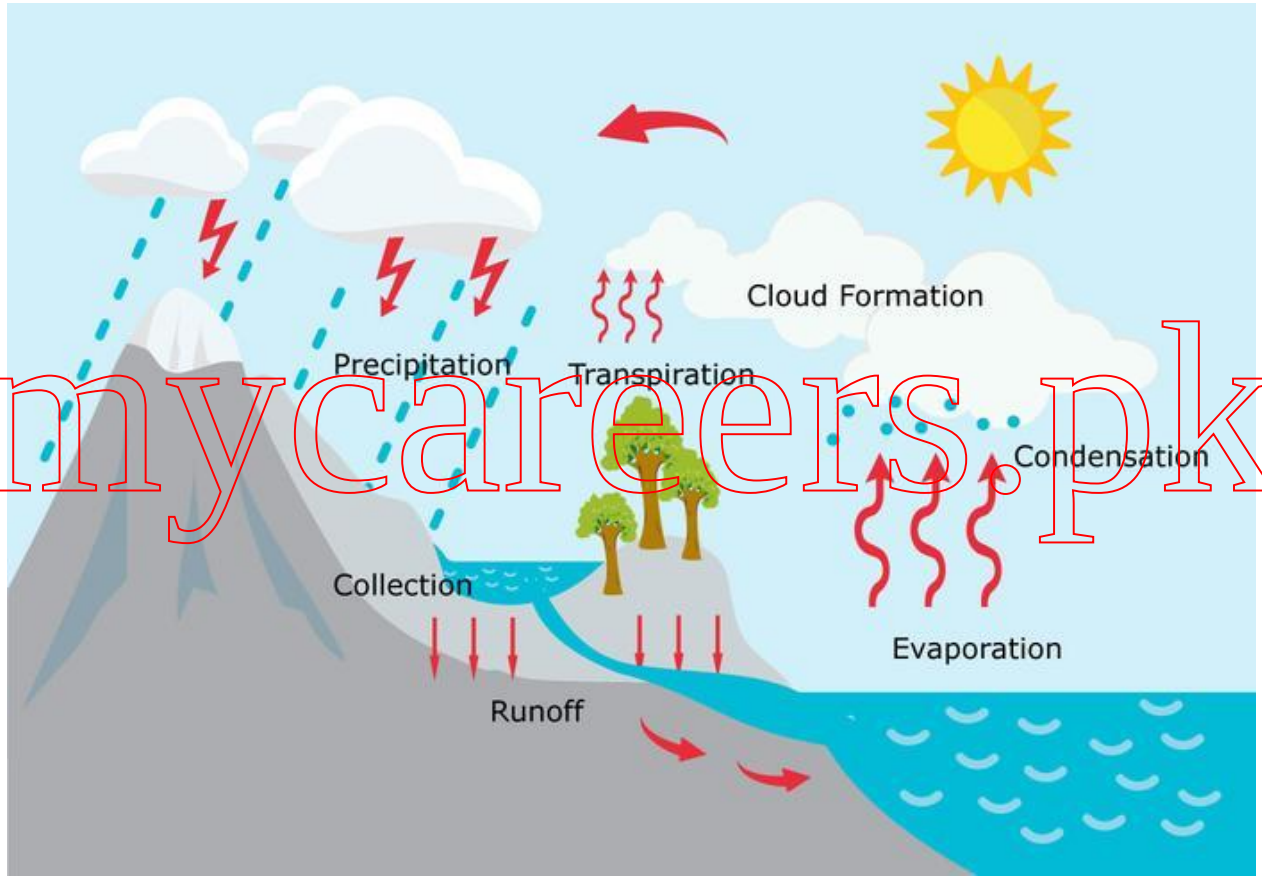
How water goes from land to vapor in the atmosphere

There are three main ways that water on land turns into vapor:

Evaporation - This is the main process by which water goes from the ground to vapor in the atmosphere. Around 90 percent of the water vapor in the atmosphere got there through evaporation. Evaporation takes place only on the water's surface. It takes energy in the form of heat. Hot water will evaporate more easily than cold water. The sun provides a lot of the energy for evaporation in the water cycle, primarily causing evaporation from the surface of the ocean.

Sublimation - This is when water moves directly to vapor from ice or snow without ever melting into water. Good conditions for sublimation to occur is when ice or snow is in very cold conditions, but it is windy and the sun is shining.

Transpiration - Transpiration is when plants release water on to their leaves that then evaporates into vapor. Plants will release a lot of water as they grow. Around 10 percent of the water vapor in the



atmosphere is estimated to come from transpiration.

Water in the atmosphere We see water in the atmosphere in the form of clouds. There is a small amount of water even in clear skies, but clouds are where water has started to condense. Condensation is the process of water vapor becoming liquid water. Condensation is a major step in the water cycle. The atmosphere helps to move water around the world. It takes water that evaporated from the ocean and moves it over land where clouds and storms form to water plants with rain.

Precipitation

Precipitation is when water falls from the atmosphere back to land. Once enough water gathers in a cloud droplets of water will form and fall to the earth. Depending on the temperature and weather this

could be rain, snow, sleet, or even hail.

Water storage

A lot of the Earth's water does not take part in the water cycle very often., Much of it is stored. The Earth stores water in a number of places. The ocean is the largest storage of water. Around 96 percent of the Earth's water is stored in the ocean. We can't drink the salty ocean water, so fortunately for us, freshwater is also stored in lakes, glaciers, snow caps, rivers, and below the ground in groundwater storage.

POLLUTION

Pollution is when something is added to the environment that is harmful or poisonous to living things. Smoke or dust in the air is a type of pollution as it is bad for the lungs when we breath in. Sewage in drinking water is another type of pollution, as it can make people ill because it contains germs and viruses. People living next to a building site where there is too much noise can become sick as they cannot sleep.

As pollution grows, ways to combat it has grown too. Solar energy and wind energy give people other ways to power their homes. When people use these alternative forms of energy, they put less carbon dioxide into the environment. Pollution is of four types; Air, Noise, Water, and Soil or Land pollution.

Air pollution

Here are some ways from which air pollution occurs. Air pollution is caused by poisonous gases, sulphur dioxide, nitrogen dioxide, carbon monoxide and very small particulates. It is also caused by the smoke and harmful gases released by the firesthat make vehicles and factories go. Use of coal, wood and kerosene as fuels for fire also causes air pollution. Air pollution may cause breathing problems such as asthma or other health problems. It also causes diseases like cancer. Air pollution causes global warming and acid rain. It results in increased temperatures, erratic rains and drought worldwide. This makes it difficult for the living organisms to survive.

Water pollution

Water pollution is the presence of harmful materials in water, such as sewage, dissolved metals, waste from farms, factoriesand crude oil spilled from oil tankers. The three main substances that pollute water are nitrates from fertilizers, sewage and detergents.

Activities such as bathing and washing clothes near lakes, ponds or rivers add nutrients like nitrogen and phosphorous into the water bodies.This leads to excessive growth of algae on the surface of water. It blocks the penetration of sunlight and air, thus reducing oxygen.

Pollution causes harm to organisms living in water and can also harm people's health. In extreme cases it may cause problems such as cancer.

Noise pollution

Noise pollution also known as sound pollution is noise which is harmful to humans and animals. This includes the sound of vehicles, loud speakers, etc. Noise pollution can cause ear problems or even permanent deafness, especially to older people.

Soil pollution or land pollution

Soil pollution (also known as land pollution) is when man-made chemicals, such as hydrocarbons, heavy metals, solvents, get into the soil. These chemicals come from industrial activities and from bad waste disposal. Soil pollution may cause health risks. The chemicals can produce harmful vapors, or they can contaminate water supplies underneath the polluted soil.

Plastic pollution
Plastic pollution is the accumulation of plastic products in the environment that adversely affects wildlife, wildlife habitat, or humans.

Thermal pollution
A common cause of thermal pollution is the use of water as a coolant by power plants and industrial manufacturers. This puts back warm water, and so raises the temperature and decreases the oxygen content of the water.

OZONE LAYER

The **ozone layer** is a layer of ozone high up in the Earth's atmosphere stratosphere. In the region between about 10 kilometres and about 50 kilometres above ground, the atmosphere contains more ozone (O_3). The exact amount of ozone that can be found varies, the seasons influence it; it is also different in different places on the Earth.

Over the last hundred years the ozone layer has been damaged by man-made chemicals, especially ones called CFCs (chlorofluorocarbons). CFCs were used for various purposes. They have been replaced by other substances for most applications. These CFCs are broken down in the upper atmosphere where they react with the ozone. This causes ozone depletion.

DEPLETION OF OZONE LAYER:
Ozone is a gas that is present in the ozone layer in the stratosphere of the Earth. There, it will absorb almost all ultraviolet light which is harmful to many organisms. The term **Ozone depletion** can refer to a number of distinct, but related phenomena:

- Since about the 1970s, there has been a decrease in total volume of the Ozone in the ozone layer, of about 4%, per decade.
- There are seasonal variations in the ozone layers; in springtime, there is less ozone in the ozone layer over the polar regions, esp. the south pole. This is generally known as **ozone hole**.
- In addition to these well-known stratospheric phenomena, there are also springtime polar tropospheric ozone depletion events.

GLOBAL WARMING

Global warming is a slow steady rise in Earth's surface temperature. Temperatures today are 0.74 °C (1.33 °F) higher than 150 years ago. Many scientists say that in the next 100–200 years, temperatures might be up to 6 degrees Celsius higher than they were before the effects of global warming were discovered.
Of the greenhouse gases, the basic cause seems to be a rise in atmosphericcarbon dioxide concentration, as predicted by Svante Arrhenius a hundred years ago. When people use fossil fuels like coal and oil, this adds carbon dioxide to the air. When people cut down many trees (deforestation), this means less carbon dioxide is taken out of the atmosphere by those plants.
As the Earth's surface temperature becomes hotter the sea level becomes higher. This is partly because water expands when it gets warmer. It is also partly because warm temperatures make glaciers melt. The sea level rise causes coastal areas to flood. Weather patterns, including where and how much rain or snow there is, will change. Deserts will probably increase in size. Colder areas will warm up faster than warm areas. Strong storms may become more likely and farming may not make as much food.

ACID RAIN:

Acid rain, or acid deposition, is a broad term that includes any form of precipitation that contains acidic components, such as sulfuric acid or nitric acid, according to the Environmental Protection Agency (EPA).

The precipitation is not necessarily wet or liquid; the definition includes dust, gasses, rain, snow, fog and hail. The type of acid rain that contains water is called wet deposition. Acid rain formed with dust or gasses is called dry deposition.

Causes

The term acid rain was coined in 1852 by Scottish chemist Robert Angus Smith, according to the Royal Society of Chemistry, which calls him the "father of acid rain." Smith decided on the term while examining rainwater chemistry near industrial cities in England and Scotland. He wrote about his findings in 1872 in the book "Air and Rain: The Beginnings of a Chemical Climatology."

Effects

Acid rain affects nearly everything. Plants, soil, trees, buildings and even statues can be transformed by the precipitation.

Acid rain has been found to be very hard on trees. It weakens them by washing away the protective film on leaves, and it stunts growth. A paper released in the online version of the journal of Environmental Science and Technology in 2005 showed evidence of acid rain stunting tree growth.

DISEASES / SYNDROMES / DISORDERS

- **Malaria is caused by the Plasmodium parasite. The parasite can be spread to humans through the bites of infected mosquitoes.**
- There are many different types of plasmodium parasite, but only 5 types cause malaria in humans.
- These are:
- **Plasmodium falciparum** – mainly found in Africa, it's the most common type of malaria parasite and is responsible for most malaria deaths worldwide
- **Plasmodium vivax** – mainly found in Asia and South America, this parasite causes milder symptoms than Plasmodium falciparum, but it can stay in the liver for up to 3 years, which can result in relapses
- **Plasmodium ovale** – fairly uncommon and usually found in West Africa, it can remain in your liver for several years without producing symptoms
- **Plasmodium malariae** – this is quite rare and usually only found in Africa
- **Plasmodium knowlesi** – this is very rare and found in parts of southeast Asia

Symptoms of Malaria

- **Symptoms**
- A malaria infection is generally characterized by the following signs and symptoms:
- Fever
- Chills
- Headache
- Nausea and vomiting
- Muscle pain and fatigue
- Other signs and symptoms may include:
- Sweating

- Chest or abdominal pain Cough

Extra:

- Each year, approximately **210 million people** are infected with malaria, and about **440,000 people die from the disease.** Most of the people who die from the disease are young children in Africa.
- While the disease is uncommon in temperate climates, malaria is still common in tropical and subtropical countries.

DENGUE

- Dengue fever, also known as break **bone fever**, is a **mosquito-borne infection** that can lead to a severe flu-like illness. It is caused by four different viruses and spread by ***Aedes* mosquitoes**

- **Prevention From Dengue / Malaria**
- No vaccine can protect against dengue fever. Only avoiding mosquito bites can prevent it. Anyone who lives in or travels to an at-risk area can use a number of ways to avoid being bitten.
-
- **Clothing**: Reduce the amount of skin exposed by wearing long pants, long-sleeved shirts, and socks, tucking pant legs into shoes or socks, and wearing a hat.
- **Mosquito repellents**: Use a repellent with at least 10 percent concentration of diethyltoluamide (DEET), or a higher concentration for longer lengths of exposure. Avoid using DEET on young children.
- **Mosquito traps and nets**: Nets treated with insecticide are more effective, otherwise the mosquito can bite through the net if the person is standing next to it. The insecticide will kill mosquitoes and other insects, and it will repel insects from entering the room.
- **Door and window screens**: Structural barriers, such as screens or netting, can keep mosquitos out.
- **Avoid scents**: Heavily scented soaps and perfumes may attract mosquitos.
- **Camping gear**: Treat clothes, shoes, and camping gear with permethrin, or purchase clothes that have been pretreated.
- **Timing**: Try to avoid being outside at dawn, dusk, and early evening.
- **Stagnant water**: The *Aedes* mosquito breeds in clean, stagnant water. Checking for and removing stagnant water can help reduce the risk.

HEPATITIS

- Hepatitis is **the inflammation of the liver.** Although hepatitis can be the symptom of many illnesses, including autoimmune diseases, it is most often caused by a viral infection.
- **There are five main types of viral hepatitis — A, B, C, D and E.**
- **Symptoms:**
- jaundice (a yellowing of the skin and eyes)
- abdominal pain
- loss of appetite
- nausea and vomiting
- diarrhea
- fever

Prevention of Hepatitis

- Routine childhood hepatitis A vaccination

- Hepatitis B vaccination is also available, and it is 95 percent effective in preventing viral infections and its chronic consequences, according to the WHO.
- Although there is no vaccine for hepatitis D, the disease can still be prevented by vaccinating against hepatitis B.

Polio

- Polio is a contagious viral illness that in its most severe form causes nerve injury leading to paralysis, difficulty breathing and sometimes death.

- Polio is a viral infection that can cause paralysis and death in its most severe forms.
- It can spread easily from person to person.
- The World Health Organiation (WHO) aim is to eradicate polio completely and, if this happens, it will be only the third disease to have been beaten in this way, after smallpox and rinderpest.

HEART ATTACK

- An acute myocardial infarction, also called a heart attack, happens when a blood **vessel in the heart suddenly becomes blocked**. Blood vessels carry blood and oxygen. When a blood vessel in the heart gets blocked, blood cannot get to part of the heart. This part of the heart does **not get enough oxygen**. This is called **ischemia.**
- heart muscle becomes ischemic (does not get enough blood and oxygen), the ischemia often causes chest pain. This is called Angina Pectoris. If the ischemia lasts long enough, the **heart muscle that is not getting enough oxygen dies. This is called an infarction.**
  "Myocardial infarction" means **"infarction (muscle death)** in the heart muscle

Causes:

- **Coronary artery disease** When cholesterol and fatty deposits build up in the heart's arteries, less blood can reach the heart muscle. This buildup is known as atherosclerosis. The result may be chest pain (angina).
- **High blood pressure (hypertension or HBP**) Uncontrolled HBP is a major risk factor for developing heart failure.
- **Abnormal heart valves Heart valve problems** can result from disease, infection (endocarditis) or a defect present at birth.
- **Heart muscle disease (dilated cardiomyopathy, hypertrophic cardiomyopathy)** or **inflammation (myocarditis)** Any damage to the heart muscle – whether because of drug or alcohol use, viral infections or unknown reasons – increases the risk of heart failure.
- **Diabetes** increases the risk for developing heart failure. People with diabetes tend to develop hypertension and atherosclerosis from elevated lipid levels in the blood. Both hypertension and atherosclerosis have been linked to heart failure.
- **Obesity** Obesity can cause the heart to work much harder than for a non-obese person. Being obese is also a cause of sleep apnea and can cause cardiomyopathy.

NOTES COMPILED BY TAHIR HABIB

GLOSSARY

abiotic factor
nonliving aspect of the environment such as sunlight and soil
absolute dating
carbon-14 or other method of dating fossils that gives an approximate age in years
absorption
process in which substances such as nutrients pass into the blood stream
acid
solution with a pH lower than 7
acid rain
low-pH precipitation that forms with air pollution combines with water
acquired immunodeficiency syndrome (AIDS)
disorder characterized by frequent opportunistic infections that eventually develops in people who are infected with human immunodeficiency virus (HIV)
action potential
reversal of electrical charge across the membrane of a resting neuron that travels down the axon of the neuron as a nerve impulse
activation energy
energy needed to start a chemical reaction
active immunity
ability to resist a pathogen that results when an immune response to the pathogen produces memory cells
active transport
movement of substances across a plasma membrane that requires energy
adaptation
characteristic that helps living things survive and reproduce in a given environment
adaptive radiation
process by which a single species evolves into many new species to fill available niches
adolescence
period of transition between the beginning of puberty and adulthood during which significant physical, mental, emotional, and social changes occur
adolescent growth spurt
period of rapid growth that occurs during puberty
adrenal glands
pair of endocrine glands located above the kidneys that secrete hormones such as cortisol and adrenaline
aerobic respiration
type of cellular respiration that requires oxygen
age-sex structure
number of individuals of each sex and age in a population
aggression
behavior that is intended to cause harm or pain
air pollution
chemical substances and particles released into the air mainly by human actions such as burning fossil fuels

Air Quality Index (AQI)
assessment of the levels of pollutants in the outdoor air that is based on their human health effects
alcoholic fermentation
type of anaerobic respiration that includes glycolysis followed by the conversion of pyruvic acid to ethanol and carbon dioxide and the formation of NAD^+
algae (singular, alga)
plant-like protists such as diatoms and seaweeds
algal bloom
excessive growth of algae in bodies of water because of high levels of nutrients, usually from fertilizer in runoff
allele
one of two or more different versions of the same gene
allele frequency
how often an allele occurs in a gene pool relative to the other alleles for that gene
allergen
any antigen that causes an allergy
allergy
disease in which the immune system makes an inflammatory response to a harmless antigen
allopatric speciation
evolution of a new species that occurs when some members of an original species become geographically separated from the rest of the species
alternation of generations
change back and forth from one generation to the next between haploid gametophyte and diploid sporophyte stages in the life cycle of plants
alveoli (singular, alveolus)
tiny sacs at the ends of bronchioles in the lungs where pulmonary gas exchange takes place
amoeboid
type of protozoa, such as *Amoeba,* that moves with pseudopods
amino acid
small molecule that is a building block of proteins
amniote
animal that produces eggs with internal membranes that allow gases but not water to pass through so the embryo can breathe without drying out (reptile, bird, or mammal)
amniotic sac
enclosed membrane containing fluid that surrounds and protects a fetus
amphibian
ectothermic, tetrapod vertebrate that may live on land but must return to water in order to reproduce
anabolic reaction
endothermic reaction in organisms
anaerobic respiration
type of cellular respiration that does not require oxygen
analogous structure
structure that is similar in unrelated organisms because it evolved to do the same job, not because it was inherited from a common ancestor
anaphase
third phase of mitosis during which sister chromatids separate and move to opposite poles of the cell
angiosperm
type of seed plant that produces seeds in the ovary of a flower

animal
heterotrophic, multicellular eukaryote with cells that lack cell walls; member of the animal kingdom
animal behavior
any way that animals interact with each other or the environment
Annelida
invertebrate phylum of segmented worms such as earthworms
antheridia (singular, antheridium)
male reproductive organs of the gametophyte generation of plants that produce motile sperm
antibiotic drug
drug that kills bacteria and cures bacterial infections and diseases
antibiotic resistance
ability to withstand antibiotic drugs that has evolved in some bacteria
antibody
large, Y-shaped proteins produced by B cells that recognize and bind to antigens in a humoral immune response
antigen
molecule that the immune system identifies as foreign and responds to by forming antibodies
aphotic zone
area in aquatic biomes deeper than 200 meters
aquatic biome
water-based biomes, defined by the availability of sunlight and the concentration of dissolved oxygen and nutrients in the water
aquifer
underground layer of rock that stores water
arboreal
of or pertaining to trees, as in arboreal, or tree-living, mammal
Archaea
one of two prokaryote domains that includes organisms that live in extreme environments
archegonia (singular, archegonium)
female reproductive organs of the gametophyte generation of plants that produce eggs
artery
type of blood vessel that carries blood away from the heart toward the lungs or body
arthropod
invertebrate in the phylum Arthropoda, characterized by a segmented body, hard exoskeleton, and jointed appendages
artificial selection
process in which organisms evolve traits useful to humans because people select which individuals are allowed to reproduce and pass on their genes to successive generations
asexual reproduction
reproduction that involves a single parent and results in offspring that are all genetically identical to the parent
asthma
respiratory system disease in which air passages of the lungs periodically become too narrow, making breathing difficult
atherosclerosis
condition in which plaque builds up inside arteries
athlete's foot
infection of the skin between the toes by the fungus *Trichophyton*

ATP (adenosine triphosphate)
energy-carrying molecule that cells use to power their metabolic processes
autoimmune disease
type of disease, such as type 1 diabetes, in which the immune system attacks the body's cells as though they were pathogens
autonomic nervous system (ANS)
division of the peripheral nervous system that controls involuntary activities not under conscious control such as heart rate and digestion
autosome
chromosomes 1–22 in humans that contain genes for characteristics unrelated to sex
autotroph
organism that makes its own food
axon
long extension of the cell body of a neuron that transmits nerve impulses to other cells.

B:

Bacteria
domain of prokaryotes, some of which cause human diseases
bark
tissue that provides a rough, woody external covering on the stems of trees
base
solution with a pH higher than 7
B cell
type of lymphocyte that fights infections by forming antibodies
bilateral symmetry
symmetry of a body plan in which there are distinct head and tail ends, so the body can be divided into two identical right and left halves
bile
fluid produced by the liver and stored in the gall bladder that is secreted into the small intestine to help digest lipids and neutralize acid from the stomach
binary fission
type of cell division that occurs in prokaryotic cells in which a parent cells divides into two identical daughter cells
binomial nomenclature
method of naming species with two names, consisting of the genus name and species name
biochemical reaction
chemical reaction that occurs inside the cells of living things
biodiversity
the variety of life and its processes; including the variety of living organisms, the genetic differences among them, and the communities and ecosystems in which they occur
biofilm
colony of prokaryotes that is stuck to a surface such as a rock or a host's tissue
biogeochemical cycle
interconnected pathways through which water or a chemical element such as carbon is continuously recycled through the biotic and abiotic components of the biosphere
biogeography

study of how and why plants and animals live where they do

biology
science of life, study of life

biomass
total mass of organisms at a trophic level

biome
group of similar ecosystems with the same general type of physical environment

biosphere
part of Earth where all life exists, including land, water, and air

biotechnology
use of technology to change the genetic makeup of living things in order to produce useful products

bioterrorism
intentional release or spread of agents of disease

biotic factor
living aspects of the environment, including organisms of the same and different species

bird
bipedal, endothermic, tetrapod vertebrate that lays amniotic eggs and has wings and feathers

bladder
hollow, sac-like organ that stores urine until it is excreted from the body

blastocyst
fluid-filled ball of cells that develops a few days after fertilization in humans

blood
fluid connective tissue that circulates throughout the body through blood vessels

blood pressure
force exerted by circulating blood on the walls of blood vessels

blood type
genetic characteristic associated with the presence or absence of antigens on the surface of red blood cells

body mass index (BMI)
estimate of the fat content of the body calculated by dividing a person's weight (in kilograms) by the square of the person's height (in meters)

bone
hard tissue in most vertebrates that consists of a collagen matrix, or framework, filled in with minerals such a calcium

bone marrow
soft connective tissue in spongy bone that produces blood cells

bone matrix
rigid framework of bone that consists of tough protein fibers and mineral crystals

brain
central nervous system organ inside the skull that is the control center of the nervous system

brain stem
lowest part of the brain that connects the brain with the spinal cord and controls unconscious functions such as heart rate and breathing

bryophyte
type of plant that lacks vascular tissues, such as a liverwort, hornwort, or moss

budding
type of asexual reproduction in yeasts in which an offspring cell pinches off from the parent cell.

C :

Calvin cycle
second stage of photosynthesis in which carbon atoms from carbon dioxide are combined, using the energy in ATP and NADPH, to make glucose

Cambrian explosion
spectacular burst of new life that occurred at the start of the Paleozoic Era

cancer
disease that occurs when the cell cycle is no longer regulated and cells divide out of control

candidiasis
infection of the mouth or of the vagina in females that is caused by the yeast *Candida*

capillary
smallest type of blood vessel that connects very small arteries and veins

capsid
protein coat that surrounds the DNA or RNA of a virus particle

carbohydrate
organic compound such as sugar or starch

carbon cycle
interconnected pathways through which carbon is recycled through the biotic and abiotic components of the biosphere

carcinogen
anything that can cause cancer

cardiac muscle
involuntary, striated muscle found only in the walls of the heart

cardiovascular disease (CVD)
any disease that affects the heart or blood vessels

carnivore
consumer that eats animals

carrying capacity (K)
largest population size that can be supported in an area without harming the environment

cartilage
dense connective tissue that provides a smooth surface for the movement of bones at joints

catabolic reaction
exothermic reaction in organisms

cell
basic unit of structure and function of living things

cell body
central part of a neuron that contains the nucleus and other cell organelles

cell cycle
repeating series of events that a cell goes through during its life, including growth, DNA, synthesis, and cell division

cell division
process in which a parent cell divides to form two daughter cells

cell-mediated immune response
type of immune response in which T cells destroy cells that are infected with viruses

cell theory

theory that all living things are made up of cells, all life functions occur within cells, and all cells come from already existing cells

cellular respiration
process in which cells break down glucose and make ATP for energy

cell wall
rigid layer that surrounds the plasma membrane of a plant cell and helps support and protect the cell

Cenozoic Era
age of mammals that lasted from 65 million years ago to the present

central dogma of molecule biology
doctrine that genetic instructions in DNA are copied by RNA, which carries them to a ribosome where they are used to synthesize a protein (DNA → RNA → protein)

central nervous system (CNS)
one of two main divisions of the nervous system that includes the brain and spinal cord

central vacuole
large saclike organelle in plant cells that stores substances such as water and helps keep plant tissues rigid

centromere
region of sister chromatids where they are joined together

cephalization
concentration of nerve tissue in one end of an animal, forming a head region

cerebellum
part of the brain below the cerebrum that coordinates body movements

cerebrum
largest part of the brain that controls conscious functions such as reasoning and sight

Chargaff's rules
observations by Erwin Chargaff that concentrations of the four nucleotide bases differ among species; and that, within a species, the concentrations of adenine and thymine are always about the same and the concentrations of cytosine and guanine are always about the same

chemical bond
force that holds molecules together

chemical digestion
chemical breakdown of large, complex food molecules into smaller, simpler nutrient molecules that can be absorbed by the blood

chemical reaction
process that changes some chemical substances into others

chemoautotroph
producer that uses energy from chemical compounds to make food by chemosynthesis

chemosynthesis
process of using the energy in chemical compounds to make food

chitin
tough carbohydrate that makes up the cell walls of fungi and the exoskeletons of insects and other arthropods

chlamydia
sexually transmitted bacterial infection that is the most common STI in the United States

chlorophyll
green pigment in a chloroplast that absorbs sunlight in the light reactions of photosynthesis

chloroplast
organelle in the cells of plants and algae where photosynthesis takes place

chordates
consists of all animals with a notochord, dorsal hollow nerve cord, post-anal tail, and pharyngeal slits during at least some stage of their life
chromatid
one of two identical copies of a chromosome that are joined together at a centromere before a cell divides
chromatin
grainy material that DNA forms when it is not coiled into chromosomes
chromosomal alteration
mutation that changes chromosome structure
chromosome
coiled structure made of DNA and proteins containing sister chromatids that is the form in which the genetic material of a cell goes through cell division
cilia (singular, cilium)
short, hairlike projections, similar to flagella, that allow some cells to move
ciliate
type of protozoa, such as *Paramecium,* that moves with cilia
circadian rhythm
regular change in biology or behavior that occurs in a 24-hour cycle
circulatory system
organ system consisting of the heart, blood vessels, and blood that transports materials around the body
clade
group of related organisms that includes an ancestor and all of its descendants
climate
average weather in an area over a long period of time
climax community
final stable stage of ecological succession that may be reached in an undisturbed community
cloaca
body cavity with a single opening in amphibians, reptiles, and monotreme mammals that collects and excretes wastes from the digestive and excretory systems and gametes from the reproductive system
Cnidaria
invertebrate phylum that includes animals such as jellyfish and corals that are characterized by radial symmetry, tissues, and a stinger called a nematocyst
codominance
relationship between two alleles for the same gene in which both alleles are expressed equally in the phenotype of the heterozygote
codon
group of three nitrogen bases in nucleic acids that makes up a code “word” of the genetic code and stands for an amino acid, start, or stop
coelom
fluid-filled body cavity
coevolution
process in which two interacting species evolve together, with each species influencing the other’s evolution
commensalism
symbiotic relationship in which one species benefits while the other species is not affected
community

all of the populations of different species that live in the same area

compact bone

dense outer layer of bone that is very hard and strong

comparative anatomy

study of the similarities and differences in the structures of different species

comparative embryology

study of the similarities and differences in the embryos of different species

competition

relationship between living things that depend on the same resources in the same place and at the same time

competitive exclusion principle

principle of ecology stating that two different species cannot occupy the same niche in the same place for very long

complementary base pair

pair of nucleotide bases that bond together—either adenine and thymine (or uracil) or cytosine and guanine

complete digestive system

digestive system consisting of a digestive tract and two body openings (mouth and anus)

compound

substance with a unique, fixed composition that consists of two or more elements

condensation

process in which water vapor changes to tiny droplets of liquid water

cone

structure consisting of scales that bear naked seeds in the type of seed plants called gymnosperms

connective tissue

tissue made up of cells that form the body's structure, such as bone and cartilage

consumer

organism that consumes other organisms for food

cooperation

type of animal behavior in which social animals live and work together for the good of the group

courtship

animal behavior that is intended to attract a mate

cranium

part of a vertebrate endoskeleton that encloses and protects the brain; also called the skull

crop

sac-like structure in the digestive system of birds that stores and moistens food before it is digested

crossing-over

exchange of genetic material between homologous chromosomes when they are closely paired during meiosis I

cuticle

waxy, waterproof substance produced by epidermal cells of leaves, shoots, and other above-ground parts of plants to prevent damage and loss of water by evaporation

cyanobacteria

Gram-positive blue-green photosynthetic bacteria of the type that added oxygen to Earth's early atmosphere and evolved into chloroplasts of eukaryotic cells

cytokinesis

splitting of the cytoplasm to form daughter cells when a cell divides

cytoplasm

all of the material inside the plasma membrane of a cell (excluding organelles)
cytoskeleton
structure of filaments and tubules in the cytoplasm that provides a cell with an internal framework

D:
dead zone
area in the ocean or other body of water where low oxygen levels from excessive growth of algae have killed all aquatic organisms
deciduous plant
type of plant that seasonally loses its leaves to reduce water loss during the cold or dry season each year and grows new leaves later in the year
decomposer
organism that breaks down the remains of dead organisms and other organic wastes
demographic transition
changes in population that occurred in Europe and North America beginning in the 18th century, in which death rates fell and population growth rates increased, followed by birth rates falling and population growth rates decreasing
dendrite
extension of the cell body of a neuron that receives nerve impulses from other neurons
dependent variable
variable in a scientific experiment that is affected by another variable, called the independent variable
deposit feeder
animal that obtains organic matter for nutrition by eating soil or the sediments at the bottom of a body of water
dermal tissue
type of plant tissue that covers the outside of a plant in a single layer of cells called the epidermis
dermis
lower layer of the skin that is made of tough connective tissue and contains blood vessels, nerve endings, hair follicles, and glands
detritivore
decomposer that consumes detritus
detritus
substance composed of dead leaves, other plant remains, and animal feces that collects on the soil or at the bottom of a body of water
dialysis
medical procedure in which blood is filtered through a machine in patients with kidney failure
diaphragm
large, sheet-like muscle below the lungs that allows breathing to occur when it contracts and relaxes
differentiation
process by which unspecialized cells become specialized into one of many different types of cells, such as neurons or epithelial cells
diffusion
type of passive transport that does not require the help of transport proteins
digestion
process of breaking down food into nutrients that can be absorbed by the blood
digestive system
organ system that breaks down food, absorbs nutrients, and eliminates any remaining waste
diploid

having two of each type of chromosome

directional selection

type of natural selection for a polygenic trait in which one of two extreme phenotypes is selected for, resulting in a shift of the phenotypic distribution toward that extreme

dispersal

movement of offspring away from their parents

disruptive selection

type of natural selection for a polygenic trait in which phenotypes in the middle of the phenotypic distribution are selected against, resulting in two overlapping phenotypes, one at each end of the distribution

DNA (deoxyribonucleic acid)

double-stranded nucleic acid that makes up genes and chromosomes

DNA replication

process of copying of DNA prior to cell division

domain

taxon in the revised Linnaean system that is larger and more inclusive than the kingdom

dominant allele

allele that masks the presence of another allele for the same gene when they occur together in a heterozygote

dormancy

state in which a plant slows down cellular activity and may shed its leaves

double helix

double spiral shape of the DNA molecule

drug abuse

use of a drug without the advice of a medical professional and for reasons not originally intended

drug addiction

situation in which a drug user is unable to stop using a drug

E:

facilitated diffusion

diffusion with the help of transport proteins

Fallopian tube

one of two female reproductive organs that carry eggs from the ovary to the uterus and provide the site where fertilization usually takes place

feces

solid waste that remains after food is digested and is eliminated from the body through the anus

fermentation

type of anaerobic respiration that includes glycolysis followed by the conversion of pyruvic acid to one or more other compounds and the formation of NAD^+

fertilization

union of two gametes that produces a diploid zygote

fetus

developing human organism between weeks 8 and 38 after fertilization

fibrous root

threadlike root that makes up part of the fibrous root system of some plants

filter feeder

animal that obtains organic matter for nutrition by filtering particles out of water

fish

ectothermic, aquatic vertebrate with a streamlined body and gills for absorbing oxygen from water
fitness
relative ability of an organism to survive and produce fertile offspring
flagella (singular, flagellum)
long, thin protein extensions of the plasma membrane in most prokaryotic cells that help the cells move
flagellate
type of protozoa, such as *Giardia,* that moves with flagella
flower
structure in angiosperms consisting of male and female reproductive structures that attracts animal pollinators
follicle-stimulating hormone (FSH)
pituitary gland hormone that stimulates the ovaries to secrete estrogen and follicles in the ovaries to mature
food
organic molecules such as glucose that organisms use for chemical energy
food chain
diagram that represents a single pathway through which energy and matter flow through an ecosystem
food web
diagram that represents multiple intersecting pathways through which energy and matter flow through an ecosystem
fossil
preserved remains or traces of organisms that lived in the past
fossil record
the record of life as told by the study and analysis of fossils
frameshift mutation
deletion or insertion of one or more nucleotides that changes the reading frame of the genetic material
freshwater biome
aquatic biome such as a pond, lake, stream, or river in which the water contains little or no salt
fruit
structure in many flowering plants that develops from the ovary and contains seeds
fungi (singular, fungus)
kingdom in the domain Eukarya that includes molds, mushrooms, and yeasts

G:
Galápagos Islands
group of 16 small volcanic islands in the Pacific Ocean 966 kilometers (600 miles) off the west coast of South America, where Darwin made some of his most important observations during his voyage on the *HMS Beagle*
gall bladder
sac-like organ that stores bile from the liver and secretes it into the duodenum of the small intestine
gamete
reproductive cell produced during meiosis that has the haploid number of chromosomes
gametogenesis
development of haploid cells into gametes such as sperm and egg
gametophyte
haploid generation in the life cycle of a plant that results from asexual reproduction with spores and that produces gametes for sexual reproduction
gastrointestinal (GI) tract

organs of the digestive system through which food passes during digestion, including the mouth, esophagus, stomach, and small and large intestines

gene
unit of DNA on a chromosome that is encoded with the instructions for a single protein

gene cloning
process of isolating and making copies of a gene

gene expression
use of a gene to make a protein

gene flow
change in allele frequencies that occurs when individuals move into or out of a population

gene pool
all the genes of all the members of a population

generalist
organism that can consume many different types of food

gene theory
theory that the characteristics of living things are controlled by genes that are passed from parents to offspring

gene therapy
way to cure genetic disorders by inserting normal genes into cells with mutant genes

genetic code
universal code of three-base codons that encodes the genetic instructions for the amino acid sequence of proteins

genetic disorder
disease caused by a mutation in one or a few genes

genetic drift
a random change in allele frequencies that occurs in a small population

genetic engineering
using biotechnology to change the genetic makeup of an organism

genetics
the science of heredity

genetic trait
characteristic that is encoded in DNA

genetic transfer
method of increasing genetic variation in prokaryotes that involves cells "grabbing" stray pieces of DNA from their environment or exchanging DNA directly with other cells

genital herpes
sexually transmitted infection caused by a herpes virus that is characterized by periodic outbreaks of blisters on the genitals

genital warts
small, rough growths on the genitals caused by a sexually transmitted infection with human papillomavirus (HPV)

genotype
alleles an individual inherits at a particular genetic locus

genus
taxon above the species in the Linnaean classification system; group of closely related species

geologic time scale
time line of Earth based on major events in geology, climate, and the evolution of life

germination

early growth and development of a plant embryo in a seed

germline mutation
mutation that occur in gametes

giardiasis
disease caused by *Giardia* protozoa that spreads through contaminated food or water

gills
organs in aquatic organisms composed of thin filaments that absorb oxygen from water

gizzard
food-grinding organ in the digestive system of birds and some other animals that may contain swallowed stones

global warming
recent rise in Earth's average surface temperature generally attributed to an increased greenhouse effect

glucose
simple carbohydrate with the chemical formula $C_6H_{12}O_6$ that is the nearly universal food for life

glycolysis
first stage of cellular respiration in which glucose is split, in the absence of oxygen, to form two molecules of pyruvate (pyruvic acid) and two (net) molecules of ATP

Golgi apparatus
organelle in eukaryotic cells that processes proteins and prepares them for use both inside and outside the cell

gonads
glands that secrete sex hormones and produce gametes; testes in males and ovaries in females

gonorrhea
common sexually transmitted infection that is caused by bacteria

gradualism
model of the timing of evolution in which evolutionary change occurs at a slow and steady pace

Gram-negative bacteria
type of bacteria that stain red with Gram stain and have a thin cell wall with an outer membrane

Gram-positive bacteria
type of bacteria that stain purple with Gram stain and have a thick cell wall without an outer membrane

grana
within the chloroplast, consists of sac-like membranes, known as thylakoid membranes

greenhouse effect
natural feature of Earth's atmosphere that occurs when gases in the atmosphere radiate the sun's heat back down to Earth's surface, making Earth's temperature far warmer than it otherwise would be

ground tissue
type of plant tissue making up most of the interior of the roots and stems of plants that carries out basic metabolic functions and provides support and storage

groundwater
water that exists in the ground either in the soil or in rock layers below the surface

growing season
period of time each year when it is warm enough and wet enough for plants to grow

gymnosperm
type of seed plant that produces bare seeds in cones

H:

habitat

physical environment in which a species lives and to which it has become adapted

habitat loss

destruction or disruption of Earth's natural habitats, most often due to human actions such as agriculture, forestry, mining, and urbanization

hair follicle

structure in the dermis of skin where a hair originates

haploid

having only one chromosome of each type

Hardy-Weinberg theorem

founding principle of population genetics that proves allele and genotype frequencies do not change in a population that meets the conditions of no mutation, no migration, large population size, random mating, and no natural selection

heart

muscular organ in the chest that that pumps blood through blood vessels when it contracts

heart attack

blockage of blood flow to heart muscle tissues that may result in the death of cardiac muscle fibers

hepatitis B

inflammation of the liver caused by infection with hepatitis B virus, which is often transmitted through sexual contact

herbivore

consumer that eats producers such as plants or algae

heterotroph

organism that gets food by consuming other organisms

heterozygote

organism that inherits two different alleles for a given gene

homeobox gene

gene that codes of regulatory proteins that control gene expression during development

homeostasis

process of maintaining a stable environment inside a cell or an entire organism

homologous chromosomes

pair of chromosomes that have the same size and shape and contain the same genes

homologous structure

structure that is similar in related organisms because it was inherited from a common ancestor

homozygote

organism that inherits two alleles of the same type for a given gene

host

species that is harmed in a parasitic relationship

human genome

all of the DNA of the human species

Human Genome Project

international science project that sequenced all 3 billion base pairs of the human genome

human immunodeficiency virus (HIV)

virus transmitted through body fluids that infects and destroys helper T cells and eventually causes acquired immunodeficiency syndrome (AIDS)

human papilloma virus (HPV)

sexually transmitted virus that causes genital warts and cervical cancer

humoral immune response

type of immune response in which B cells produce antibodies against antigens in blood and lymph

hybrid
offspring that results from a cross between two different types of parents
hydrogen bond
type of chemical bond that forms between molecules: found between water molecules
hydrostatic skeleton
type of internal support in an animal body that results from the pressure of fluid within the body cavity known as the coelom
hypertension
high blood pressure
hyphae (singular, hypha)
thread-like filaments that make up the body of a fungus and consist of one or more cells surrounded by a tubular cell wall
hypothalamus
part of the brain that secretes hormones
hypothesis
possible answer to a scientific question; must be falsifiable

I:
immigration
movement of individuals into a population
immune response
specific defense against a particular pathogen
immune system
body system that consists of skin, mucous, membranes, and other tissues and organs that defends the body from pathogens and cancer
immunity
ability to resist a pathogen due to memory lymphocytes or antibodies to the antigens the pathogen carries
immunization
deliberate exposure of a person to a pathogen in order to provoke an immune response and the formation of memory cells specific to that pathogen
immunodeficiency
inability of the immune system to fight off pathogens that a normal immune system would be able to resist
implantation
process in which a blastocyst embeds in the endometrium lining the uterus
incomplete digestive system
digestive system that consists of a digestive cavity and a single opening that serves as both mouth and anus
incomplete dominance
relationship between the alleles for a gene in which one allele is only partly dominant to the other allele so an intermediate phenotype results
incubation
period of bird reproduction when one or both parents sit on, or brood, the eggs in order to keep them warm until they hatch
independent assortment
independent segregation of chromosomes to gametes during meiosis
independent variable

variable in a scientific experiment that is manipulated by the researcher to investigate its effect on another variable called the dependent variable

infancy
first year of life after birth in humans

inflammatory response
nonspecific response the body first makes to tissue damage or infection

inheritance of acquired characteristics
mistaken idea of Jean Baptiste Lamarck that evolution occurs through the inheritance of traits that an organism develops in its own life time

innate behavior
behavior closely controlled by genes that occurs naturally, without learning or practice, in all members of a species whenever they are exposed to a certain stimulus; also called instinctive behavior

instinct
ability of an animal to perform a behavior the first time it is exposed to the proper stimulus

integumentary system
human body system that includes the skin, nails, and hair

interneuron
type of neuron that carries nerve impulses back and forth between sensory and motor neurons

interphase
stage of the eukaryotic cell cycle when the cell grows, synthesizes DNA, and prepares to divide

interspecific competition
relationship between organisms of different species that strive for the same resources in the same place

intertidal zone
in marine biomes, the narrow strip along the coastline that is covered by water at high tide and exposed to air at low tide

intraspecific competition
relationship between organisms of the same species that strive for the same resources in the same place

invertebrate
animal that lacks a vertebral column, or backbone

K:

kelp
multicellular seaweed that may grow as large as a tree and occurs in forests found throughout the ocean in temperate and arctic climates

keratin
tough, fibrous protein in skin, nails, and hair

keystone species
species that plays an especially important role in its community so that major changes in its numbers affect the populations of many other species in the community

kidney
main organ of the excretory system that filters blood and forms urine

kidney failure
loss of the ability of nephrons of the kidney to function fully

kingdom
largest and most inclusive taxon in the original Linnaean classification system

Krebs cycle
second stage of aerobic respiration in which two pyruvate (pyruvic acid) molecules from the first stage react to form ATP, NADH, and $FADH_2$

***K*-selected**
species in which population growth is controlled by density-dependent factors and population size is generally at or near carrying capacity

L:
lactation
production of milk for an offspring by mammary glands, which occurs in all female mammals after giving birth or laying eggs
lactic acid fermentation
type of anaerobic respiration that includes glycolysis followed by the conversion of pyruvic acid to lactic acid and the formation of NAD^+
lancelets
members of the subphylum Cephalochordata
large intestine
organ of the digestive system that removes water from food waste and forms feces
larva (plural, larvae)
juvenile stage that occurs in the life cycle of many invertebrates, fish, and amphibians and that differs in form and function from the adult stage
larynx
organ of the respiratory system between the pharynx and trachea that is also called the voice box because it allows the production of vocal sounds
last universal common ancestor (LUCA)
hypothetical early cell (or group of cells) that gave rise to all subsequent life on Earth
latency
period of dormancy of a virus inside a living body that may last for many years
law of independent assortment
Mendel's second law stating that factors controlling different characteristics are inherited independently of each other
law of segregation
Mendel's first law stating that the two factors controlling a characteristics separate and go to different gametes
learning
change in behavior that occurs as a result of experience
leukocyte
white blood cell produced by bone marrow to fight infections
lichen
an organism that results from a mutualistic relationship between a fungus and a cyanobacterium or green alga
life cycle
series of stages a sexually reproducing organism goes through from one generation to the next
ligament
band of fibrous connective tissue that holds bones together
light reactions
first stage of photosynthesis in which light energy from the sun is captured and changed into chemical energy that is stored in ATP and NADPH
lignin
tough, hydrophobic carbohydrate molecule that stiffens and waterproofs vascular tissues of plants
linkage map

map that shows the positions of genes on a chromosome based on the frequency of crossing-over between the genes

linked genes
genes that are located on the same chromosome

Linnaean classification system
system of classifying organisms based on observable physical traits; consists of a hierarchy of taxa, fro the kingdom to the species

lipid
organic compound such as fat or oil

liver
organ of digestion and excretion that secretes bile for lipid digestion and breaks down excess amino acids and toxins in the blood

locus
position of a gene on a chromosome

logistic growth
pattern of population growth in which growth slows and population size levels off as the population approaches the carrying capacity

lung
organ of the respiratory system in which gas exchange takes place between the blood and the atmosphere

luteinizing hormone (LH)
pituitary gland hormone that stimulates the testes to secrete testosterone and the ovaries to secrete estrogen

lymph
fluid that leaks out of capillaries into spaces between cells and circulates in the vessels of the lymphatic system

lymphatic system
system of the body consisting of organs, vessels, nodes, and lymph that produces lymphocytes and filters pathogens from body fluids

lymph node
small structures located on lymphatic vessels where pathogens are filtered from lymph and destroyed by lymphocytes

lymphocyte
type of leukocyte that is a key cell in the immune response to a specific pathogen

M:

macroevolution
evolutionary change that occurs over geologic time above the level of the species

macronutrient
nutrient such as carbohydrates, proteins, lipids, or water that is needed by the body in relatively large amounts

malaria
disease caused by *Plasmodium* protozoa and transmitted by mosquitoes in tropical and subtropical regions of the world

mammal
endothermic, tetrapod vertebrate that lays amniotic eggs and has mammary glands (in females) and hair or fur

mammary gland

gland in female mammals that produces milk for offspring

mantle

layer of tissue that lies between the shell and body of a mollusk and forms a cavity, called the mantle cavity, that pumps water for filter feeding

marine biome

aquatic biome in the salt water of the ocean

marsupial

therian mammal in which the embryo is born at an early, immature stage and completes its development outside the mother's body in a pouch on her belly

mass extinction

extinction event in which many if not most species abruptly disappear from Earth

matter

anything that takes up space and has mass

mechanical digestion

physical breakdown of chunks of food into smaller pieces by organs of the digestive system

medusa (plural, medusae)

basic body plan in cnidarians such as jellyfish that is bell-shaped and typically motile

meiosis

type of cell division in which the number of chromosomes is reduced by half and four haploid cells result

melanin

brown pigment produced by melanocytes in the skin that gives skin most of its color and prevents UV light from penetrating the skin

memory cell

lymphocyte (B or T cell) that retains a "memory" of a specific pathogen after an infection is over and thus provides immunity to the pathogen

menarche

beginning of menstruation, first monthly period in females

menopause

period during which menstrual cycles slow down and eventually stop in middle adulthood

menstrual cycle

monthly cycle of processes and events in the ovaries and uterus of a sexually mature human female

menstruation

process in which the endometrium of the uterus is shed from the body during the first several days of the menstrual cycle; also called monthly period

meristem

type of plant tissue consisting of undifferentiated cells that can continue to divide and differentiate and from which plants grow in length or width

mesoderm

embryonic cell layer in many animals that is located between the endoderm (inner cell layer) and ectoderm (outer cell layer)

mesophyll

specialized tissue inside plant leaves where photosynthesis takes place

Mesozoic Era

age of dinosaurs that lasted from 245–65 million years ago

messenger RNA (mRNA)

type of RNA that copies genetic instructions from DNA in the nucleus and carries them to the cytoplasm

metabolism

sum of all the biochemical reactions in an organism

metamorphosis
process in which a larva undergoes a major transformation to change into the adult form, which occurs in amphibians, arthropods, and other invertebrates
metaphase
second phase of mitosis during which chromosomes line up at the equator of the cell
microevolution
evolutionary change that occurs over a relatively short period of time within a population or species
micronutrient
nutrient such as a vitamin or mineral that is needed by the body in relatively small amounts
migration
regular movement of individuals or populations each year during certain seasons, usually to find food, mates, or other resources
mineral
chemical element such as calcium or potassium that is needed in relatively small amounts for proper body functioning
mitochondria (singular, mitochondrion)
organelle in eukaryotic cells that makes energy available to the cell in the form of ATP molecules
mitosis
process in which the nucleus of a eukaryotic cell divides
model
representation of part of the real world
molecular clock
using DNA (or proteins) to measure how long it has been since related species diverged from a common ancestor
Mollusca
phylum of invertebrates that are generally characterized by a hard outer shell, a mantle, and a feeding organ called a radula
molting
process in which an animal sheds and replaces the outer covering of the body, such as the exoskeleton in arthropods
monosaccharide
simple sugar such as glucose that is a building block of carbohydrates
monotreme
type of mammal that reproduces by laying eggs
motility
the ability to move
motor neuron
type of neuron that carries nerve impulses from the central nervous system to muscles and glands
mucous membrane
epithelial tissue that lines inner body surfaces and body openings and produces mucus
mucus
slimy substance produced by mucous membranes that traps pathogens, particles, and debris
multiple allele trait
trait controlled by one gene with more than two alleles
muscle fiber
long, thin muscle cell that has the ability to contract, or shorten
muscle tissue
tissue made up of cells that can contract; includes smooth, skeletal, and cardiac muscle tissue

muscular system
human body system that includes all the muscles of the body
mutagen
environmental factors that causes mutations
mutation
change in the sequence of bases in DNA or RNA
mutualism
type of symbiotic relationship in which both species benefit
mycelium
body of a fungus that consists of a mass of threadlike filaments called hyphae
mycorrhiza
mutualistic relationship between a plant and a fungus that grows in or on its roots
myelin sheath
lipid layer around the axon of a neuron that allows nerve impulses to travel more rapidly down the axon
MyPlate
visual guideline for balanced eating, replacing MyPyramid in 2011
MyPyramid
visual dietary guideline that shows the relative amounts of foods in different food groups that should be eaten each day

N:
natural resource
something supplied by nature that helps support life
natural selection
evolutionary process in which some living things produce more offspring than others so the characteristics of organisms change over time
nature-nurture debate
debate over the extent to which genes (nature) or experiences in a given environment (nurture) control traits such as animal behaviors
nectar
sweet, sugary liquid produced by the flowers of many angiosperms to attract animal pollinators
Nematoda
phylum of invertebrates called roundworms, which have a pseudocoelom and complete digestive system
neocortex
layer of nerve cells covering the cerebrum of the mammalian brain that plays an important role in many complex brain functions
nephron
structural and functional unit of the kidney that filters blood and forms urine
nerve
one of many cable-like bundles of axons that make up the peripheral nervous system
nerve impulse
electrical signal transmitted by the nervous system
nervous system
human body system that carries electrical messages throughout the body
nervous tissue
tissue made up of neurons, or nerve cells, that carry electrical messages
neuron

nerve cell; structural and functional unit of the nervous system

neurotransmitter

chemical that carries a nerve impulse from one nerve to another at a synapse

niche

role of a species in its ecosystem that includes all the ways the species interacts with the biotic and abiotic factors of the ecosystem

nitrogen cycle

interconnected pathways through which nitrogen is recycled through the biotic and abiotic components of the biosphere

nitrogen fixation

process of changing nitrogen gas to nitrates that is carried out by nitrogen-fixing bacteria in the soil or in the roots of legumes

nondisjunction

failure of replicated chromosomes to separate during meiosis II, resulting in some gametes with a missing chromosome and some with an extra chromosome

nonrenewable resource

natural resource that exists in a fixed amount and can be used up

notochord

stiff support rod that runs from one end of the body to the other in animals called chordates

nucleic acid

organic compound such as DNA or RNA

nucleotide

small molecule containing a sugar, phosphate group, and base that is a building block of nucleic acids

nucleus (plural, nuclei)

organelle inside eukaryotic cells that contains most of the cell's DNA and acts as the control center of the cell

nutrient

substance the body needs for energy, building materials, or control of body processes

O:

obesity

condition in which the body mass index is 30.0 kg/m^2 or greater

observation

anything that is detected with the senses

omnivore

consumer that eats both plants and animals

oogenesis

process of producing eggs in the ovary

open circulatory system

type of circulatory system in which blood flows not only through blood vessels but also through a body cavity

operator

a region of an operon where regulatory proteins bind

operon

region of prokaryotic DNA that consists of a promoter, an operator, and one or more genes that encode proteins needed for a specific function

organ

structure composed of more than one type of tissue that performs a particular function

organelle
structure within the cytoplasm of a cell that is enclosed within a membrane and performs a specific job
organic compound
compound found in living things that contains mainly carbon
organism
an individual living thing
organ system
group of organs that work together to do a certain job
osmosis
diffusion of water molecules across a membrane
ossification
process in which mineral deposits replace cartilage and change it into bone
osteoblast
type of bone cell that makes new bone cells and secretes collagen
osteoclast
type of bone cell that dissolves minerals in bone and releases them back into the blood
osteocyte
type of bone cell that regulates mineral homeostasis by directing the uptake of minerals from the blood and the release of minerals back into the blood as needed
ovary
one of two female reproductive organs that produces eggs and secretes estrogen
ovipary
type of reproduction in which an embryo develops within an egg outside the mother's body
ovovivipary
type of reproduction in which an embryo develops inside an egg within the mother's body but in which the mother provides no nourishment to the developing embryo in the egg
ovulation
release of a secondary oocyte from the uterus about half way through the menstrual cycle
ozone hole
hole in the ozone layer high in the atmosphere over Antarctica caused by air pollution destroying ozone

P:
paleontologist
scientist who finds and studies fossils to learn about evolution and understand the past
Paleozoic Era
age of "old life" from 544–245 million years ago that began with the Cambrian explosion and ended with the Permian extinction
pancreas
gland near the stomach that secretes insulin and glucagon to regulate blood glucose and enzymes to help digest food
parasite
species that benefits in a parasitic relationship
parasitism
symbiotic relationship in which one species benefits while the other species is harmed
parathyroid glands
a pair of small glands in the neck that secretes hormones that regulate blood calcium
passive immunity

type of immunity to a particular pathogen that results when antibodies are transferred to a person who has never been exposed to the pathogen

passive transport
movement of substances across a plasma membrane that does not require energy

pathogen
disease-causing agent such as a bacterium, virus, fungus, or protozoan

pedigree
chart showing how a trait is passed from generation to generation within a family

penis
male reproductive organ containing the urethra, through which sperm and urine pass out of the body

periosteum
tough, fibrous membrane that covers the outer surface of bone

peripheral nervous system (PNS)
one of two major divisions of the nervous system that consists of all the nervous tissue that lies outside the central nervous system

peristalsis
rapid, involuntary, wave-like contraction of muscles that pushes food through the GI tract and urine through the ureters

Permian extinction
extinction at the end of the Paleozoic Period that was the biggest mass extinction the world had ever seen until then

petal
outer parts of flowers that are usually brightly colored to attract animal pollinators

pH
scale that is used to measure acidity

phagocytosis
process in which leukocytes engulf and break down pathogens and debris

pharmacogenomics
field that is tailoring medical treatments to fit our genetic profiles

pharynx
long, tubular organ that connects the mouth and nasal cavity with the larynx through which air and food pass

phenotype
characteristics of an organism that depend on how the organism's genotype is expressed

phloem
type of vascular tissue in a plant that transports food from photosynthetic cells to other parts of the plant

phospholipid bilayer
double layer of phospholipid molecules that makes up a plasma membrane

photic zone
area in an aquatic biome that extends to a maximum depth of 200 meters

photoautotroph
producer that uses energy from sunlight to make food by photosynthesis

photosynthesis
process of using the energy in sunlight to make food (glucose)

photosystem
group of molecules, including chlorophyll, in the thylakoid membrane of a chloroplast that captures light energy

phylogenetic tree
diagram that shows how species are related to each other through common ancestors
phylogeny
evolutionary history of a group of related organisms
phytoplankton
bacteria and algae that use sunlight to make food
pineal gland
gland of the endocrine system that secretes the hormone melatonin that regulates sleep-wake cycles
pioneer species
type of species that first colonizes a disturbed area
pistil
female reproductive structure of a flower that consists of a stigma, style, and ovary
pituitary gland
master gland of the endocrine system that secretes many hormones, the majority of which regulate other endocrine glands
placenta
temporary organ that consists of a large mass of maternal and fetal blood vessels through the mother's and fetus's blood exchange substances
placental mammal
therian mammal in which a placenta develops during pregnancy to sustain the fetus while it develops inside the mother's uterus
plant
multicellular eukaryote with chloroplasts, cell walls made of cellulose, and specialized reproductive organs
plasma
golden-yellow fluid part of blood that contains many dissolved substances and blood cells
plasma membrane
thin coat of lipids (phospholipids) that surrounds and encloses a cell
plasmid
small, circular piece of DNA in a prokaryotic cell
platelet
cell fragment in blood that helps blood clot
Platyhelminthes
invertebrate phylum of flatworms that are characterized by a flat body because they lack a coelom or pseudocoelom
pleiotropy
situation in which a single gene affects more than one trait
pneumonia
disease in which the alveoli of the lungs become inflamed and filled with fluid as a result of infection or injury
point mutation
change in a single nucleotide base in the genetic material
polarity
difference in electrical charge between different parts of the same molecule
pollen
tiny grains that bear the male gametes of seed plants and transfer sperm to female reproductive structures
pollination

fertilization in plants in which pollen is transferred to female gametes in an ovary

polygenic characteristic

characteristic, or trait, controlled by more than one gene, each of which may have two or more alleles

polymerase chain reaction (PCR)

biotechnology process that makes many copies of a gene or other DNA segment

polynucleotide

chain of nucleotides that alone or with another such chain makes up a nucleic acid

polyp

basic body plan in cnidarians such as jellyfish that is tubular in shape and typically sessile

polypeptide

chain of amino acids that alone or with other such chains makes up a protein

polysaccharide

chain of monosaccharides that makes up a complex carbohydrate such as starch

population

all the organisms of the same species that live in the same area

population density

average number of individuals in a population per unit of area or volume

population distribution

describes how the individuals are distributed, or spread throughout their habitat

population genetics

science focusing on evolution within populations that is the area of overlap between evolutionary theory and Mendelian genetics

population growth rate (r)

how fast a population changes in size over time

population pyramid

bar graph that represents the age-structure of a population

Porifera

invertebrate phylum of sponges, which have a non-bony endoskeleton and are sessile as adults

precipitation

water that falls from clouds in the atmosphere to Earth's in the form of rain, snow, sleet, hail, or freezing rain

predation

relationship in which members of one species consume members of another species

predator

species that consumes another in a predator-prey relationship

prediction

statement that tells what will happen under certain conditions

pregnancy

carrying of one or more offspring from fertilization until birth

prey

species that is consumed by another in a predator-prey relationship

primary succession

change in the numbers and types of species that live in a community that occurs in an area that has never before been colonized

probability

the likelihood, or chance, than a certain event will occur

producer

organism that produces food for itself and other organisms

product
substance that forms as the result of a chemical reaction
prokaryote
single-celled organism that lacks a nucleus
prokaryotic cell
cell without a nucleus that is found in single-celled organisms
promoter
region of a gene where a RNA polymerase binds to initiate transcription of the gene
prophase
first phase of mitosis during which chromatin condense into chromosomes, the nuclear envelope breaks down, centrioles separate, and a spindle begins to form
protein
organic compound made up of amino acids
protein synthesis
process in which cells make proteins that includes transcription of DNA and translation of mRNA
protist
kingdom in the domain Eukarya that includes all eukaryotes except plants, animals, and fungi
protozoa (singular, protozoan)
animal-like protists such as *Amoeba* and *Paramecium*
pseudocoelom
partial, fluid-filled cavity inside the body of some invertebrates
pseudopod
temporary, foot-like extension of the cytoplasm that some cells use for movement or feeding
psychoactive drug
drug that affects the central nervous system, generally by influencing the transmission of never impulses in the brain
puberty
period during which humans become sexually mature
pulmonary circulation
part of the circulatory system that carries blood between the heart and lungs
punctuated equilibrium
model of the timing of evolution in which long periods of little evolutionary change are interrupted by bursts of rapid evolutionary change
Punnett square
chart for determining the expected percentages of different genotypes in the offspring of two parents
pupa
life cycle stage of many insects that occurs between the larval and adult stages and during which the insect is immobile, may be encased within a cocoon, and changes into the adult form

R:
radial symmetry
symmetry of a body plan in which there is a distinct top and bottom but not distinct head and tail ends, so the body can be divided into two halves like a pie
reactant
starting material in a chemical reaction
recessive allele
allele that is masked by the presence of another allele for the same gene when they occur together in a heterozygote

recombinant DNA
DNA that results when DNA from two organisms is combined
red blood cell
type of cell in blood that contains hemoglobin and carries oxygen
reflex
rapid motor response to a sensory stimulus in which nerve impulses travel in an arc that includes the spinal cord but not the brain
regeneration
regrowing of tissues, organs, or limbs that have been lost or damaged
regulatory element
region of DNA where a regulatory protein binds
regulatory protein
protein that regulates gene expression
relative dating
method of dating fossils by their location in rock layers; determines which fossils are older or younger but not their age in years
renewable resource
natural resource that can be replenished by natural processes as quickly as humans use it
reproduction
process by which living things give rise to offspring
reproductive system
system of organs that produces gametes and secretes sex hormones
reptile
ectothermic, tetrapod vertebrate that lays amniotic eggs; includes crocodiles, lizards, snakes, and turtles
reservoir
part of a biogeochemical cycle that holds an element or water for a long period of time
respiration
exchange of gases between the body and the outside air
respiratory system
organ system that brings oxygen into the body and releases carbon dioxide into the atmosphere
resting potential
difference in electrical charge across the plasma membrane of a neuron that is not actively transmitting a nerve impulse
rhizoid
hair-like structure in a nonvascular plant that absorbs water and minerals and anchors the plant to a surface
ribosomal RNA
type of RNA that helps form ribosomes and assemble proteins
ribosome
organelle inside all cells where proteins are made
ringworm
skin infection caused by the fungus *Trichophyton* that causes a characteristic ring-shaped rash
RNA (ribonucleic acid)
single-stranded nucleic acid that helps make proteins
RNA world hypothesis
hypothesis that RNA was the first organic molecule to evolve and that early life was based on RNA, rather than DNA or protein
root hair

tiny hairlike structure that extends from an epidermal cell of a plant root and increases the surface area for absorption

root system
all the roots of a plant, including primary roots and secondary roots

***r*-selected**
species in which population growth is rapid but death rates are high so population size is generally below the carrying capacity

runoff
precipitation that falls on land and flows over the surface of the ground

S:

saprotroph
decomposer such as a fungus or protozoan that feeds on any remaining organic matter that is left after other decomposers do their work

saturated fatty acid
molecule in lipids in which carbon atoms are bonded to as many hydrogen atoms as possible

sauropsid
type of early amniote that evolved during the Carboniferous Period and eventually gave rise to dinosaurs, reptiles, and birds

scavenger
decomposer that consumers the soft tissues of dead animals

science
distinctive way of gaining knowledge about the natural world that tries to answer questions with evidence and logic

scientific investigation
plan for asking questions and testing possible answers

scientific law
statement describing what always happens under certain conditions in nature

scientific method
the process of a scientific investigation

scientific theory
broad explanation that is widely accepted as true because it is supported by a great deal of evidence

sebaceous gland
gland in the dermis of skin that produces sebum, an oily substance that waterproofs the skin and hair

secondary succession
change in the numbers and types of species that live in a community that occurs in an area that was previously colonized but has been disturbed

seed
structure produced by a seed plant that contains an embryo and food supply enclosed within a tough coat

seed coat
tough covering of a seed that protects the embryo and keeps it from drying out until conditions are favorable for germination

segmentation
division of an animal body into multiple segments

semen
fluid containing sperm and gland secretions that nourish sperm and carry them through the urethra and out of the body

sensory neuron
type of neuron that carries nerve impulses from tissue and organs to the spinal cord and brain
sensory receptor
specialized nerve cell that responds to a particular type of stimulus such as light or chemicals
sepal
part of a flower that helps protect it while it is still in bud
sessile
of or relating to an animal that is unable to move from place to place
sex chromosome
X or Y chromosome (in humans)
sex hormone
chemical messenger that controls sexual development and reproduction
sex-linked gene
gene located on a sex chromosome
sex-linked trait
traits controlled by a gene located on a sex chromosome
sexual dimorphism
differences between the phenotypes of males and females of the same species
sexually transmitted infection (STI)
infection caused by a pathogen that spreads mainly through sexual contact; also known as sexually transmitted disease (STD)
sexual reproduction
type of reproduction that involves the fertilization of gametes produced by two parents and produces genetically variable offspring
sixth mass extinction
current mass extinction caused primarily by habitat loss due to human actions
skeletal muscle
voluntary, striated muscle that is attached to bones of the skeleton and helps the body move
skeletal system
human body system that consists of all the bones of the body as well as cartilage and ligaments
sliding filament theory
theory that explains muscle contraction by the sliding of myosin filaments over actin filaments within muscle fibers
slime mold
fungus-like protist commonly found on rotting logs and other decaying organic matter
small intestine
long, narrow, tube-like organ of the digestive system where most chemical digestion of food and virtually all absorption of nutrients take place
smooth muscle
involuntary, nonstriated muscle that is found in the walls of internal organs such as the stomach
social animal
animal that lives in a society
society
close-knit group of animals of the same species that live and work together
sodium-potassium pump
type of active transport in which sodium ions are pumped out of the cell and potassium ions are pumped into the cell with the help of a carrier protein and energy from ATP
soil

mixture of eroded rock, minerals, organic matter, and other materials that is essential for plant growth and forms the foundation of terrestrial ecosystems

solution
mixture that has the same composition throughout

somatic mutation
mutation that occurs in cells of the body other than gametes

somatic nervous system (SNS)
division of the peripheral nervous system that controls voluntary, conscious activities and reflexes

spawning
depositing large numbers of gametes in the same place and at the same time by fish or amphibians

specialization
evolution of different adaptations in competing species, which allows them to live in the same area without competing

speciation
process by which a new species evolves

species
group of organisms that are similar enough to mate together and produce fertile offspring

sperm
male gamete

spermatogenesis
process of producing sperm in the testes

spermatophyte
type of plant that reproduces by producing seeds

spinal cord
thin, tubular bundle of nervous tissue that extends from the brainstem down the back to the pelvis and connects the brain with the peripheral nervous system

spongy bone
light, porous inner layer of bone that contains bone marrow

sporangium (plural, sporangia)
structure on a plant of the sporophyte generation that produces spores for asexual reproduction

sporophyte
diploid generation in the life cycle of a plant that results from sexual reproduction with gametes and that produces spores for asexual reproduction

sporozoa (singular, sporozoan)
type of protozoa that cannot move as adults

stabilizing selection
type of natural selection for a polygenic trait in which phenotypes at both extremes of the phenotypic distribution are selected against, resulting in a narrowing of the range of phenotypic variation

stamen
male reproductive structure of a flower that consists of a stalk-like filament and a pollen-producing anther

stimulus
something that triggers a behavior

stomach
sac-like organ of the digestive system between the esophagus and small intestine in which both mechanical and chemical digestion take place

stomata (singular, stoma)
tiny pore in the epidermis of a plant leaf that controls transpiration and gas exchange with the air

stroma
space outside the thylakoid membranes of a chloroplast where the Calvin cycle of photosynthesis takes place
sublimation
process in which ice and snow change directly to water vapor
survivorship curve
graph that represents the individuals still alive at each age in a population
sustainable use
use of resources in a way that meets the needs of the present and also preserves the resources for the use of future generations
sweat gland
gland in the dermis of skin that produces the salty fluid called sweat, which excretes wastes and helps cool the body
swim bladder
balloon-like internal organ in most fish that can be used to move up or down through the water column by changing the amount of gas it contains
symbiosis
close relationship between organisms of different species in which at least one of the organisms benefits from the relationship
sympatric speciation
evolution of a new species that occurs when without geographic separation first occurring between members of an original species
synapse
place where an axon terminal meets another cell
synapsid
type of early amniote that evolved during the Carboniferous Period and eventually gave rise to mammals
synthetic biology
field of biology involved in engineering new functions from living systems
syphilis
sexually transmitted infection caused by bacteria that may eventually be fatal if untreated
systemic circulation
part of the circulatory system that carries blood between the heart and body
taproot
single, thick primary root that characterizes the root system of some plants
target cell
type of cell on which a particular hormone has an effect because it has receptor molecules for the hormone
TATA box
regulatory element that is part of the promoter of most eukaryotic genes
taxa
a grouping of organisms in a classification system such as the Linnaean system; for example, species or genus
taxonomy
science of classifying organisms
T cell
type of lymphocyte involved in cell-mediated immunity in which cells infected with viruses are destroyed

telophase
last stage of mitosis during which chromosomes uncoil to form chromatin, the spindle breaks down, and new nuclear membranes form
tendon
tough connective tissue that attaches skeletal muscle to bones of the skeleton
terrestrial biome
a biome of or pertaining to land, as in terrestrial ecosystem
testis (plural, testes)
one of two male reproductive organs that produces sperm and secretes testosterone
testosterone
male sex hormone secreted by the testes
tetrapod
vertebrate with four legs (amphibian, reptile, bird, or mammal)
therapsid
type of extinct organism that lived during the Permian Period and gave rise to mammals
therian mammal
viviparous mammal that may be either a marsupial or placental mammal
thylakoid membrane
membrane in a chloroplast where the light reactions of photosynthesis occur
thyroid gland
large endocrine gland in the neck that secretes hormones that control the rate of cellular metabolism throughout the body
tissue
group of cells of the same kind that perform a particular function in an organism
trachea
long, tubular organ of the respiratory system, also called the wind pipe, that carries air between the larynx and lungs
tracheophyte
type of plant that has vascular tissues, such as a seed plant or flowering plant
transcription
process in which genetic instructions in DNA are copied to form a complementary strand of mRNA
transfer RNA (tRNA)
type of RNA that brings amino acids to ribosomes where they are joined together to form proteins
transgenic crop
crop that has been genetically modified with new genes that code for traits useful to humans
translation
process in which genetic instructions in mRNA are “read” to synthesize a protein
transpiration
process in which plants give off water vapor from photosynthesis through tiny pores, called stomata, in their leaves
transport protein
protein in a plasma membrane that helps other substances cross the membrane
trichomoniasis
common sexually transmitted infection that is caused by protozoa
trilobite
oldest known arthropod, which is now extinct and known only from numerous fossils
trophic level

feeding position in a food chain or food web, such as producer, primary consumer, or secondary consumer

tropism

turning by an organism or part of an organism toward or away from an environmental stimulus

tumor

abnormal mass of cells that may be cancerous

tunicates

members of the subphylum Urochordata are tunicates (also called sea squirts)

NOTES COMPILED BY TAHIR HABIB

U:

unsaturated fatty acid

molecule in lipids in which some carbon atoms are bonded to other groups of atoms rather than to hydrogen atoms

ureter

muscular, tube-like organ of the urinary system that moves urine by peristalsis from a kidney to the bladder

urethra

muscular, tube-like organ of the urinary system that carries urine out of the body from the bladder; in males, it also carries sperm out of the body

urinary system

organ system that includes the kidneys and is responsible for filtering waste products and excess water from the blood and excreting them from the body

urination

process in which urine leaves the body through a sphincter at the end of the urethra

urine

liquid waste product of the body that is formed by the kidneys and excreted by the other organs of the urinary system

uterus (plural, uteri)

female reproductive organ in therian mammals where an embryo or fetus grows and develops until birth

V:

vaccine

substance containing modified pathogens that does not cause disease but provokes an immune response and results in immunity to the pathogen

vacuole

large saclike organelle that stores and transports materials inside a cell

vagina

female reproductive organ that receives sperm during sexual intercourse and provides a passageway for a baby to leave the mother's body during birth

vascular tissue

type of tissue in plants that transports fluids through the plant; includes xylem and phloem

vector

organism such as an insect that spreads pathogens from host to host

vegetative reproduction

asexual reproduction in plants using nonreproductive tissues such as leaves, stems, or roots

vein

type of blood vessel that carries blood toward the heart from the lungs or body

ventilation
process of carrying air from the atmosphere into the lungs
vertebrae (singular, vertebra)
repeating bony units that make up the vertebral column of vertebrates
vertebral column
bony support structure that runs down the back of a vertebrate animal; also called a backbone
vertebrate
animal with a vertebral column, or backbone
vesicle
small saclike organelle that stores and transports materials inside a cell
vesicle transport
type of active transport in which substances are carried across the cell membrane by vesicles
vestigial structure
structure such as the human tailbone or appendix that evolution has reduced in size because it is no longer used
villi (singular, villus)
microscopic, finger-like projections in the mucous membrane lining the small intestine that form a large surface area for the absorption of nutrients
virion
individual virus particle that consists of nucleic acid within a protein capsid
virus
tiny, nonliving particle that contains DNA but lacks other characteristics of living cells
vitamin
organic compound needed in small amounts for proper body functioning
vivipary
type of reproduction in which an embryo develops within, and is nourished by, the mother's body
vulva
external female reproductive structures, including the labia and vaginal opening

W:
water cycle
interconnected pathways through which water is recycled through the biotic and abiotic components of the biosphere
water mold
fungus-like protist commonly found in moist soil and surface water
weed
plant that is growing where people do not want it
wetland
area that is saturated with water or covered by water for at least one season of the year
white blood cell
type of cell in blood that defends the body against invading microorganisms or other threats in blood or extracellular fluid

X:
xerophyte
plant that is adapted to a very dry environment

X-linked gene
gene located on the X chromosome
X-linked trait
trait controlled by a gene located on the X chromosome
xylem
type of vascular tissue in a plant that transports water and dissolved nutrients from roots to stems and leaves

Z:
zooplankton
tiny animals that feed on phytoplankton
zygospore
diploid spore in fungi that is produced by the fusion of two haploid parent cells
zygote
diploid cell that forms when two haploid gametes unite during fertilization