

- ✓ CAM photosynthesis – is a type of photosynthesis in which CO₂ is fixed at night into 4C compound during the day the stomata closed and the carbon is fixed via the Calvin cycle.
- CAM helps plants conserve water and is often characteristics of **xerophytes plants**.
- ✓ CAM plants are those growing in desert e.g. Cacti
- ✓ In the extreme heat, if stomata open during the day is a sure path to desiccation and death for the plants.
- ✓ Plants open their stomata at night when temperatures fall.
- ✓ CAM photosynthesis is effective in desert plants because it separates the light-dependent and light-independent stages in time; the leaves only open their stomata to allow the light independent reactions to take place during the night, saving precious water.

The CAM photosynthesis cycle

1. At night, the plants open their stomata to allow in CO₂, which then reacts with PEP in mesophyll cells to form oxaloacetate, and then malate just as in the C₄ pathway.
2. The malate is then stored in the vacuoles of these cells overnight.
3. During the day, the light-dependent reactions generate ATP and reduced NADP so that the Calvin cycle can continue.
4. Malate is released from the vacuoles and is broken down to glycerate, releasing CO₂ for the reactions of the Calvin cycle.

BIOLOGY GRADE 12

UNIT 1

MICROORGANISMS

1.1. Bacteria

Types of microorganisms

Microorganism- literally means a very small (minute) organism.

-are organisms that are too small to be seen by our naked eye but can be seen with aid of microscope.

Microorganisms can be, i. **unicellular** organisms that made only one cell.
ii. **Multicellular** organisms that have more than one cell.

Microorganisms are subject of microbiology.

Microbiology is the branch of biology that deals with microorganisms.

There are five main groups of microorganisms, each groups can be subdivided.

1. Protozoa- studied by protozoology
2. Algae - >> >> phycology.
3. Bacteria - >> >> Bacteriology
4. Fungi- >> >> Mycology.
5. Viruses- >> >> Virology.

Protozoa, Fungi and Algae

Protozoa: - are found in kingdom of **protista**

- Consists of unicellular organisms that lack cell wall and chloroplast.
- Can't makes their own food, i.e. all are heterotrophic organisms.
- Most of them are motile(able to move).

Protozoans are subdivided into four based on their locomotary structure.

i. **Amaeboids**:- have locomotary structure called **pseudopoda** or 'false foot'.

Pseudopoda is protrusion of cytoplasm, sometimes used for feeding through phagocytosis.

Eg. Entamoeba histolytica - cause amoebic dysentery

ii. **Flagellates**:- have flagella as locomotary structure that made of microtubules.

Eg. Gardia lambella- cause Gardiasis

Trypanosoma spp- causes sleeping sickness.

iii. **Ciliates**:- move by means of locomotary structure called Cilia which also made of microtubules. E.g. Paramecium

iv. **Sporozoa**:- have no locomotary structures.

Eg. Plasmodium species.-cause malaria

Fungi:- found in kingdom mycota.

- Have cell wall that made of chitin.

- But have no chloroplast, so they can't make their own food.

- They are heterotrophic ---some are **saprotrophic** (saprobionts).

--- Some are **parasitic**.

The saprotrophic - release enzymes to digest dead matters or substrate on w/c they grow, and the products of digestion are then absorbed into fungus to help it grow and reproduce.

The parasitic - live on other living things, absorbing food w/c are digested by others. Fungi- consist of organisms from unicellular to multicellular.

Unicellular fungi:- are like **yeast**, candida and Tenia pedis.

Yeast (saccharomyces)- used in bread(e.g. bakery saccharomyces) and alcoholic drink (eg. brewery saccharomyces) making process. Candida- is yeast like fungi that causes thrush in humans as opportunistic infection, called **Candidiasis**.

Multicellular fungi- some are visible and others are microscopic. Microscopic multicellular fungi eg. Bread molds

Molds are made of *hyphae* w/c is microscopic strand slender (filamentous) cell of fungi that branches to form network mass called *mycelium*.

Mode of reproduction of fungi**Asexual reproduction:-**

i. Budding -in yeast

ii. Sporulation-reproduction by producing asexual reproduction structure called spores.

iii. Fragmentation- breaking of hyphae into pieces.

Sexual reproduction:-

- Conjugation (simplest form of sexual reproduction), eg. Molds

Algae:- Found in kingdom protistae

- Consists of unicellular and multicellular eukaryotic organisms.

- They have cell-wall, that made of cellulose.

- They have chloroplast, so that they can photosynthesize food.

- They live in fresh and marine water body, so that they are phytoplankton or 'sea weeds', i.e. they are sources of food for other aquatic organisms and also sources of O₂ to aquatic environment.

They are classified into six groups

i. **Dianoflagelata**

ii. **Euglenophyta**; only algae that lack cell wall,

iii. **Diatoms**.

iv. **Chlorophyta**- green algae

v. **Phaeophyta**;- brown algae from w/c cosmetics are made

vi. **Rhodophyta**;-red algae from w/c Agar is extracted

. Excerpt phaeophyta, others are microscopic.

Bacteria

-Are unicellular prokaryotic organisms.

-In prokaryotic cells, there is no true nucleus and membrane bounded organelles. Bacteria do not contain mitochondria, chloroplast, endoplasmic reticulum, etc.

Structure of Bacteria

(What are bacteria looking like?)

- Most have **capsule** or **glycocalyx**, which is protective slime layers.
- Some bacteria have **flagella**; w/c is simple type.
- Most bacteria contain **pili (fimbriae)** around the surface of the cell, w/c use to attach on other surfaces.
- All bacteria have **cell membrane**, **cell wall** (that made of peptidoglycan), cytoplasm, ribosome (70's), and DNA (looped and naked).
- The region where DNA is found in the cytoplasm is called **nucleoid**.
- Some bacterial cells have small circular self-replicating DNA called **plasmids**

Shapes of bacteria

(Are all bacteria the same shape?)

Bacteria have different size, shape, and arrangement.

Size

Bacterial cell vary greatly in their size and usually much smaller than eukaryotic cells. Their length is between (0.1) 1µm to 10µm.

Shape

Bacterial shapes come in three main shapes.

1. cocci(sing. Coccus):- spherical bacteria
 2. Baccilli(sing. bacillus):- rod shape bacteria
 3. spirochates:-spiral or corkscrew-shaped bacteria
- (Vibro: rod when curved into coma shape. eg. Vibro cholerae)

Other way of classifying bacteria Arrangement

i. Coccus	ii. Bacillus	iii. Spirochates
1. Single(coccus)	1. Single(bacillus)	1. Spirochates
2. pair(diplococcus)	2. Pair(diplobacillus)	2. Borella
3. chain(streptococcus)	3. Chain(streptobacillus)	3. Treponema
4. cluster(staphylococcus)	4. Flagellates	4. Spirilla

Based on differential stain:

Differential stain- is a test that uses staining to classify organisms or organic material. Types of differential stain

1. Gram stain
2. Acid fast stain
3. Special stain- used to stain flagella and endospores.

Gram staining; - is a test for classifying bacteria and it named after Hans Christian Gram.

Gram staining produces different result with different types of bacteria based on thickness of cell wall.

1. Gram positive bacteria: - bacteria that stained **purple** and have thick cell wall.
2. Gram negative bacteria: - bacteria that stained **pink** and have thin cell wall.

Procedures in gram staining technique

1. Fixation
 2. Simple staining by **crystal violet**, then all bacteria turn to purple.
 3. Treating with **iodine** to form violet-iodine complex.
 4. Decolorizing by washing off with 95% **ethanol**.
 5. Counter stain using secondary stain called **safranin**.
- ✓ At the end some bacteria stain as pink, called gram negative. And others stained as purple, called gram positive.

Gram-positive bacteria

- have more peptidoglycan in the cell wall.

- No outer membrane surrounding the cell wall.
 - Not harmful except bacterium that cause tuberculosis.
- E.g. Lactobacilli (makes yogurt & buttermilk), Streptococcus, Staphylococcus

Gram-negative bacteria

- have much less peptidoglycan in their cell wall.
 - Have membrane out- side peptidoglycan cell wall.
 - The outer membrane secretes endotoxin-which is resistant to many antibiotics.
 - Almost all cause more serious disease, and more difficult to treat.
- Eg. Rhizobacteria grow in root nodules of legumes, Vibrio cholerae, Bordetella pertussis, Neisseria gonorrhoeae, Neisseria meningitidis

Mode of nutrition of Bacteria

i. Autotrophic - is two type

1. Chemosynthetic -use energy from exergonic chemical reaction.
 2. Photosynthetic - use energy from light to make food.
- ✓ Photosynthesis (photophosphorylation) takes place along the plasma membrane of bacterial cell.

ii. Heterotrophic - which are two types: 1. saprotrophic 2. Parasitic

Mode of reproduction of bacteria

1. Binary fission
2. Conjugation

The ecology and importance of bacteria

The ecology of bacteria

Bacteria are adapted to live everywhere inside and outside living organisms. Bacteria live in various physical parameters based on the availability of light and O₂, as well as the pH, temperature and salinity of the environment.

On basis of O₂ availability - bacteria can be:

- Obligate aerobes- that require O₂ for growth
- Obligate anaerobes- those which are inhibited or killed by O₂, and which grow only in its absence
- Facultative anaerobes- which grow either in the presence or absence of O₂.

On basis of temperature availability - bacteria can be:

- **psychrophiles**- that live at very cold temperatures
- **mesophiles**- Those which flourish at room temperature (25°C) or at the temperature of warm- blooded animals (37°C)
- **thermophiles**- those that live at high temperatures (greater than 45 °C)

On basis of PH: bacteria can be:

- ✓ **Acidophiles:** prefers an acid medium eg. Lactobacillus acidophilus, present in the vagina of post-pubescent females. Helicobacter pylori, cause gastritis in human.
- ✓ **Alkaliphiles:** bacteria grow best at high alkaline pH. E.g. Vibrio cholerae, the cause of cholera

Large intestine of human contains large number of bacteria. Eg. E.coli

- ✓ There are about 10 bacterial cells for every cell of human body.

1.2 The ecology and uses of bacteria

Importance of bacteria:

- cause disease in plants or animals.** Human diseases caused by bacterial pathogens include tuberculosis, whooping cough, diphtheria, tetanus, gonorrhea, syphilis, pneumonia, cholera and typhoid fever, to name a few.
- **used in many biotechnology (industrial processes).** The biotechnology industry uses bacterial cells for the production of biological substances that are useful to human existence, including fuels,

foods, medicines, hormones, enzymes, proteins, and nucleic acids.

-have great role in recycling of nutrient or biogeochemical cycling.

The role of bacteria and other microorganisms in infectious diseases

Some diseases are caused by invasion of body by **microorganisms**. Organisms that cause disease are called **pathogens**. A disease that is caused by microorganisms infecting the body is called **infectious** or **communicable** disease.

The bacteria that cause these diseases have special structural or biochemical properties that determine their **virulence** or **pathogenicity**. These include:

1. Ability to colonize and invade their host;
2. Ability to resist or withstand the antibacterial defenses of the host;
3. Ability to produce various toxic substances that damage the host.

-Germ theory of disease states that diseases can be caused by microorganisms, which proposed by **Louis Pasteur**. **Robert Koch** and **Joseph lister** are also involved on the development of this theory.

Contribution of Louis Pasteur

- disproved the spontaneous generation theory once and for all.
- Discovered fermentation process.
- Discovered pasteurization process.
- Discovered vaccines.
- identified some microorganisms.

Contribution of Joseph lister

- Discovered disinfection processes. He showed carbolic acid (phenol), disinfectant that prevent infection in bones during surgery.

Contribution of Robert Koch

- He is called father of bacteriology.
- identified many microorganisms that cause diseases.
- provided koch's postulate.

koch's postulate:

- i. The microorganisms must always be present, when the disease present. Should not be present if the disease is not present.
- ii. The microorganisms can be isolated from infected animals (host), and grow in cultures.
- iii. Injecting such cultured microorganisms into healthy host should result in the same disease.
- iv. It should be possible to isolate the microorganisms from this newly diseased host and grow it in culture.

How microorganisms cause diseases?

Different microorganisms cause diseases in different ways.

Bacteria- cause disease by

- i. releasing toxin as they multiply to cause disease in the region of infection or other.
 - ii. Invading and physically damaging tissues.
- Bacterial diseases can be treated with **antibiotics**.

Viruses- causes by

- Disrupting the metabolic system of the cells, the genetic material of the virus become incorporated with the cell and instruct the cell to produce more viruses and finally lyses the cell as they released.
- Viruses cannot be treated with antibiotics because they are not true cells and live inside the immune cells where antibiotic cannot enter.

Fungi- Causes disease by

- i. releasing enzyme that digest the substances in the tissues.
- ii. Physically damaging the tissue as hyphae grow.
- iii. Secreting toxins.

iv. Causing allergic reaction.

Protozoans

-Cause diseases in many different ways.

Transmission of diseases causing microorganisms

-The origin of microorganisms that infect other people is called the **reservoir of infection**.

-**Reservoir of infection** is any person, animal, plant or soil or substance in which an infectious agent normally lives and reproduces.

Reservoirs of infection include:

1. **Human** beings- are reservoir of many diseases, such as common-cold, diphtheria, etc
2. **Animals**- eg. Chickens- reservoir of salmonella, Mosquitoes- reservoir of malaria
3. **soil**- reservoir of tetanus
4. **water**- reservoir for amoeba, cholera, legionnaire's disease, etc
5. **Food**- reservoir for typhoid, etc
6. **Air**- reservoir of pneumonia, TB, etc
7. **Contaminated** objects- reservoir of HIV/AIDS and trachoma

Because there are different reservoirs of disease causing organisms, there are many ways by which disease can be transmitted;

1. **Droplet infections** (Transmit Cough and sneezing). Eg. Respiratory diseases
2. **Drinking contaminated water**; cholera, typhoid, etc.
3. **Eating contaminated food**; salmonella, listeriosis, etc.
4. **Direct contact**; Athlete's foot and ring worm
5. **Sexual contact**; candidiasis, STDs, hepatitis B, etc
6. **Blood to blood contact**; AIDS and hepatitis B when drug users share needles.
7. **Animal vectors**; malaria, sleeping sickness

What other types of diseases are there?

- According to WHO'S definition:

Health is a state of complete "physical, Mental, and social well-being."

Disease is the absence of perfect health, or is a condition with specific case in which parts or all of the body made to function become non-normal or work in less efficient manner.

1. **Human induced diseases**- disease that arises as result of a person's life style or working condition.
Eg. Heart disease and fibrosis

2. **Degenerative diseases**- results from aging process during which the affected tissues deteriorate overtime due to simple 'wear and tear'.eg. Arthritis and Alzheimers

3. **Genetic diseases**- are diseases that result from action of mutated gene.
Eg. Hemophilia and sickle cell anemia

4. **Social disease**- disease that result from social activities and may lead to socially unacceptable behavior. E.g. Drug addiction, STDs, culture shock, etc

5. **Deficiency disease**- results from lack of nutrients in our diet
Eg. Scurvy and kwashiorkor (caused by a lack of protein)

Other categories of diseases

1. **Multifactorial diseases**-condition that affected by the interaction of many factors. Eg. Arteriosclerosis- caused by aging, or deposition of fats on arteries and stress and depression.
2. **Functional diseases**- caused by malfunction of an organ or system without any damage or physical sign of disease in an organ.
Eg. Heart disease, IBS (irritable bowel syndrome), ME (Myalgic Encephalopathy), or chronic fatigue syndrome.

How are bacteria used in industrial process (biotechnology)?

- food and beverage industry
- production of vinegar
- production of antibiotics
- sewage treatment

Food and beverage fermentation

Bacteria and other microorganisms have been used in manufacturing process of:

- bread, alcohol, Irigo (yogurt), cheese, etc.

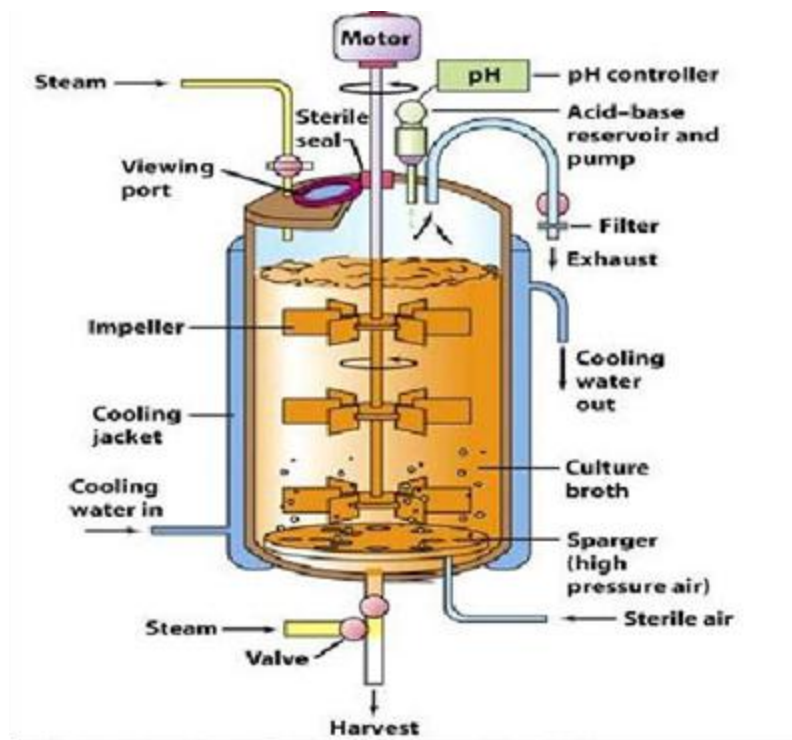
Production of vinegar

- Vinegar is a dilute solution of **ethanoic acid** in water.
- It is used in two main ways
 - to flavor food
 - to preserve food
- Vinegar** is too acidic for microorganisms to grow and multiply, keeping food in vinegar is good way of preserving, w/c is called pickling.
- **Vinegar** is produced by fermenting beer, wine, and cider for second time.
- **Acetobacter** bacteria are used to oxidize alcohol in beer, wine, and cider to ethanoic acid.
- Vinegar** is made in special fermenter w/c is filled with wood shaving and alcohol source is sprayed from the top.
- the alcohol trickles down through the wood shaving, w/c are covered with acetobacter bacteria.
- As the alcohol flow down, the bacteria oxidize it in to ethanoic acid.
- Air is blown in at the bottom to supply oxygen that bacteria need.
- Vinegar produced at the bottom of wood shaving.

Production of antibiotics

- First antibiotics is **pencillin**, made from fungi called **pencillium notatum**
- Antibiotics can be produced using genetically modified bacteria in huge special **fermenter**.
- Genetically modified bacteria are also used to produce
 - human insulin
 - Human growth hormone
 - Enzymes for d/t industries
 - Vaccines, for hepatitis B

Fermenter: is the bioreactor or vat/ tank, vessel in which fermentation occurs.



How bacteria are genetically modified?

- By genetic engineering
- Genes are section of the DNA of an organism that code for a particular protein.
- Gene can be transferred successfully from one organism into bacterium, then genetically modified bacterium will now make the protein that its new gene code for
- **Genetic engineering become possible** because of the development of three techniques
 - i. cutting gene out of DNA molecule using enzymes called **restriction endonuclease**.
 - ii. Inserting and tie gene into another molecule using **ligase enzyme**.
 - iii. Transferring gene into another cells using **Vectors**, such as plasmids, viruses, and gene gun.
- Once a gene has inserted into bacterium, the bacterium become **transgenic** or genetically modified bacterium.

How plants can be genetically modified?

Many crop plants can be genetically modified by inserting foreign gene into them. This gives the plants new traits, such as: - resistant to diseases:

- Resistant to pest
- Longer shelf life
- Faster growth rate
- increase food quality

- Plants can be genetically modified in cellular levels during **cell (tissue) culturing** in laboratory under controlled conditions.
- Genetic engineering of plants becomes difficult to biologist because plant cells do not accept plasmid, as bacteria.
- Biologists discovered **Agrobacterium tumefaciens** bacteria that regularly infect plant cells.
- Agrobacterium, acts as vector to carry genes that have been inserted into bacterium to cells of plants.
- But agrobacterium cannot be used to genetically modify all types of plants.
 - I.e. agrobacterium cannot infect cereals, such as maize.
- To solve this problem, biologists developed a **gene gun** that used to shoot the gene in to cells of plant.

- Gene gun shoots bullets 'tiny pellets of gold' that are covered in DNA.
- Gene gun has made possible to genetically modify some plants such as maize, tobacco, potato, carrots, apple, soya bean, etc.

Sewage treatment

- ✓ All types of sewage treatment depend on the action of microorganisms to oxidize polluting organic present in sewage.

There are two main methods

1. Percolating filter methods
2. Activated sludge methods

1. Percolating filter methods

- First sewage is screened to remove large pieces of debris and then stand in large settlement tank to allow suspended matter settle out.
- The sewage is allowed to trickle through beds of stones, which covered by large number of microorganisms (bacteria, fungi, and protozoa).
- As the sewage trickles through the filter beds, the microorganisms digest the organic matter and absorb the products.
- When the liquid reaches the bottom of the filter bed, polluting organic matter has been removed.
- The treated sewage can be discharged into river.

2. The activated sludge method

- First the sewage is screened and allowed to stand in settlement tank, as in percolating filter method.
- The this is pumped into treatment tank, where
 - i. activated sludge, rich in microorganisms is added
 - ii. Oxygen is blown through mixture.
- In oxygenated mixture, the microorganisms from added activated sludge oxidize the polluting organic matter.
- Some of the sludge formed is recycled to seed tanks.

The role of bacteria in an ecosystem

- ➔ Bacteria play role in recycling of minerals in ecosystem.
- ➔ Many bacteria are decomposers (they breakdown complex molecules into much smaller molecules).
- ➔ Some simpler molecules are absorbed for bacterial metabolism, the other are released to the environment.
- ➔ Elements that recycled, are carbon, Nitrogen, sulphur, and phosphorous

1. Nitrogen cycle

- ✓ The element nitrogen is found in many important organic molecules in all living organisms such as Protein, nucleic acids, and ATP.
- ✓ When organisms die, nitrogen contained by them made to other organisms
- ✓ Several different types of bacteria are involved in the recycling of nitrogens. The role of bacteria in Nitrogen cycle

1. Nitrogen fixation- nitrogen gas is fixed into NO_3 that needed by plants to make protein.

Eg. Rhizobium

2. Ammonification- protein in dead organism and waste of animals are breakdown to release Ammonium (NH_4). Eg. Ammonifying bacteria

3. Nitrification: Occur with two steps.

Eg. Nitrifying bacteria

i. NH_4	Nitrosomonas	→	NO_2
ii. NO_2	Nitrobacter	→	NO_3

4. Denitrification - reduce NO_3 into Nitrogen gas returning nitrogen into air and reducing the amount of nitrogen in the soil.

Eg. Denitrifying bacteria - Pseudomonas

2. Sulphur Cycles

Sulphur is found in fewer types of organic molecules than nitrogen.

- is found in many protein

The role of bacteria in sulphur cycles:

i. Decomposition- sulphur is released from protein of dead matter as H_2S , which give 'the rotten egg' smell.

Eg. Desulphovibrio (Anaerobe)

ii. Oxidation of Hydrogen sulphide- H_2S is oxidized to release sulphur

Eg. Photosynthetic sulphur bacteria (anaerobe)

iii. Oxidation of sulphur - sulphur is oxidized to sulphate ion.

Eg. Non-photosynthetic sulphur bacteria (aerobes)

If the population of bacteria that involved in Nitrogen and sulphur cycle were reduced, then the cycling of these elements could not occur.

1.3 What are Viruses?

Viruses: are acellular or non-cellular particles (virion) consisting of DNA or RNA surrounded by a coat of protein or sheath called **capsid**.

✓ They infect all cellular life including: Bacteria, protists, Fungi, Plants, and Animals.

Virion: is particle of viruses.

Virions lack nucleus, cytoplasm, mitochondria, chloroplast, and ribosome.

Because of lack these organelles, they **cannot** carry out:

- ✓ Respiration and photosynthesis.
- ✓ DNA replication and protein synthesis.
- ✓ Transport (active and passive).
- ✓ Facilitated diffusion

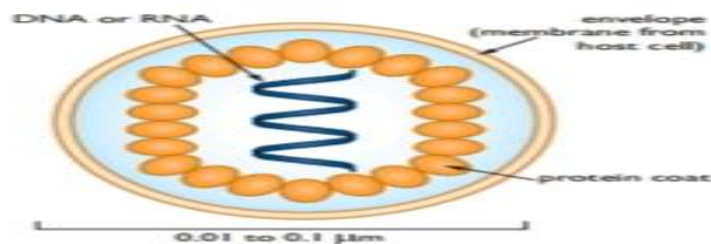


Figure 1.24 The structure of a typical virus

- To carry out such process, when they **hijack** biochemical machinery of host cell.
- They multiply only inside host cell (obligatory) intracellular parasites.
- They are not cell like:
 - Neither prokaryotic nor Eukaryotic.
- Their size is between **0.01-0.1** micro meters.
- Some of them have lipids and proteins made membrane outside capsid
- Others have proteins and enzymes inside capsid.
- a. Viruses that contain membrane around capsid are called **enveloped viruses**. Envelope is derived from host cell membrane during viral multiplication. It provides protection from **dryness**, and helps to attach them to host cell membrane by **spike**.
 - ❖ E.g. Herpes virus, Retrovirus.

- b. Viruses lack envelopes are **non-enveloped viruses**. E.g. Adenovirus, Bacteriophage.
- ✚ **Note: Envelope** is additional layer surrounding protein coat.
- ✚ **Host Range:** is a virus host range of cell type or host sps w/c virus is able to infect, including human, bacteria, fungi, protists and plants.
- ✚ **However,** most viruses are able to infect specific types of cell only one host (host cell specificity).
- ✚ They are often rely on specific attachments to host cells and binding to specific receptor.

Classification of viruses

- ✓ Classified based on morphology (shape), type of organisms they infect and nature of their genetic material.
- ✓ Based on type of organisms they infect, viruses classified into:
 1. Animal –infecting viruses: e.g. Chickenpox.
 2. Bacteria-infecting viruses: e.g. Bacteriophage
 3. Plant-infecting viruses: e.g. Tobacco mosaic virus.
- ✓ Based on types of nucleic acid and strategy for replication, 3 major groups of viruses are:
 1. **DNA VIRUSES**
 - ❖ Have DNA as genetic material. E.g. Herpes simplex w/c causes cold sore, chickenpox, smallpox, adenovirus, and bacteriophage.
 2. **RNA VIRUSES**
 - ❖ Have RNA as genetic material. E.g. H1N1, Ebola, Influenza, Hepatitis, Polio, measles etc.
 3. **Retroviruses:** have RNA as genetic material, but RNA reverse-transcribe into DNA after entering a host cell. The retroviral DNA can then integrate into chromosomal DNA of host cell. E.g. HIV, Human T-cell leukemia virus (blood cancer), Rous sarcoma virus w/c cause tumors in chickens.

Viral multiplication: nucleic acid in virus contains genes for virion's structural components and genes for few of enzymes needed for synthesis of new viruses. However, enzymes needed for protein synthesis, ribosome, tRNA, & energy production supplied by host cell & used for synthesizing of viral proteins & enzymes. To multiply, they invade host cell & take over host's metabolic machinery.

Multiplication of Bacteriophage

- ✓ Bacteriophages multiply by 2 mechanisms:
 - a) The lytic cycle
 - b) Lysogenic cycle
- A. **The Lytic Cycle or T-4 Bacteriophages**
 - ❖ It leads to death of bacterial cell & replication of virus.

Stages:

- I. **Attachment:** virus attaches to host cell membrane through viral spikes.
- II. **Penetration:** virus injects its DNA into bacterium releasing phage lysozyme enzyme to breaks down a portion of cell wall. The capsid remains outside bacterial cell.
- III. **Biosynthesis:** synthesis of viral nucleic acid and proteins. Host protein synthesis is stopped by virus-induced degradation of DNA.
- IV. **Maturation:** bacteriophage DNA & capsids are assembled into complete virus.

V. **Release (lysis):** host cell lyses & new virions are released.

B. The lysogenic cycle:

_It does not cause lyses & death of host cell when they multiply.

-Viral DNA is incorporated into host cell's DNA & phage remains **latent**

-The latent virus multiplies along with host cell until environmental factors trigger viruses.

-when environmental factor triggers virus, viral DNA begins producing viral proteins.

-The whole viruses then assembled.

- Assembled virions leave bacterial cell either by chronic exocytosis from plasma membrane or by lytic process.

HIV AND AIDS

- HIV is retrovirus which has **RNA** as genetic material.
- Surrounded by a coat of fatty acid said to be viral envelop or membrane.
- Made from different type of component. Such as:
 - Enzymes, Glycoprotein, Antigen, Genetic material (RNA), Protein shell, Lipid membrane.
- The spikes structure on the surface of HIV particles are made from:
 - 3 molecules of **GP120** & 1 molecule of **GP41**.
- HIV infects parts of immune system said to be T-helper cells.
- **GP120** of HIV particles bind with **CD4** of T-helper cell to release their RNA

HIV MULTIPLICATION

- After HIV particles has bound to CD4 receptor of T-helper it can be reproduced with in T-cells.
- Three enzymes are required for HIV multiplication.
 1. Reverse transcriptase: used to convert viral RNA to DNA.
RNA-----DNA
 2. Integrase enzyme: used to insert viral DNA into host's DNA.
 3. Protease enzyme: used to assemble viral components into new HIV.

✓ Their Genome replication is:

RNA → DNA → RNA → VIRAL PROTEIN → VIRAL ENZYME → NEW VIRUS

Stages of HIV infection

✓ There are 3 d/t stages of HIV infection.

- I. **Acute stage:** is the initial stage of HIV infection. After HIV infection, the WBC start producing antibody can be used in diagnosis of HIV.
- II. **Latency period:** is the stage when the body replaces the CD4 lymphocyte of T-helper cell as fast as they are destroyed.
- III. **Disease period (AIDS):** AIDS related complex (ARC) can appear. Final stage of HIV infection.

- Number of T-helper cells & antibody production decline when the number of HIV particles increases.
- Because of the reduction in number of T-helper cells, the immune system function reduced & many opportunistic infection including; Pneumonia & TB together cancer like **Kaposi's sarcoma**.

Effect of antiretro viral Drugs

- ✓ AIDS has no cure or vaccines. But, anti-retro viral drugs can be used in slowing down the progression of infection of HIV to AIDS. These drugs are:
 1. **Entry inhibitors:** drugs attach to CD4 of T-helper or GP120 of HIV & prevent their binding together.
 2. **Nucleotide reverse transcriptase inhibitors:** drugs that attach to the nucleotide & prevent reverse transcription to be used by HIV to convert the viral RNA into viral DNA.
 3. **Non-nucleotide reverse transcriptase inhibitors:** drugs that attach to enzyme & prevent the reverse transcription used by HIV to convert viral RNA to viral DNA.
 4. **Protease enzyme inhibitor:** drugs that prevent HIV's protease enzymes from the assembling of viral components into new HIV.

Highly Active Antiretroviral Treatment (HAART)

- ✚ Uses antiretroviral drugs in combination to make an effective treatment against HIV even if it has side effect.
- ✚ HIV mutates (change) into different strain from time to time. Here of it has been difficult to develop the preventing vaccine & curative drug against.

Impact of HIV/ AIDS

- ✚ HIV has social and economic impact on:
 - An individual
 - Family
 - country

Control and prevention of HIV /AIDS

- ✚ The spread of HIV can be reduced by:
 - Responsible sexual behavior
 - Limiting the number of sexual partners
 - Using ABC method-abstain, be faithful, use condom
 - Male circumcision-reduces the risk of males acquiring the disease.

UNIT 2 ECOLOGY

2.1 Cycling matter through ecosystems

Why is it important that materials are recycled?

- ✓ All the organisms in the ecosystem are **interdependent** and **interact with their physical environment**.

- ✓ Ecology is the branch of science that describes the interaction between **different species with each other** and with the **nonliving environment**.
- ✓ Ecosystems look unchanging, but they are in fact always changing.
- ✓ Materials are always being 'moved around' within an ecosystem when organisms are:
 - feed
 - excrete
 - respire
 - breathe
 - die and are decomposed.
- ✓ The molecules that are moved, store large amounts of energy in the bonds holding the atoms together.
- ✓ So, as materials are moved, energy is transferred also.
- ✓ **Decomposers** (**bacteria and fungi**) have key role in returning nutrients to the ecosystem.
- ✓ Decomposers feed by a method known as **saprobiotic** nutrition (feed on dead matter)
- ✓ They secrete enzymes onto the dead matter that digest the complex organic molecules into simpler, smaller ones.
- ✓ But, unlike you, their extracellular digestion does not take place in a gut, it takes place in the soil, or wherever the dead matter happens to be.
- ✓ Micro-organisms absorb these products their extracellular digestion.
- ✓ However, besides **hydrolytic enzymes that break down** complex organic molecules have many enzymes for other purposes.
- ✓ E.g. many of the decomposers have an enzyme that releases the amino group from amino acids and converts it to **ammonia**, by the process of **Ammonification**.

➤ **The main stages in the carbon cycle**

The main processes involved in cycling carbon through ecosystems are:

- **Photosynthesis** – the process that fixes carbon atoms from carbon dioxide into organic compounds (e.g., glucose)
- **Feeding and assimilation** – feeding passes carbon atoms in complex molecules to the next trophic level in the food.
- Assimilated:- become part of the body of that organism
- **Respiration** – releases inorganic carbon dioxide from organic compounds
- **Fossilization** – forming of fossil fuels (e.g. coal, oil, and peat).
- **Combustion** – fossil fuels are burned, releasing carbon dioxide into the atmosphere.

➤ **The main stages in the nitrogen cycle**

- ✓ Nitrogen is found in many biological compounds of proteins, amino acids, DNA, RNA and ATP.
- ✓ The main processes in the Nitrogen cycle are:
 - Plants absorb nitrates from the soil.
 - The nitrates are then used to form amino acids to synthesize proteins.

- The plants are eaten by animals, and then the proteins digested and assimilated into animal proteins.
- Both plants and animals die, & decomposers decay the excretory products and detritus, to release NH_4^+ by Ammonification into the soil.
- Nitrifying bacteria oxidize the ammonium ions to nitrite (NO_2^-) by Nitrosomonas and then to nitrates (NO_3^-) by Nitrobacter by the process called nitrification.
- Denitrifying bacteria reduce nitrate to nitrogen gas that escapes from the soil.
- Nitrogen-fixing bacteria 'fix' nitrogen gas into ammonium ions, in two ways.
 - Nitrogen-fixing bacteria free in the soil reduce nitrogen gas into ammonium ions in the soil (Azotobacter and Klebsiella).
 - Nitrogen-fixing bacteria in nodules on the roots of legumes form ammonium ions to synthesize amino acids (Rhizobium).

➤ phosphorus cycle

- ✓ Phosphorus is present in organisms in the form of phosphates.
 - Phosphate is absorbed from the soil (or water) by plants
 - These are passed along food chains to various herbivores and carnivores.
 - Their dead bodies are decomposed and phosphate ions are released from *phospholipids, ATP, DNA and RNA and returned to the soil or water*
 - Phosphates also enter the soil (or water) as a result of the weathering of rocks and form fertilizers.
 - Over millions of years, phosphate ions can leach into the seas and become part of newly forming sedimentary rock.

➤ Sulphur recycles

- ✓ The core cycle is between the soil, plants, animals, and special decomposers.
 - Sulphate ions in the soil are taken up by plants (sulphur-containing amino acids, such as methionine and cysteine).
 - these are passed to animals by feeding and digestion
 - On death of the plants and animals, *Desulphovibrio bacteria* release the sulphur in the proteins in the form of hydrogen sulphide (H_2S) in anaerobic conditions.

In some aquatic environments the H_2S is oxidized to sulphur(S) by *photosynthetic sulphur bacteria* $[2\text{H}_2\text{S} + \text{CO}_2 \rightarrow (\text{CH}_2\text{O}) + \text{H}_2\text{O} + 2\text{S}]$

- Sulphur bacteria, (Thiobacillus), oxidize the hydrogen sulphide (sulphur) to sulphate (SO_4^{2-}), with an intermediate sulphite (SO_3^{2-}) in aerobic conditions.
- Sulphur can also become incorporated in rocks that yield fossil fuels.
- Combustion of fossil fuels oxidizes the sulphur to sulphur dioxide (SO_2) for pollutant atm and the formation of acid rain.
- in the atmosphere, the sulphur dioxide becomes oxidized to sulphite and sulphate which dissolve in rainwater to form a mixture of sulphurous and sulphuric acid: acid rain

➤ The water cycle

- ✓ Water is essential to all living organisms in all kinds of ways:

- It makes up 70% of all cells.
- It is an essential requirement of photosynthesis.
- It is the basis of all transport systems in organisms.
- It provides a means of removing excretory products.

✓ **In addition, in our daily lives:**

- To wash our clothes & others
- To flush away waste
- To make products such as paper, steel and beer.
- To generate electricity.
- In a system, called 'hydroponics', to grow plants in a soil-free medium.

2.2 Ecological succession

- ✓ Succession the process where one ecosystem replaces another ecosystem.
- ✓ The ecosystems that exist today did not always exist.
- ✓ They have developed from other previous systems by **succession**.
- First began on completely bare ground (Bare rock).
- Very soon, lichens can be seen growing on the surface of the rock & resilient organisms (are able to recover easily & quickly) called **pioneer species**.
- The living lichens grow into the rock causing it to crumble.
- When the lichens die, decomposers act on the remains to release mineral ions into the crumbled rock.
- The mixture of dead remains, crumbled rock, and mineral ions forms a primitive soil.
- This less harsh environment is suitable for mosses.

So, spores of mosses can now 'germinate', grow, and continue.

- **Bare Rock** → **lichen, mosses stage** → **annual herb stage** → **perennial herb stage** → **scrubs stage** → **forest stage**
 - The various stages in a succession are called **seres**.
 - The final, most complex, state of a succession is the **climax community**.

➤ The essence of succession:

- Organisms colonize an area.
- They change the abiotic conditions in the area.
- This allows other species to colonize the area.
- The new species compete with there before and become dominant.
- They also then change the abiotic conditions, and the process continues.

➤ The following trends occur in any succession

- The total biomass of the community increases.
- The species diversity increases.
- The number of ecological niches increases.
- Food webs become more complex.
- The community becomes more stable

- A lake or pond can undergo a succession that results in the water being replaced by sediments allowing land plants to grow.
- Both successions end with the same climax.
- Because the first takes place from rock it is called a *xerosere*.
- The second, starting from water, is a *hydrosere*
- Where a succession starts from bare, ground, or from a newly formed pond with no life, called a *primary succession*.
- Sometimes, communities are destroyed by fire or a farmer or some other human intervention, then a new succession in such area is said to be a *secondary succession*.
- Secondary successions to the original climax are usually much quicker than primary successions. because:
 - the succession is not starting from bare rock/open water
 - the soil is already present

➤ **Different areas have different climax communities**

Factors that could influence the type of climax community formed include:

- Temperature
- Precipitation (rainfall)
- The presence of grazing animals
- Soil type
- Soil depth.

2.3 Biome

Biome: Is geographical or regional area with specific:

_climate, plants, soil, and animals

_is a region of the earth characterized by distinct zone of life

Temperature & Precipitation: is the most significant factors of climate in determining biome types.

_ There are 2 major types of biomes such as:

1. Terrestrial biomes &
2. Aquatic biomes

I. Terrestrial biomes: are biomes that consisting of an area of lands defined by several factors:

_ Temp., precipitation (rainfall), Plants (flora), Animals (Fauna), Soil type (edaphic factor).

Characteristics of terrestrial factors

No	Biomes	Precipitation	Temp	Soil	Plant	Animal
1	Hot desert	Almost none	Hot	Poor	Sparse-succulents (cacti), sage brush	Sparse-insects, arachnids, reptiles & birds
2	Cold desert	Almost none	Cold	Poor	Sparse-microorganisms & some Lichens	Sparse-polar bears, seals
3	Thorn forest (shrubs)	_Dry summer, rainy winter	Hot summer, cool winter	Poor	Shrubs, some woodland like scrub oak	Drought-& fire adapted animals
4	Tundra	Dry	Cold	Permafrost (frozen soil)	Lichens & mosses	Migrating animals
5	Boreal(Taiga) Forest	Adequate	Cool year round	Poor, rocky soil	Conifers	Many mammals, birds, reptiles insects, arachnids
6	Temperate deciduous forest	“	Cool season & warm season	Fertile soil	Deciduous trees	Many mammals, birds, reptiles, insects etc.
7	Tropical Montane forest	8_9 wet months, air always humid	Always warm	Fertile soil	Ferns, large deciduous trees, epiphytes	Many animals
8	Tropical rain forest	Very wet	Always warm	Poor, thin soil	Many plants, epiphytes common	Many animals

- The moisture portion of western high lands consists of the tropical montane vegetation with:
 - Dense, Luxuriant forest, rich under growth.
 - Higher annual rainfall but lower Temperature.
- The drier sections at lower elevation of western & eastern elevation of montane forests are mixed with grassland.
- However the temperate grass land covers the higher altitude of western & eastern high lands.
- The tropical dry forest found in rift valley & low land together with some dry grass land contains the portion of Danakil. The reason why high species richness of plants & animals are observed in Ethiopia b/c there are several biomes with in country.

2. **Aquatic Biomes**: are biomes where life exists from the top of the sea to bottom of sea.

Can be classified as:

- a) Marine biomes
- b) Fresh water biomes

Biome	Salt content	Moving or standing	Other feature	Animals and plants
Marine:				
oceanic, pelagic	High	Moving	The region of the ocean where light penetrates	Many fish, mammals and plankton
oceanic, abyssal	High	Less movement	The region of the ocean where no light penetrates	Angler fish, sulphur bacteria at vents
Coral reef	High	Moving	Most diverse of all marine habitats. Have many strata like a rainforest.	Corals, many fish, many seaweeds
Estuarine	Intermediate	Extreme movement	Unique habitat due to mixing of saltwater and fresh water	Shore birds, fish, crabs, mangroves, kelps, sea grass
Fresh water:				
Ponds and lakes	Fresh water	Standing	Are stratified as top layer absorbs more heat and light	Large numbers of plankton, plants and animals in top layer
Streams and rivers	Fresh water	Moving	Water is highly oxygenated	Algae, plankton, plants and fish
Wetlands	Fresh water	Standing	Water is very nutrient rich	Many plants and animals – highest of all aquatic biomes

2.4 Biodiversity

Biodiversity: refers to the number, variety, & variability of living organisms (plants, animals, & microbes).

- ✓ Is the species richness.
- ✓ It is seen at level of Gene, species, culture & ecosystem.
- ✓ Can increase when:
 - New species created
 - New genetic variations of species produced.
 - New ecosystem formed.

Components of biodiversity:

- It is measured by 4 elements such as:
 - 1) **Species diversity:** is refers to the variety of species in a region.
 - Can be measured by elements such as:
 - a. **Species richness:** is the total number of species in a defined area.
 - b. **Species abundance:** is the relative number among species.
 - c. **Taxonomic diversity:** is the variation of species from each other in their distribution like family, order, classes, genera, & phyla.
 - 2) **Genetic diversity:** is the variation of genes of species based on the DNA.

3) **Culture diversity**: is manifested by diversity in terms of:

- Language
- Land management practice
- Social structure etc.

Ecosystem diversity: is the broad difference between ecosystem type, diversity habitat, & ecological processing occurring within an area.

Index of diversity: is the number indicating biodiversity of an ecosystem

It is used to calculate species diversity. One index of diversity (d) is **Simpson's index** diversity. It can be calculated by formula:

$$d = \frac{N(N-1)}{\sum n(n-1)}$$

where d = index of diversity

N = Total number of organisms in an area

n = total number of organisms of each species in an area

The higher value of index of diversity shows that:

- high species diversity
- A number of successful species to be formed.
- Ecosystem becomes more stable.
- The environmental factor is likely to be less hostile
- More ecological niches to be found.

The low value of index of diversity shows that:

- Low species diversity.
- Ecosystem becomes less stable, only in-dominant species.
- The environmental factor is likely to be more hostile.
- Less ecological niches to be found.

Human influence on biodiversity

- Human affected biodiversity in two ways such as:

- ✚ Deforestation
- ✚ Agriculture

Deforestation: is the process of destruction of forests.

- Forests are cleared to make land ready for:
 - ✚ Mining
 - ✚ Agriculture
 - ✚ Construction
- They are also needed to obtain timber from forest to make:
Paper, furniture, charcoal

Tropical rainforest: is the most complex & species richness of ecosystem.

- ✓ Even though many trees are very tall, the root systems are shallow & trees can easily fall.
- ✓ The root systems grow shallow in nutrient poor soils.
- ✓ Soils are poor in nutrients because many mineral ions from soils remain **locked up** in the huge trees.
- ✓ The only recycling of nutrients that occur on a regular basis takes place when leaves fall.
- ✓ There is no accumulation of detritus as decomposers rapidly break down the leaves to release the mineral ions they contain.
- ✓ The roots take up most of mineral ions & leaving few mineral ions in the soil

Effect of agriculture on biodiversity

- ✓ The large areas of land are given over to the production of one crops plant.
- ✓ This brings about the reduction of biodiversity for several reasons.

These are:

- ✓ The area is dominated by one species reduces the number of niches for organisms to fill.
- ✓ The organisms that lives there are considered as pest as they reduce the productive yield.
- ✓ They are controlled by use of pesticide.
- ✓ Hedgerows are removed from area to create bigger & more productive yield. This causes the production of the number of habitat, niches, & biodiversity of an area.

Biodiversity in Africa

There are high floras & fauna in Africa as plants provide the number of habitat & niches for mammals.

Africa has:

- ✓ 1/4th of the world's mammal species about 1229 out of 4700.
- ✓ 900 mammals species found in SSA (sub-Saharan Africa).
- ✓ 137 mammals species found in Madagascar.
- ✓ 79 antelope species found in eastern & southern Africa.
- ✓ 1/5th of world's birds species in Africa 2000 out of 2000.
- ✓ 1600 birds are endemic to SSA.
- ✓ 950 Amphibian species found in Africa.
- ✓ Therefore, Africa & South America is the continent of the highest number of Amphibians.
- ✓ Ethiopian has better biodiversity than most of African countries except Kenya & Democratic Congo.
- ✓ Different climate & altitude give **different biomes** which lead to high biodiversity.
- ✓ Ethiopia is one of the 12 centers of the origin of some cultivated crops called **Vavilov's centers**.
- ✓ 11 of them have genetic diversity centers in Ethiopia. These are:
 1. Coffea Arabica- coffee
 2. Eragrostis teff – Teff
 3. Ensete ventriculatum- Enset
 4. Coccinia Abyssinica- Anchote
 5. Guizotia Abyssinica- Niger seed-Nug
 6. Brassica carinata – Ethiopian rape -Gomenzer.
 7. Carthamus tinctorius – sunflower- suf.

8. Ricinus communis- Castor bean – Gulo.
9. Sorghum Spp. – sorghum
10. Hordeum Spp. – Barley
11. Linum usitatissimum- Linseed – Telba.

Forage plants or crops: are used as animal feed in Ethiopia.

- ✓ 46 endemic species of legumes are important as forage plant used to increase fertility of soil.
- ✓ 6500-6700 plant species found in Ethiopia out of these 1156 (10- 12%) are endemic.

Vertebrate diversity of Ethiopia

Vertebrate group	Order	Family	Genera	Species	Endemic
Mammals	12	40	144	277	22
Birds	24	87	306	861	27
Reptiles	4	15	36	78	3
Amphibians	5	7	19	63	17
Fish	5	14	33	101	4

Direct effect of humans practice on biodiversity

- ✓ Deforestation, fuel wood collection, & illegal logging.
- ✓ Over grazing by stock mammals.
- ✓ Over hunting reduces number of species hunted.
- ✓ Introduction of improved variety decreases genetic diversity as the only improved variety is used.
- ✓ Introduction of alien invasive species- these often out compete native species for the available resources & make themselves extinct locally.

Indirect effect of humans practice on biodiversity

- ✓ High population growth.
- ✓ Under valuation of biodiversity resource by governmental body.
- ✓ Promotion of unsustainable exploitation resource by legal & institutional system.
- ✓ Disregard of traditional communal land management system.

Biodiversity loss concern

According to millennium assessment findings, biodiversity loss contributes to:

- ✓ Worsening health,
- ✓ Decreasing food security
- ✓ Worsening social relation.
- ✓ Increasing of vulnerability.
- ✓ Less freedom of choice & action.

- ✓ Low material wealth.

The important of ecosystem for humans

- ✓ Supporting of recycling nutrient, soil formation, & primary production.
- ✓ Providing food, fresh water, wood, fibers, & fuel.
- ✓ Regulation of climate, floods, & disease.
- ✓ Supporting of culture value like spiritual, educational, & recreational.

Conservation of biodiversity:

Conservation: is the maintenance & sustainable use of resources including preservation & restoration of ecosystem. However, we are losing 10% of our biodiversity in every 50years.

Action is needed at individual, local, regional, national, & international level to conserve biodiversity.

In 2005, the Ethiopia institution of biodiversity conservation in Addis Ababa put forward a national of biodiversity action plan based on,

- ✓ Ecological consideration
- ✓ Socio-economic

Types of conservation

They are two major types of conservation.

- In situ conservation:** is the conservation of genetic resources with in natural ecosystem in w/c they occur. E.g. National parks, biosphere, reserves, Sanctuary managed resource of nature.
- Ex-situ conservation:** is the conservation of genetic resource outside of natural ecosystem in w/c they occur. E.g. Zoo, captive breeding, aquarium, botanical garden, and gene bank..

There are 3 guiding ideas of conservation:

- ✓ Research
- ✓ Minimum intervention
- ✓ Repair rather than replace.

Ecological principles of conservation:

- ✓ Biodiversity is supported by protection of any species. Habitat maintenance is fundamental to species conserved.
- ✓ Large areas contain more species than smaller areas with similar habitat.
- ✓ Disturbance of habitat is reshaping of ecosystem.
- ✓ Climatic change will affect all of ecosystem.
- ✓ Person who is planted a key stone indigenous of trees called **Ficus vasta Forssk** at his center indigenous of tree propagation to enhance biodiversity development in Ethiopia is said to be **Professor Legesse Nagesh**.

2.5 Population

Population: is the groups of closely related organisms that can be freely interbreed & live together.

- ✓ Consists of all individuals of a species in particular habitat at specific time.
 - ✓ **Habitat** is place where population lives & obtains resources it need within its geographical range.
 - ✓ **Geographical range:** is the part of earth where a species live.
 - ✓ **Ecological niches:** is the role of population with in its habitat.
 - ✓ Several populations can live together in the same area because each exploits different habitat & different niches.
- E.g. - Phytoplankton **exploits open H₂O of pond**.
 -Decomposers inhabit detritus found at the bottom of pond.
- ✓ Basically, two species cannot occupy the same niches.
 - ✓ If they do so, one species compete with another & makes it extinct is said to be competitive exclusive principles.

Factors affecting population size

The number of population affected by:

- Natality – refers to birth rate
- Mortality – refers to death rate
- Migration – movement of population from an area to another. Divided into 2.
 - a) Immigration – is the movement of population into an area.
 - b) Emigration – is the movement of population out of an area.

Other factors controlling population sizes

1. **Abiotic factors:** are physical or environmental factors including
 - Light -CO₂ & O₂ concentration. – Physical space & nutrient
 - Temp - soil type
2. **Biotic factors:** refers to the effects onto a given population from other organisms of the same or d/t species. Some of them are:
 - a. **Predators:** are the presences of carnivores for animals or herbivores for plants.
 - Are larger sizes of organisms hunting the smaller sizes of organisms (prey).
 - b. **Disease:** causing organisms or pathogen can reduce the productivity age of population by causing fatal.
 - c. **Intra-specific competition:** is the competition between the members of the same species for the same resources in the same habitat. E.g. many human families occupying in a small plot land.
 - d. **Inter-specific competition:** is the competition between the different members of the same species for the same resources in the same habitat. E.g. Ethiopian wolves & domestic dogs hunting rats.

Population Growth

- All population shows the same pattern of the growth rate.
 - There are two types of population growth rate, such as
1. **Arithmetic growth rate:** number of population increases by fixed amount in each period of times.
 E.g.: 5, 10, 15, 20, 25...
 - Produces the uniform growth rate over time.
 2. **Exponential growth rate:** number of population's double in each period of times.
 E.g. 10, 20, 40, 80--which producing an ever-increasing rate over time.

Phases of population growth curve

There are 4 phases of population growth

- a. **Lag-phase:** population is adapted to the environment to reproduce but some organisms are not adapted to environment & then die.
 - Numbers of populations are static or slow or increase.
- b. **Log- phase:** all population is adapted & they reproduce rapidly due to plentiful resources.
 - Numbers of population are increasing rapidly.
 - Number of birth is rate of population is greater than the number of the death rate.
- c. **Stationary phase:** carrying capacity is reached.

Carrying capacity- is the stability of the population sizes at a certain time.

- Is determined by biotic & abiotic factors of environment.
- **Limiting factors-** decreased nutrients accumulation of toxic waste products & restricting living space begins to slow growth rate.
- **Number of birth rate & death rate are equal.**
- d. **Decline phase:** over uses of resources & highly accumulation of toxic substance cause decline in number of population.
 - Number of death rate is greater than the number of birth rate.

Human population

- Their stages of development of human population of a country can be denoted in the demographic transition in which it changes from the pre-agriculture society to
 - ✚ Industrial society
 - ✚ Post-industrial society
 - ✚ Human populations are subjected to factors affecting its development
 - ✚ These include the points at which the country or region develops agriculture & industrialization that affect:
- ❖ Birth rate
- ❖ Death rate
- ❖ Life expectance
- **Demographic transition:** model that explains the transformation of the country from having:
 - ✓ High birth rate & death rate
 - ✓ Low birth rate & death rate

Age pyramids of populations:

- Are pyramids that show the % of males & females in each age group of population.
- Can include:
 - Expanding age pyramid
 - Stationary age pyramid
 - Contracting age pyramid
- Rapid population growth can be controlled by:
 - Contraception programmed
 - Education about sex
 - **Best provision of resources to agriculture**

UNIT 3 GENETICS

3.1 Genetic crosses

Genetics: is a science of inheritance which study about variation & heredity among the offspring & their parents.

Variation: is the difference among offspring & their parents.

Heredity: is the similarity among offspring & their parents.

The elements of variation & heredity of the living organisms said to be genes.

- Genetics determine the way in w/c traits are transmitted from one generation to next.
- It concerned with the unit of inheritance or genes.

The relationship between alleles, genes, DNA & chromosomes

- ❖ **Alleles**:- are alternative form of gene.
 - are d/t version of the same genes.
 - occupy the same locus on the homologous chromosomes.
- ❖ **Locus**: is the position or location of the genes on the chromosomes.
- ❖ **Genes**: is the section of DNA or chromosomes to determine the characteristic of organisms - is the sequence of base or nucleotide in DNA or RNA molecules.
- ❖ **Chromosomes**: -are long threads like structure which is responsible for transmission of genetic information
 - are wrapped around histone protein.
 - Made of DNA & histone protein.
 - Store genes

DNA + Histone protein $\longrightarrow$ Chromatids $\longrightarrow$ chromosomes

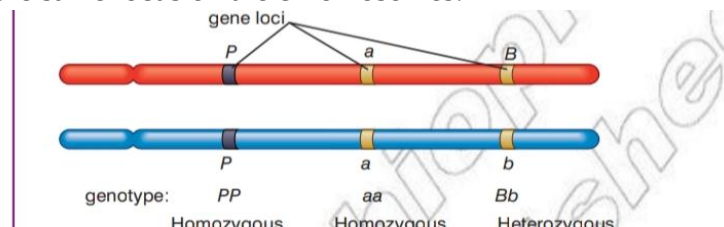
Maternal and Paternal Chromosomes

- Sexually reproducing organisms receive one set of chromosomes from their parents (male & females). E.g. in each human cell, there are 46 number of chromosomes, 23 chromosomes are coming from mother and called **maternal chromosomes** & 23 chromosomes are coming from father called and **Paternal chromosomes**.
- The maternal & paternal chromosomes come together during fertilization to form **homologous pairs**.

Homologous and Non- homologous chromosomes

1) **Homologous Chromosomes**:

- ✓ Are chromosomes come in pair
- ✓ Are structurally & functionally similar chromosomes because they carry the same gene at the same locus on the chromosomes.



2) **Non- homologous chromosomes**:

- ✓ Are structurally & functionally different chromosomes because they carry different genes at the same locus on the chromosomes.
- ✓ **Homozygous organism**: have similar alleles for a particular gene on the homologous pair.

- ✓ **Heterozygous organisms**: have different alleles for a particular gene on the homologous pair.

Genotype and Phenotype

Genotype: is genetic composition or internal expression of organisms for a given trait.

- Is an internal appearance of organisms
E.g. AA, BB, Aa, Bb, DD, Dd etc.

Phenotype: is the physical or external appearance of organisms.

- Is an observable characteristic of organisms resulting from an interaction between genotype and environment
E.g. Phenotype = shape, height, color etc.

How do we predict ratios in a monohybrid cross?

-Monohybrid cross- is a genetic cross or breeding situation that relates to just one trait or feature.

Gregor Mendel

Gregor Mendel is said to be the father of genetics because he showed the law & mechanisms of inheritance in eukaryotic organisms. He discovered rules by which genes are inherited

- He used garden pea plant & breed to show mechanism of inheritance in his monastery garden.

- When he conducted his experiment, Mendel selected the pea plants due to their 5 major characteristics such as:

- Produce large number of seed.
- Easily cultivated.
- Have short life cycle or short period of generation.
- Are self & cross-pollinated plants.
- Have several contrasting traits.

Techniques of Mendel breeding

-Mendel allowed self-pollination & fertilization of different lines of garden pea plants.

-**Pure (true) breeders**- are organisms that are homozygous for any given genotype which produce the same phenotype.

E.g. - Parent phenotype: Tall x Short

-P1 genotype TT x tt
 -P1 gametes T \ T t / t

x	T	T
t	Tt	Tt
t	Tt	Tt

- All F1 -first filial generation produced from P1- Phenotype- all (100%) are **tall**
- Genotype -all (100%) are **Tt**

- Mendel used the same producers for all contrasting traits or characters which include:

1. Removed stamen from purple flowered plant to prevent self-pollination.
2. Used a paint brush to transfer pollen grain from white flowered to carpel of purple flower.
3. Then, pollinated carpel produces the pea pod containing several pea seeds.
4. He collected & grew all seeds from all pods.
5. When plants were mature. He noted the color of their flower.

- He also carried out reciprocal crosses. In this case he also pollinated white-flowered plants with pollen from purple-flowered plants.

- When he analyzed his data, he formulated **four** concepts such as:

- a) Concept of unit character or trait
- b) “ “ Dominance and Recessive
- c) “ “ law of Segregation
- d) “ “ Law of independent assortment.

1. Concept of unit character

-Every trait such as seed shape, color, flower color, position, pod shape, color, & height tall or short are controlled by heritable **factors** called **genes**.

-Mendel factors or unit character is called genes.

Unit character	Dominant trait x Recessive trait	F1 generation	F2 generation
Seed shape	Round x Wrinkled	All round	3:1
Seed color	Yellow x Green	All yellow	3:1
Flower position	Axial x Terminal	All axial	3:1
Flower color	Purple x White	All purple	3:1
Pod shape	Constricted x Smooth	All constricted	3:1
Pod flower	Green x Yellow	All green	3:1
Height	Tall x Short	All tall	3:1

2. The concept of dominance and recessive

- **Dominant traits:** traits that mask the effect of other and express itself in organism's appearance.
- If two alleles in organisms are different one is dominant & the other is recessive.
 e.g. Tt- T- is dominant allele and t- is recessive allele.

- Dominant alleles represented by capital letter & recessive alleles represented by small letter

- **Recessive traits:** traits that is controlled by recessive alleles. Expressed only when appear together in homozygous E.g. tt

3. **The concept of law of segregation:**

- Law of segregation: states that contrasting of factors or alleles separate to produce gamete or sex cell. Segregation means separation of gametes.
- Any single gamete receives only one allele for trait.
- Physical link between generation is said to be gamete.
- Is applied only for monohybrid cross.

e.g. Considering cross-breeding of one trait of flower position

- P1-phenotype-of F1- Axial x Terminal

- P1- genotype of F1- AA x aa

- P1- gamete of F1 A, A a, a

x	A	A
a	Aa	Aa
a	Aa	Aa

-All Phenotype of F1- axial 100%

-Genotype of F1- Aa (100% Aa)

Dihybrid test cross

Round, yellow seed X Wrinkled, green

RRYY X rryy

Gametes RY, ry, Ry, rY

	RY	ry	Ry	rY
RY	RRYY	RrYy	RRYy	RrYY
ry	RrYy	rryy	Rryy	rrYy
Ry	RRYy	Rryy	RRyy	RrYy
rY	RrYY	rrYy	RrYy	rrYY

Round and yellow 9

Round and green 3

Wrinkled and yellow 3

Wrinkled and green 1

Phenotypic ratio = 9:3:3:1

Genotypic ratio = 1:4:2:2:1:2:1:1

✓ There are more possibilities than in monohybrid inheritance

- homozygous for both features – **RRYY**
- heterozygous for both features – **RrYy**
- heterozygous for one feature but not the other – **RRYy** or **RrYY**

Back cross with rryy

- ✓ If the plants produced show all four possible phenotypes, the original was heterozygous for both features.
- ✓ If the plants produced all had round, yellow seeds, the original was homozygous for both features.
- ✓ If the plants produced all had round seeds but some had green and some had yellow seeds, the original was heterozygous for seed color only.
- ✓ If the plants produced all have yellow seeds but some are round and some wrinkled, the original was heterozygous for seed shape only.

❖ Are alleles always simply dominant or recessive?

- ✓ The short answer is no.
- ✓ it may be co-dominant or incomplete dominant
 - **Incomplete dominance:** when the heterozygous shows an intermediate phenotype
 - **Co-dominance:** a type of inheritance in which two versions (alleles) of the same gene are expressed separately to yield different traits in an individual.
- ✓ Example incomplete dominance in the flower color of snapdragons (sweet pea plant)
- ✓ The possible genotypes are:
 - RR – plants with red flowers.
 - rr – plants with white flowers.
 - Rr – plants with pink flowers.
- ✓ The genotype & phenotype have the same 1:2:1 ratio.

❖ Are there always two alleles of a gene?

- ✓ Some genes have more than two alleles called **multiple allele inheritance**. Basic rules are just the same. These alleles can be **dominant** or **recessive** or co **dominant**.
- ✓ An example of multiple allele inheritance occurs in the inheritance of the ABO blood groups.
- ✓ In the ABO blood grouping system, there are four blood groups, determined by the presence or absence of two antigens (A and B) on the surface of the red blood cells.
- ✓ There are three alleles involved in the inheritance of these blood groups:
 - I^A , which determines the production of the A antigen
 - I^B , which determines the production of the B antigen
 - I^O , which determines that neither antigen is produced
 Alleles I^A and I^B are codominant, but I^O is recessive to both
- ✓ The possible genotypes and phenotypes (blood groups) are shown below.

Genotype	Blood group
$I^A I^A$, $I^A I^O$	A
$I^B I^B$, $I^B I^O$	B
$I^A I^B$	AB
$I^O I^O$	O

It is possible for two parents, with blood groups A and B, to have four children, each with a different blood group!

	Father	Mother	
Parents	$I^A I^O$	$I^B I^O$	Both are heterozygous, but for different blood groups
Sex cells	I^A or I^O	I^B or I^O	Parents can make two types of gametes in equal

numbers, each with one allele

		Male sex cell	
		I^A 1/2	I^O 1/2
Female sex cell	$I^B I^O$ (1/2)	$I^A I^B$ (1/4)	$I^B I^O$ (1/4)
	I^O (1/2)	$I^A I^O$ (1/4)	$I^O I^O$ (1/4)

Figure 3.16 how the four offspring of parents with blood groups A and B can all have different blood groups

Did you know? Although the gene may have more than two alleles, because they are alleles of the same gene, any individual will still only have a maximum of two of the alleles. This is because the different alleles are found at the same locus (position) on homologous chromosomes. Because there are only two copies of each chromosome, the person can only have two alleles of the gene

Other examples of codominance when 'red' cattle (homozygous for the red allele) are bred with white cattle (homozygous for the white allele), the offspring are heterozygous and have patches of red and patches of white skin. They are called roan cattle

Two of the alleles that determine our ABO blood group are **codominant**.

What is the physical basis for these patterns of inheritance?

We began this chapter by pointing out that a gene is a part of a chromosome. For gametes to be formed, special cells in the sex organs of the organism divide by a process known as **meiosis**. When a cell divides in this manner, there are three key outcomes:

- ✓ It produces four 'daughter' cells
 - ✓ These daughter cells have only half the number of chromosomes of the original cell; they have one chromosome from each homologous pair
 - ✓ the daughter cells show genetic variation
- **meiosis**- the process by which a cell divides to form haploid gametes
 - **homologous chromosomes**- chromosomes that carry genes for the same feature at the same loci (in the same places)
 - **chromatid**- when a eukaryotic cell divides during meiosis, each of its chromosomes divides into two chromatids
 - **haploid**- a haploid cell, usually a gamete, has a single set of chromosomes instead of homologous pairs
 - **diploid**- a diploid cell has homologous pairs of chromosomes
 - **bivalent**- a pair of homologous chromosomes

- A cell does not normally divide to produce **four cells – it produces two.**
- Therefore, meiosis must entail two divisions **called meiosis I and meiosis II**
- at the start of the process, each chromosome is a double structure; it is made of two **chromatids** held together by a **centromere**
- **Synapsis**: pairing of homologous chromosomes
- This is because the DNA in each chromosome replicated prior to **meiosis commencing.**
- Before any division takes place, chromatids from different chromosomes in the homologous pair undergo ‘**crossing over**’ and exchange sections of DNA.
- **Meiosis I** follows and the two chromosomes that make up the pair are separated into different cells.
- **In meiosis II**, the two chromatids that make up each chromosome are separated into separate cells.
- Because of crossing over, **none of these chromatids are the same.**
- There is **genetic variation in the daughter cells,**
- **Four haploid** cells produced
- With just **two bivalents**, there are two possible arrangements and two different sets of gametes. **With 23 pairs of chromosomes, there are 2^{22} different combinations**
- Each bivalent aligns itself independently of the others. This is called **independent assortment** and is an important source of genetic variation in the gametes produced by meiosis.
- **Sister chromatid** -chromatids from the same chromosome; they have the same alleles in the same sequence
- **Non-sister chromatid** -chromatids from different chromosomes of a homologous pair; although the genes are the same and at the same loci, the alleles may be different
- **Cytokinesis** -the process that leads up to the cell dividing into two during meiosis

The main stages of meiosis

Meiosis I: It is divided into four phases:

- **Interphase**- chromosomes duplicate
- **Prophase** - homologous chromosomes pair and exchange segments
- **Metaphase** - tetrads line up
- **Anaphase- pairs** of homologous chromosomes split up
- **Telophase**- two haploid cells form; chromosomes are still double

After telophase there is cytokinesis.

Cytokinesis: the process that leads up to the cell dividing into two during meiosis

Meiosis II: It is divided into the same four phases, but there are some important differences:

- ✓ there is no crossing over in prophase
- ✓ the chromosomes line up side by side in metaphase
- ✓ chromatids are separated in anaphase

What about alleles that don't segregate at gamete formation – genetic linkage

- Mendel was very fortunate in his choice of organisms with which to experiment.
- All the alleles of all the genes did segregate.
- But this does not always happen; some genes inherited together with other genes – they exhibit **linkage**. The genes are linked and inherited together because they are on the same chromosome.
- The earliest 1900s study of linkage was carried out by two British geneticists, Bateson and Punnett (who also devised the Punnett square).
- William Bateson and R. C. Punnett were studying inheritance in the sweet pea. They studied two genes: one affecting flower color (*P*, purple, and *p*, red) and the other affecting the shape of pollen grains (*L*, long, and *l*, round).

-They crossed pure lines ***P/P · L/L*** (purple, long) × ***p/p · l/l*** (red, round),

$$\begin{array}{cc} PL/PL & \times & pl/pl \\ PL & \times & pl \end{array}$$

-and selfed the E_1 ***PL/pl*** heterozygotes to obtain an F_2 and shows the proportions of each **phenotype** in the F_2 plants.

	<i>PL</i>	<i>pl</i>
<i>PL</i>	<i>PL/PL</i> Purpl long	<i>PL/pl</i> Purpl long
<i>pl</i>	<i>PL/pl</i> Purple long	<i>pl/pl</i> Red round

- We now predict not a 9:3:3:1 ratio, but a 3:1 ratio of purple-flowered, long-seeded plants to red-flowered, round-seeded plants.

What we might have expected from a 9:3:3:1 ratio is:

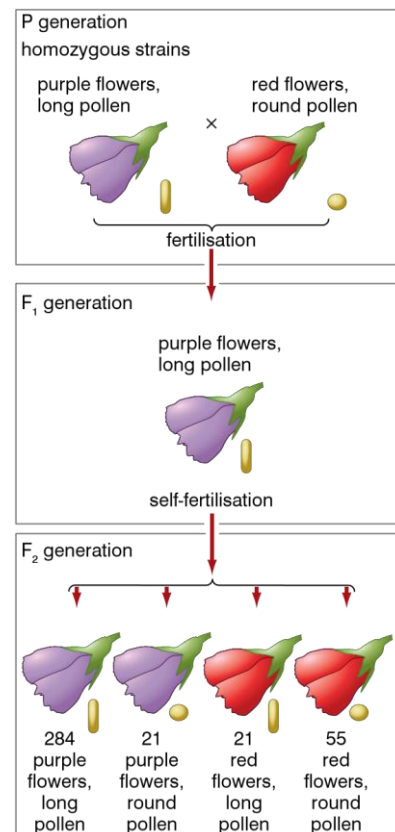
- 215 purple, long
- 71 purple, round
- 71 red, long
- 24 red, round

and from a 3:1 ratio:

- 286 purple, long
- 95 red, round

-The reason we do not get either is because the genes are **linked**,

-but there is some **crossing** over between them during **prophase of meiosis I**.



-This produces the types we *would not expect from linked inheritance*. These types are called *recombinant types*.

- Early research on *crossing over* and *recombination* was carried out using *fruit flies*. They are convenient experimental animals because:
 - small animals with a short life cycle (just two weeks)
 - cheap and easy to breed and keep in large numbers
 - they have only 4 pairs of chromosomes, per cell
 - the chromosomes, are large and easily observed
 - staining reveals dark bands which correspond to particular genes

Early 1900s, *Thomas Morgan* was able to prove, that genes carried on chromosomes are the physical basis of inheritance.

- ✓ *A H Sturtevant*, worked on *linkage* and *crossing over* in *Drosophila*.
- ✓ He made predictions about what offspring to expect:
 - if there was no crossing over and then counted the number of expected
 - And recombinant types to find the percentage of recombinant types.

-This percentage of recombinant types is called the *crossover value* and is *a measure of how far apart the genes are on a chromosome*.

-A *low crossover frequency* indicates that the genes are *close together*;

-A high one that they are *further apart*-crossing over will occur between them

-Gene mapping has been used to 'track down' genes that cause disease (for example, cystic fibrosis and Huntington's disease)

How is knowledge of genetics important in crossbreeding and inbreeding crops and stock?

Inbreeding- involves breeding animals or plants with close relatives. This can cause problems such as infertility in the resulting offspring

Hybrid vigor- the increased vigor or productivity of organisms resulting from crossbreeding different varieties of the same species

Selective breeding: where organisms are chosen to breed with a specific outcome in mind.

Cross-breeding- is an established breeding method used in breeding to increase overall productivity.

Cross-breeding, natural or planned, has been important in producing many of the high-yielding crop plants we now grow

Commercial cattle farmers may cross-breed animals for two related reasons:

- To take advantage of hybrid vigour

- To take advantage of the good qualities of two or more breeds and to combine these qualities to improve market suitability
- Because it is the result of increased heterozygosity, the term hybrid vigour is sometimes replaced by heterosis.

What about genes on the sex chromosomes?

Sex determination

- Sex is determined by the **X** and **Y** chromosomes.
 - **Males** have one **X** chromosomes, and one **Y** , chromosomes and have two different sex chromosomes they are called the *heterogametic sex*,
 - Females have two **X** chromosomes and are *the homogametic sex*.
 - They both have 44 (22 pairs) autosomes – non-sex chromosomes
 - In any family, or in any mating in mammals, the predicted ratio of males to females is 1:1,
 - The **Y chromosomes** that appears to determine a person's sex, the action of one gene on this chromosomes, the **SRY** gene that determines the *formation of testes*.
 - **SRY gene** the dominant gene on the Y chromosomes that causes a mammal to develop as a male
 - In the early development of the embryo, a region called the **urogenital ridge** develops into a '**bi-potential gonad**'
 - The same structure can develop into either **ovary or testis**.
 - ✓ When the **SRY** gene is activated, the **bi-potential gonad** develops into **a testis**, and *the embryo is male*.
 - ✓ If the **SRY gene is absent** (or **inactivated** for some reason), genes on the **X chromosomes** , and on the autosomes cause the **bi-potential gonad** to develop into **an ovary**, and the embryo is **female**
 - ✓ Individuals with only one **X chromosomes** , and **no Y chromosomes** , (**written X-**) develop into females, but with slightly **masculinised features** abnormal(**Turner syndrome**), **sterile**
 - ✓ Similarly, individuals with **two X chromosomes**, and **one Y chromosomes**, (**XXY**) develop into males, but with **feminized features**. abnormal (**Klinefelter syndrome**), **sterile**
 - ✓ These individuals are also **sterile**, the abnormal number of chromosomes, arises as a result of **nondisjunction of the sex chromosomes**, during meiosis. the chromosomes , **do not segregate properly** into the gametes,
- ### Other systems of sex determination
- ✓ In birds it is **females** are **heterogametic sex** and **males the homogametic sex**! But they don't have **X and Y** chromosomes,
 - ✓ They have **W and Z**. Females are **ZW** and males **ZZ**.
 - ✓ In some reptiles, such as **alligators**, sex is determined by the **temperature at which the egg is incubated**.
 - ✓ Some **snails** start out male, and then become female!

- ✓ In tropical clown fish, the dominant individual in a group becomes female while the other ones are male, and in **blue wrasse fish the reverse**.
- ✓ Some species have no sex-determination system – they are **hermaphrodite (have both male and female sex organs)**.
- ✓ Hermaphrodites include the common earthworm and some species of snails.

The genes on the sex chromosomes

- ✓ Genes found only on the X chromosome or on the Y chromosome are said to be **sex-linked**.
Genes found only on the Y chromosome include those that determine:
 - One form of the degenerative condition retinitis pigmentosa (in which eyesight becomes progressively weaker and may lead to blindness)
 - One form of deafness, these particular conditions can only be inherited by males, as only males have the Y chromosome.
- ✓ Genes found only on the X chromosome include those that determine:
 - Red-green color blindness
 - One form of hemophilia
- ✓ These conditions can be inherited by females and males as both possess at least one X chromosome.
- ✓ Many of these conditions are determined by **recessive alleles**, including both red-green color blindness and hemophilia.
- ✓ These conditions are more common in men than in women because:
 - Men only have one X chromosome
 - If this chromosome carries the recessive allele for **hemophilia**, there is no corresponding dominant allele on the Y chromosome to mask its effect
 - Women have two X chromosomes
 - Both these need to carry the recessive allele for **hemophilia** for a woman to suffer from conditions as, if only one of them did, the dominant allele on the other X chromosome would mask its effects
 - A man needs to inherit only one X chromosome with a recessive hemophilia allele to suffer from the condition, whereas a woman must inherit two; this is less likely to happen
- ✓ **karyotype** a photograph of all the chromosomes in a cell arranged in homologous pairs
- ✓ Even though the **X** and **Y** chromosomes are **very different**, but they have **homologous regions**

- ✓ This region follows the same pattern of inheritance as genes on the autosomes and is concerned with control of **metabolic activities** in cells.

Sex-linked features determined by recessive alleles on the X chromosome share the following characteristics:

- They are much more common among males (because females must inherit two chromosomes carrying the recessive allele, whereas males must inherit only one)
- Affected males inherit the allele from their mother
- Affected females inherit one allele from each parent (so the father will be affected)
- Females who are heterozygous for the condition are called carriers
- They may 'skip' a generation and then appear in the males only

Genotypes of sex-linked features include the appropriate sex chromosomes as well as the alleles. E.g.;-for red-green color blindness, **B** represents the allele for normal vision and **b** represents the allele for red-green color blindness.

The possible genotypes and phenotypes are:

- X^BY – normal male
- X^bY – affected male
- X^BX^B – normal female
- X^BX^b – carrier female (is not color blind)
- X^bX^b – affected female.

If you were not told that this was a sex-linked feature, there are several hints:

- It clearly skips a generation
- It is more common in the males
- The only affected female has an affected father

3.2 Molecular genetics

- ❖ The nucleotides are held together by **bonds** between the **sugar in one nucleotide** and the **phosphate group** in the next.
- ❖ The nucleotides in one strand are paired with nucleotides in the other according to the base-pairing rule. This states:
 - **Adenine-containing nucleotides will always be opposite to Thymine-containing nucleotides**

➤ *Cytosine-containing nucleotides will always be opposite to*

Guanine-containing nucleotides

- ❖ Base-paired on the two strands, sequences of bases are **complementary**.
- ❖ **Hydrogen bonds** that hold the two strands together are **quite weak**,
- ❖ The bonds hold the nucleotides in each strand are **much stronger than the hydrogen bonds**.
- ❖ The stability of the DNA is important in ensuring the genetic code – does not become corrupted
- ❖ *The amount of adenine is equal to the amount of thymine, the amount of guanine is equal to the amount of cytosine*

How does the DNA molecule replicate itself?

- The ability of a DNA molecule to make an exact copy of itself is the basis of all methods of reproduction and the **basis of passing on genetic information** from one generation to the next.
- Even though they did not know the details, in **1953, Watson and Crick** discoverers of the structure of DNA proposed that DNA must replicate semi-conservatively.
- This means that the DNA molecule replicates in such a way that:
 - ✓ each new DNA molecule formed contains one strand from the original DNA
 - ✓ both new DNA molecules formed are identical to each other and to the original molecule
- DNA replication involves **enzymes and proteins**, but the key stages are as follows:
 - ✓ Molecules of the enzyme **DNA helicase** break hydrogen bonds and ‘unwind’ helix revealing two single-stranded regions.
 - ✓ Molecules of **DNA polymerase** follow the helicase along each single-stranded region, which acts as a template for the synthesis of a new strand.
 - ✓ The DNA polymerase assembles free DNA nucleotides into a new strand alongside each of the template strands. The base sequence in each of these new strands is complementary because of the base-pairing rule, **A-T, C-G**.
 - ✓ The processes of unwinding followed by complementary strand synthesis progresses along the whole length of the DNA molecule.
 - ✓ The result is two DNA molecules that are identical to each other (and to the original molecule); each contains one strand from the original DNA molecule and one newly synthesized strand that is complementary to this.
- ❖ **DNA helicase** the enzyme that initiates the separation of the polynucleotide strands during DNA replication
- ❖ **DNA polymerase** the enzyme that initiates the building of a new complementary polynucleotide strand of DNA following separation of the original two strands
- Gene cloning** means making multiple copies of a gene. The principal methods are divided into two main categories; these are:
 - **In vivo cloning** – the gene is introduced into a cell and is copied as the cell divides

- **In vitro cloning** – this does not take place in living cells but the DNA is copied many times over using the polymerase chain reaction (PCR).

➤ This process **mimics** the natural **semi-conservative replication of DNA** in a machine called a **PCR machine**.

How are organisms cloned?

- There are advantages and disadvantages to both methods of gene cloning.
- **In vitro cloning using the PCR** is both quicker and cheaper. Billions of copies of a gene can be made within a few hours at low cost.
- However, if the gene is to be used by an organism to make a product – for example, by a bacterium to allow it to make insulin – then in vivo cloning delivers the gene already in the organism.

A clone of organisms is a group of organisms produced asexually from one parent.

- The members of the clone are genetically identical to each other and to the parent organism.
- **Genetically modified organism** an organism created using genetic engineering which contains a transferred gene or genes
- Cloning of plant practiced for thousands of years. More recently the technique of **micro propagation** made it possible to produce a clone of thousands of identical plants from just one parent plant
- **Micro propagation** is the rapid vegetative propagation of plants under **in vitro conditions** of high light intensity, controlled temperature and a defined nutrient medium. The technique has been applied to a substantial number of commercial vegetatively propagated plant species.

E.g.-These small groups of a few hundred cells are placed in test tubes containing a special medium with hormones that induce root growth. They are then transferred to another medium containing hormones to induce shoot growth. When they have grown sufficiently, the small plantlets transferred to a compost and grown on. In this way, thousands of identical plants can be produced.

Most of the world's bananas are now produced by micro propagation.

- You cannot just cut pieces of animals however animals have been cloned. The first mammal to be cloned, and still the most famous, was **Dolly the sheep**.

E.g.-Dolly's genetic mother was a type of sheep called 'Finn-Dorset'. Dolly was produced by transferring a diploid nucleus to an egg cell that had been enucleated (had its nucleus removed). Once the nucleus had been successfully transferred, the egg cell was stimulated to divide by a small electric current. When development had reached a stage called a blastocyst, the embryo was implanted into a surrogate 'mother' ewe. Seven months later, Dolly was born. She was genetically identical to the Finn-Dorset ewe (female sheep) from whom the genetic material had been obtained

- **A Finnish Dorset is a crossed-breed sheep, half Finn sheep, and half Dorset breed.**
- **Dolly the sheep, first mammal to be cloned from an adult somatic cell, was a Finnish Dorset**

What is genetic engineering?

- ❖ **Genetic engineering** is a process in which the **genome of an organism is altered**, usually by having an extra gene from a different organism added.
- ❖ The organism is then a **genetically modified or a transgenic organism**.
- ❖ **Transgenic organism** a genetically modified organism that contains a gene or genes transferred from another organism belonging to a different species
- ❖ Much of the early work on genetic engineering was done to genetically modify bacteria.
- ❖ One of the first of these products to be produced by transgenic bacteria was human insulin.
 - ✓ The gene that controls the production of human insulin was extracted from human pancreas cells
 - ✓ And transferred to the bacteria.
 - ✓ Once modified, the bacteria were then cultured on a massive scale in a fermenter
 - ✓ And the insulin harvested and purified before distribution.
- ❖ Genetically modified bacteria produce a range of products, including:

- **Enzymes for the food industry**

- Thermo stable enzymes for washing powders

- Human insulin

- Human growth hormone

- Vaccines (for example, for prevention of hepatitis B)

- Bovine somatotrophin (to increase milk yield and muscle development in cattle)

- ❖ Plants have also been genetically modified so that they:

- are disease resistant

- have an improved yield

- produce a specific product (for example, golden rice is genetically modified rice that produces beta-carotene – important in the formation of vitamin A, which prevents night blindness)

Genetic engineering has many potential benefits. Some of these are described below:

- Disease could be prevented by detecting people/plants/animals that are genetically prone to certain hereditary diseases,
- treat infectious diseases by implanting genes that code for antiviral proteins specific to each antigen.
- Genetically engineered plants and animals can be produced to give increased growth rates and reduced susceptibility to disease

- Animals and plants can be ‘tailor made’ to show desirable characteristics.
- Genetic engineering could increase genetic diversity, and produce more variant alleles
- Genetic engineering is a much quicker process than traditional selective breeding

How can gene technology be used in forensic science?

- **Fingerprints** have been used for many years to help place a suspect at the scene of a crime, with the exception of identical twins,
- An individual’s fingerprints are unique.
- **genetic fingerprinting** a forensic technique that is used to try to solve **crimes by matching** DNA found at crime scenes with the DNA of suspects
- **Genetic fingerprinting** has nothing to do with actual fingerprints. It is a technique for comparing the DNA of different people
- DNA in the cells of the body is known as **non-coding DNA**.
- The **non-coding DNA** is found **between genes and contains base sequences** that are repeated,
- These repeating sequences of non-coding DNA are called **mini-satellites**
- **Mini-satellites** form the basis of a genetic fingerprint.
- The mini-satellites are inherited along with **the coding DNA from one or other parent**.
- The DNA used for analysis obtained from any type of cell that has a nucleus. Eg- blood (white blood cells could supply the DNA), skin or semen
- ❖ The main stages in preparing a genetic fingerprint are:
 - ✓ DNA is isolated from the cells.
 - ✓ The DNA cut into fragments using restriction enzymes. The fragments that are obtained are treated with **alkali** to separate the strands of each DNA fragment.
 - ✓ The fragments are separated by gel electrophoresis. Smaller fragments (with a lower molecular mass) move further than larger fragments.
 - ✓ The invisible pattern of separated DNA fragments is transferred from the gel to a nylon membrane. The membrane is placed over the gel in a tray of ‘flow-buffer’ and is held in place by paper towels and a weight. The buffer soaks up through the gel, carrying the fragments of DNA with it. The buffer can pass through the membrane (to be absorbed by the paper towels), but the DNA cannot. It remains in the **nylon membrane** in the same relative position as it was in the gel.
 - ✓ **A radioactive gene probe** is applied to the membrane. This is made of single-stranded DNA (**called c-DNA**) and binds with base sequences in the mini-satellite regions.
 - ✓ The membrane is placed over a piece of X-ray film to reveal the positions of those fragments that have bound to the probe.
- ❖ **Gel electrophoresis** is a technique that uses a thick block of gel (jelly-like material) to act as a ‘**molecular sieve**’
- ❖ The size of DNA molecules is usually measured in **kilobase pairs** (thousands of pairs of bases).

- ❖ The fragments used in a genetic fingerprint are single stranded, so there are no base pairs. Their size is measured in **kilobases**.
- ❖ The chance of two people having the same genetic fingerprint (unless they are identical twins) is about **1 in 1 000 000**.
- ❖ This means that a genetic fingerprint provide strong evidence of **involvement** in or **innocence of a crime**.

3.3 Protein synthesis

How does a cell 'know' to make a protein?

- ✓ The code for a protein is specified by DNA
- ✓ Has to be carried to the ribosomes and can assemble the amino acids in the correct sequence to form the protein.
- ✓ DNA is a huge molecule and remains in the nucleus at all times.

The following events occur:

- The DNA code for the protein is rewritten in a molecule of messenger RNA (mRNA); this rewriting of the code is called **transcription**.
- The mRNA travels from the nucleus through pores in the nuclear envelope to the ribosomes.
- Free amino acids are carried from the cytoplasm to the ribosomes by molecules of transfer RNA (tRNA).
- The ribosome reads the mRNA code and assembles the amino acids carried by tRNA into a protein; this is called **translation**.

- ✓ **mRNA (messenger RNA)** is a nucleic acid that transmits the genetic code from DNA to ribosome
- ✓ **transcription** process converts genetic information from a DNA code into an mRNA code
- ✓ **tRNA (transfer RNA)** transfers individual amino acids during translation
- ✓ **ribosome** the part of a cell that makes proteins
- ✓ **translation** process in which the mRNA code is converted into a sequence of amino acids

What is the genetic code like?

- ✓ The genetic code is held in the DNA molecule.
- ✓ A gene is a sequence of base triplets (**sequence of three**) in the DNA molecule that carries the code for a protein.
- ✓ With four different bases to work with (**adenine, thymine, cytosine and guanine**),
- ✓ There are **64 possible triplet codes**, but **only 20 amino acids are used** to make all the different proteins.
- ✓ **What is the purpose of the other 44 codes?** In fact, none of these is **spare or redundant**.
- ✓ only one of the strands of the DNA molecule carries the code for proteins. This is called **the coding strand or the sense strand**.
- ✓ The other strand is the **non-coding or antisense strand**.
- ✓ Most amino acids have more than **one code**.
- ✓ Only methionine and tryptophan have just one triplet that codes for them; arginine has six.
- ✓ Three of the triplets (**TAA, TAG, and TGA**) do not code for amino acids at all. They are 'stop' codes that signify the end of a coding sequence. Because there is this extra capacity in the genetic code, over and above what is essential, it is said to be a degenerate code.

- ✓ Besides being a triplet and degenerate code, the DNA code is a non-overlapping code.
- ✓ *This means that each triplet is distinct from all other triplets. The last base in one triplet cannot also be the first base (or second base) in another triplet.*
- ✓ The **genetic code** is also a **universal code**.
- ✓ This means that the **triplet TAT** is the DNA code for the amino acid **tyrosine** in a **human**, a giant **redwood tree**, a **bacterium or in any other** living organism
- ✓ **codon** a triplet of **mRNA** bases that has the code needed to make one protein

How does transcription take place in eukaryotic cells?

- ❖ During this process, the coded information in the DNA of one gene is used to synthesise a mol of mRNA that will carry the code to the ribosomes.
- ❖ mRNA is similar to DNA that built from nucleotides; however, it is different from DNA in a number of ways:
 - It is a much smaller molecule
 - It is single stranded
 - The base thymine is replaced by uracil
 - The sugar in the nucleotides is ribose, not deoxyribose
- ❖ The triplets of bases in mRNA that code for amino acids are called **codons**
- ❖ **anticodon** a triplet on tRNA complementary to a codon in mRNA
- ❖ The mRNA codons are identical to the DNA triplets that code for specific amino acids, except that U (uracil) is substituted for T (thymine).
- ❖ To form the single-stranded mRNA when transcription takes place, only the antisense strand of DNA is transcribed.
- ❖ Transcribing this would produce a complementary sequence of bases, similar to those in the antisense strand, which would not code for anything.

In eukaryotic cells, transcription takes place in the following way:

- ✓ The enzyme DNA-dependent RNA polymerase (RNA polymerase) binds with a section of DNA next to the gene to be transcribed.
- ✓ Transcription factors activate the enzyme.
- ✓ The enzyme begins to 'unwind' a section of DNA. RNA polymerase moves along the antisense strand, using it as a template for synthesizing the mRNA.
- ✓ The polymerase assembles free RNA nucleotides into a chain in which the base sequence is complementary to the base sequence on the antisense strand of the DNA. This, therefore, carries the same triplet code as the sense strand (except that uracil replaces thymine).
- ✓ The completed molecule leaves the DNA; the strands of DNA rejoin and re-coil.
- ❖ The mRNA molecule now contains the code for the protein that was held in the DNA of the gene.

How does translation take place?

- All tRNA molecules have the same basic structure.
- The 'cloverleaf' configuration of the molecule has at one end a triplet of bases called an anticodon.
- This anticodon will be complementary to one of the mRNA codons.
- The other end of the tRNA molecule has an **attachment site** for the amino acid that is specified by the mRNA codon.
- Ribosomes are made from ribosomal RNA (rRNA) and proteins organised into a large and a small subunit.
- Within the ribosome, there are three sites that can be occupied by a tRNA molecule, called the **A, P and E sites**

The following events take place:

- ✓ The first two codons of the mRNA enter the ribosome.
- ✓ tRNA molecules (with amino acids attached) have complementary anticodons to the first two codons of the mRNA bind to those codons.
- ✓ A peptide bond forms between the amino acids carried by these two tRNA molecules and the **dipeptide** is transferred to the tRNA in the **A** site.
- ✓ Ribosome moves along the mRNA by one codon, bringing third codon into the ribosome; at the same time the 'free' tRNA exits ribosome and tRNA with dipeptide moves into the **P** site.
- ✓ A tRNA with a complementary anticodon binds with the third codon, bringing its amino acid into position next to the second amino acid.
- ✓ A peptide bond forms between the second and third amino acids.
- ✓ Ribosome moves along the mRNA by one codon, bringing the fourth mRNA codon into the ribosome, and the whole process is repeated until a '**stop**' **codon** is in position and translation ceases.
- ❖ The translation of mRNA code into a protein molecule requires energy. However, this does not come from the hydrolysis of ATP as is usual in a cell, but from the hydrolysis of a similar molecule, **GTP – Guanosine Triphosphate**. It is hydrolyzed to **GDP and Pi**

How is protein synthesis different in prokaryotic cells?

- ❖ The process of **protein synthesis** is essentially similar in both **eukaryotic and prokaryotic** cells, with DNA being transcribed to mRNA, which is then translated to a polypeptide chain.
- ❖ However, there are some differences and these are linked to the fact that:
 - Prokaryotic cells do not have a nucleus
 - Prokaryotic mRNA does not need post-transcriptional processing

- Prokaryotes: transcription and translation are coupled; mRNA can be translated by ribosomes at one end of its molecule while it is still being transcribed from DNA at the other end

- ➔ Eukaryotes: transcription and translation are separated

- Transcription occurs in the **nucleus**

- translation occurs in the **cytoplasm**

- Eukaryotic mRNAs are modified before leaving the nucleus

What becomes of the proteins that are synthesized?

- ✓ All our proteins are synthesised,
- ✓ But all our cells do not synthesise all our proteins.
- ✓ ***The twenty amino acids that make up proteins*** are alanine, arginine, asparagine, aspartic acid, cysteine, glutamine, glutamic acid, glycine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, proline, serine, threonine, tryptophan, tyrosine and valine
- The average adult protein requirement per day is about **50 grams**.
- The proteins are hydrolyzed to amino acids in our gut and absorbed into the blood plasma by active transport.
- they are then transported to the cells where they are used to synthesise
- Some amino acids can be made in our bodies by a process called **transamination**,
- the amino group of an amino acid is removed and transferred to a **keto acid**.
- The keto acid then becomes a different amino acid.
- Some amino acids not made from transamination, but from our food like fish, meat cereal, milk etc.

What controls gene expression?

- ✓ The fact that some genes are sex-limited tells us that all genes aren't active all the time.
- ✓ e.g. – the genes that control the colour of your iris are present in all your cells, but all your other cells aren't this colour – just the iris.
- ✓ Somehow, we can control which genes are active where.

How are genes switched on?

- ✓ Very often, genes are switched on by 'transcription factors' that are present in the cell. These transcription factors are usually proteins that bind to a regulatory sequence of DNA near to the gene they influence.
- ✓ The transcription factors bind to a **promoter**
- ✓ The RNA polymerase transcribes the antisense strand of the DNA as it moves along; the gene is now being **expressed**.
- ✓ Some cancers are caused by hormones acting as transcription factors
- ✓ Oestrogen is a steroid hormone it binds with a receptor in the cytoplasm.
- ✓ The oestrogen-receptor complex moves into the nucleus and binds with and activates specific genes.
- ✓ In the breasts, and lining of the uterus, the activated genes cause cell division.

- ✓ Many breast cancers are said to be oestrogen-receptor positive, and cancer cells have oestrogen receptor hormone can bind, causing the same increase in cell division as it does in normal breast tissue.
- ✓ The anti-cancer drug tamoxifen can bind with the oestrogen receptors

How are genes switched off?

- ❖ Transcription factors that promote the expression of genes.
- ❖ Other factors (group of substances) can act to repress gene action is known as **short interfering RNA (siRNA)**.
- ❖ **siRNA** are unusual because they are very short only about 21 to 23 nucleotides long and are double stranded.
- ❖ They don't act on the gene itself, but they 'interfere with' or 'silence' the mRNA once it has been transcribed from the DNA. **This is called posttranscriptional interference**
- **the action of siRNA is as follows:**
 - Double-stranded RNA (dsRNA) is produced in the nucleus from a range of genes.
 - Then split into the very short lengths that characterise siRNA by an **enzyme called 'Dicer'**.
 - The antisense strand of the siRNA then binds with a **complex of molecules called RISC**.
 - The siRNA binds with mRNA allows RISC to degrade/cleave the mRNA into small fragments.
- *Researchers have already shown that they can use siRNA*
 - ✓ *to treat HIV by prevent the replication of HIV by silencing*
 - ✓ *Can silence genes associated with cancer.*

Mutation

What are mutations?

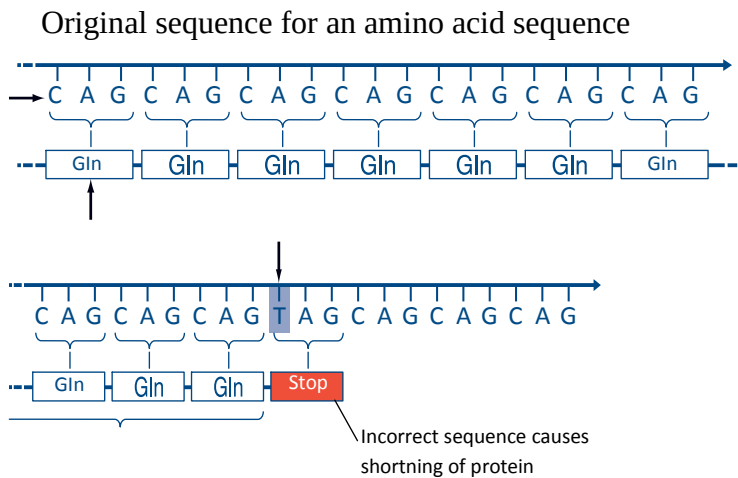
- ❖ **Mutation** is any spontaneous (random) change in the genetic material of an organism
- ❖ There can be -large structural changes involving
 - whole chromosomes or parts of chromosomes,
 - or changes that involve only a single base are called **point mutations**
- ❖ There are several types of **point mutation** that the bases in the DNA sequence of a gene is altered by **being copied wrongly** when the DNA replicates.
- ❖ The different point mutations are:
 - **Substitution**
 - **Addition**
 - **Deletions**

- ❖ The change to the gene can be dramatic and the result can be that the protein the gene should code for is **not made at all** or a **different protein** is made

A) **Substitution** one base is replaced by a different bases

GAC	GGG	ATT	GAG	GAG	GAC	GGG	ATG	GAG	GAG
Original sequence					Mutated sequence				

- ❖ The triplet **ATT** has been changed to **ATG** (no other triplet is affected). The original triplet, **ATT**, codes for the amino acid **isoleucine**. However, the new triplet, **ATG**, codes for **methionine** and the same protein would have been synthesized.
- ❖ Other substitutions can result in a 'stop' triplet. In this case transcription ceases when it reaches the stop code and a non-functional mRNA results.



- Mutation **causes sickle cell anemia** abnormal hemoglobin that causes the red blood cells to collapse into sickle-shaped cells under conditions of low oxygen concentration. **The sickled cells often fracture and stick together and block capillaries.**

B. Addition and deletion

- ❖ Deletion mutation a base is 'missed out' during replication one DNA nucleotide being omitted from the sequence
- ❖ **Addition:** an extra base is added.
- ❖ Both these are more significant mutations than substitutions.
- ❖ Substitutions affect just one triplet and, because the DNA code is degenerate, may well have no overall effect
- ❖ Because there is one fewer or one extra base, the whole sequence after the point of the mutation is altered and these are **frame shift mutations.**
- ❖ A totally different mRNA is produced (if one is produced at all) and a non-functional protein or no protein at all

What causes point mutations?

- ❖ Mutations occur spontaneously and randomly they are accidents that occur when DNA is replicating. Mistakes happen.
- ❖ Mutations are rare events, surprising when you consider each cell contains 6×10^9 (six billion) base pairs that might mutate!
- ❖ Biologists estimate mutations arise at rate of 1 in 50×10^6 (one in fifty million) base pairs.
- ❖ Each new cell will have, on average, **120 mutations**.

This sounds rather worrying, but you should remember two things:

- Most of these mistakes (mutations) are **detected and repaired**, and
- Because **95%** of our DNA is non-coding, most mutations are **unlikely to affect coding genes**.

Rate of mutation can be increased by a number of factors including:

- Carcinogenic chemicals, for example, those in tobacco smoke
- High-energy radiation, for example, ultraviolet radiation, X-rays

What are the consequences of gene mutations?

- ❖ There are a number of factors influence the answer to this, but, really, two important ones:
 - ✓ which cells, and
 - ✓ Which genes?

❖ Mutations that occur in a normal body cell (a non-sex cell) will have one of four possible consequences:

• It will be completely harmless.

• It will damage the cell.

• It will kill the cell.

• It will make the cell cancerous, which might kill the person.

- ❖ The mutation will affect no other person; it will not be passed on to the next generation.
- ❖ However, if the mutation occurs in a sex cell, or a cell that will divide to give rise to a sex cell, then it may be **passed on to the next generation**.
- ❖ Two types of genes are really important genes called **proto-oncogenes** and **tumour suppressor genes** play important roles in regulating cell division and preventing the formation of a tumour.
- ❖ When **proto-oncogenes** mutate, they become active oncogenes, which stimulate the cell to divide in an uncontrolled manner.

- ❖ **Tumour suppressor genes** recognise uncontrolled cell division and act to suppress cell division. If these genes mutate and become inactive, a tumour will form as uncontrolled cell division continues.
- ❖ Tumor is a mass of cells created when cell replication gets out of control. Tumours cause the disease cancer

Can mutations benefit an organism?

- ❖ Mutations produce harmful effects, but mutations are the raw material of evolution.
- ❖ Mutation is the only process that creates new genes.
- ❖ **Crossing over, segregation, and random assortment in meiosis** together with **random fusion** in **fertilization**: **reshuffle existing genetic material**, but **only mutation** produces new genetic material.
- ❖ Mutations in the DNA of bacteria can give them resistance to a **specific antibiotic**, such as **penicillin or ampicillin**. These mutations arise spontaneously, as do all mutations.
- ❖ In 1947, four years after penicillin was used widely in the USA, the first penicillin-resistant bacterium was found – it was a bacterium called **Staphylococcus aureus**.
- ❖ Bacteria can also ‘**swap**’ **antibiotic resistance** genes with each other.
- ❖ confer resistance genes are found in the plasmids – the ‘extra’ small circular pieces of DNA

They can transfer these plasmids to other bacteria by:

- **Conjugation**- plasmid passes through special ‘conjugation’ tube from one bacterium to another
- **Transduction** – a virus carries the plasmid from one to another
- **Transformation** – the plasmid is absorbed from a dead bacterium
- ❖ **Antibiotic resistance** the evolution of strains of bacteria that are not affected by antibiotics. It is caused by the overuse of antibiotics

Chromosome mutations

- **Chromosome mutations** occur when there is any change in the arrangement or structure of the chromosomes occur during meiosis **at crossing over in prophase 1**
- They are much bigger events than **point mutations** and result the **death of a cell**.
- They also affect the **whole organism**. For example, if essential parts of the DNA are affected by chromosomal mutations, **a foetus may be aborted**

Inversion

- ✓ occurs when an area of DNA on **a chromosomes**, reverses its orientation on the **chromosomes**,
- ✓ Just one inversion on chromosome **16 can cause leukemia.**
- ✓ It is an inversion that leads to an embryo **having too few or too many copies of genes**, can cause the *embryo to miscarry, fail to grow, or be born with substantial medical problems.*
- ✓ *Chromosome 16 one of the 23 pairs of chromosomes in humans. It spans about 90 million base pairs and accounts for nearly 3% of DNA in cells*
- ✓ *Chromosome 21 one of the 23 pairs of chromosomes in humans. It is the smallest of the chromosomes*

Deletion

- Cause of mutation, decrease number of genes occurs due to deletion of large section of a chromosome.
- Deletion can result in a variety of genetic disorders, such as **Prader-Willi syndrome** results from a **malfunction of the hypothalamus** (a small endocrine organ at the base of the brain), which plays a crucial role *in many bodily functions, including hunger and satiety, temperature and pain regulation, fluid balance, puberty, emotions and fertility.*

Insertion

- This mutation describes an **increase in the number of genes** caused when an unequal crossover happens **during meiosis**. The chromosomes, become **abnormally long or short and stop functioning**

Duplications

- genes are duplicated results in them being **displayed twice on a single chromosome**
- Duplication of the whole **chromosome** is more serious. Having three copies of chromosome **16**, known as **trisomy 16**, **trisomy 16** leads to **babies being born with a range of medical issues**, such as
 - poor fetal growth,
 - muscular and skeletal anomalies,
 - congenital heart defects and underdeveloped lungs

Chromosome non-disjunction

- Homologous **chromosome**, do not separate successfully to opposite poles during meiosis,

- the result is one of the gametes lacking a chromosome and the other having an extra **chromosome**
- If this happens with **chromosome 21**, **Down's syndrome results**. Those condition will have 47 **chromosomes**, in every cell **chromosome, 21 cause -mental retardation, heart defects and stunted growth**

Translocations

- A piece of one chromosome is transferred to another non-homologous **chromosome**
- This type of chromosome mutation is often responsible for **chronic myelogenous leukemia**

UNIT 4

EVOLUTION

Evolution: is the change in genetic composition of a population over successive generations, which may be caused by **meiosis, hybridization, natural selection, or mutation**. This leads to a sequence of events by which the population diverges from other populations of the same species and may lead to the origin of **a new species**.

- Evolution** - is the gradual and heritable change of population through time.
- is the most comprehensive science in biology.
 - defined as the accumulation of inherited changes within populations over time.
 - describes how life originates and develops into various forms

4.1 The Origin of Life

The 5 main theories are:

1. Special Creationism
2. Spontaneous generation
3. Eternity of life
4. Cosmozoan theory
5. Biochemical origin

1. Special creation theory: attributes the origin of life to a divine event that was masterminded by the supernatural being God.

- ✓ It is nearly linked to religions.
- ✓ **Science** relies on provable events
- ✓ **Religion** relies on believing in that which cannot be proven, mainly focuses on spiritual matters, **philosophical matter** that relates to **morality**
 - concerns between **humans and their God**
 - Less concerned with **empirical observable** facts and **testable hypotheses** but rather with **faith**, the belief in things that cannot be proven.
- ✓ Religion mainly focuses on spiritual matters that, by their very nature, cannot be seen, touched, or measured effectively. It has the following versions

a. **young earth creationism**- earth is only few thousand years and created in six 24 hours days.

- ✓ Agree that the Earth is round and moves around the Sun, they interpret all geology in the light of **Noah's flood**.

b. **old earth creationism** – genesis account creation of all living things through power of God.
- Suggest earth is very old.

c. **Day – age and gap creationism**- suggest that a large gap between formation of the earth and creation of all animals and humans.

d. **Progressive creationism**- accepts big-bang as the origin of universe.

e. **Theistic evolution/ evolutionary creationism** - God invented evolution.

f. **Intelligent design**- God's handiwork can be seen in all creation

2. The theory of spontaneous generation (Abiogenesis): states that life has originated from non- living organic matter abiogenetically (spontaneously).

e. g. - rotting meat..... Flies

- Sour wine bacteria etc.

- ✓ Some of the supporters of abiogenesis were **Aristotle, Needham, Van Helmont etc.**

- ✓ The theory of spontaneous generation was first disproved by **Francesco Redi**.

- ✓ **Louis Pasteur** by his advanced experimental settings disproved the theory for the last time in the way that can convince scientists to accept biogenesis and to reject **abiogenesis**.

3. Theory of eternity of life (Biogenesis): - regards life as eternal as matter itself.

- Life only changes its form but never created from dead (non-living) substance

- **has no origin and has always existed. According to this theory life comes from life never from lifeless things, and different types of organisms have always existed on earth and shall continue to exist. However, the theory does not explain how life originated in the beginning.**

- Life is an inherent property of the universe.

- **Albert Einstein** was also one of the supporters of this theory.

4. Cosmozoan (Panspermia) Theory: hypothesize that meteorites or dust brought microorganisms to earth which then evolved to the diversity of life we see today.

- **Proposed by Richter in 1865 and supported by Arrhenius (1908)**

- But this theory lack significant support as it lacks evidence.

- It is linked to eternal theory of life.

Version 1

-Richter explained that life propagate from one place to another in the universe via Cosmozoa (germs of cosmos).

Version 2

- In 1908 the Swedish physical chemist S. Arrhenius explained this cosmozoa and gave it the name panspermia . Life like bacteria propelled by radiation pressure through inters planetary space to arrive earth.

- According to this theory air friction helped against heat for organisms to arrive Earth.

Version 3

- Pseudopanspermia(weak panspermia)

- According to this view, Organic molecules came to earth and reacted with other molecules on Earth to produce the first life.

- ✓ All forms of the cosmozoan (panspermia) theory suggest that other celestial bodies have been important in the origin of life on Earth

5. Biochemical theory of evolution (Oparin's theory): states that the first life is the result of a set of simple chemicals existed in the primitive Earth's atmosphere.

- linked to the work of two biologists:

1. **Aleksander Oparin**, a Russian biologist who first put forward his ideas in 1924, and

2. **John Haldane**, an English biologist independently put forward almost identical ideas in 1929 (before Oparin's book had been translated into English).

They both suggested that:

- The primitive atmosphere of the Earth was a reducing atmosphere with no free oxygen – as opposed to the oxygen-rich atmosphere of today
- There was an appropriate supply of energy, such as lightning or ultraviolet light, and
- This would provide the energy for reactions that would synthesis a wide range of organic compounds, such as **amino acids, sugars, and fatty acids**.

Oparin suggested that the simple organic compounds could have undergone a series of reactions leading complex molecules.

He proposed that the molecules might have formed colloidal aggregates, or ‘**coacervates**’, in an aqueous environment. The **coacervates** were able to absorb and assimilate organic compounds from the environment in a way similar to the metabolism of cells.

Haldane’s ideas about the origin of life were very similar. He proposed that the primitive sea served as a vast chemical laboratory powered by solar energy. As a result the sea became a ‘hot dilute soup’ of organic **monomers and small polymers**.

In 1953, Stanley Miller conducted his now-famous spark-discharge experiment. He passed electric sparks repeatedly through a mixture of gases that were thought to represent the primitive atmosphere of the Earth. These gases were methane (CH_4), ammonia (NH_3), water (H_2O), and hydrogen (H_2).

Stanley Miller’s spark-discharge experiment analyzed the liquid in the water trap; he found a number of simple organic molecules – like **hydrogen cyanide (HCN)**

He found a larger variety and more complex organic molecules were formed including:

- **Amino acids** – essential to form proteins
- **Pentose sugars** – needed to form nucleic acids
- **Hexose sugars** – needed for respiration and to form starch and cellulose
- **Hydrogen cyanide again** – but it has been shown that the nitrogenous bases found in nucleotides can be synthesized in the laboratory using HCN as a starting point
- ❖ **The biologist John Desmond Bernal** suggested that there were a number of clearly defined ‘stages’ in explaining the origin of life:
 - Stage 1: the origin of biological monomers
 - Stage 2: the origin of biological polymers
 - Stage 3: the evolution from molecules to cell
- ❖ Bernal suggested that evolution may have commenced at some time between stages 1 and 2.
- ❖ The first two stages have been demonstrated as being possible in the conditions of the primitive Earth, and research on stage 3 is well advanced.

Other ideas on the biochemical theory

- ❖ **Professor William Martin Dusseldorf and Dr. Michael Russell Glasgow** claim that cells came before the complex organic molecules.
- ❖ Not living cells but inorganic ones made of iron sulphide, formed not at the Earth’s surface but at the bottom of the oceans.
- ❖ In their theory, a fluid rich in compounds such as cyanide, sulphides and carbon monoxide emerged from the Earth’s crust at the ocean floor.
- ❖ It then reacted inside the tiny metal sulphide cavities.
- ❖ They provided the right **microenvironment** for chemical reactions to take place. That kept the building blocks of life concentrated at the site where they were formed rather than diffusing away into the ocean. The iron sulphide cells are where life began

- ✓ All forms of the biochemical theory (abiogenesis) suggest that: life evolved from non-biological molecules which reacted together and eventually formed pre-cells

Summary of main steps in the origin of life according to Modern theory of Origin of life

1. Free Atoms: - Hydrogen, Carbon, Nitrogen, Oxygen etc.
2. Formation of inorganic molecules: - H_2 , H_2O , NH_3 , CO_2
3. Formation of simple organic molecules:- CH_4 , HCN , simple sugars, fatty acids, glycerol, amino acids, nitrogen bases (purines and pyrimidine)
4. Formation of complex organic molecules: - Polysaccharides, fats, proteins, nucleotides, nucleic acids
5. Formation of protocell or protobiont: - Coacervates and microspheres
6. Heterotrophic prokaryotes: - Non photosynthetic and without organized nucleus
7. Autotrophic prokaryotes: - Photosynthetic and without organized nucleus
8. Eukaryotes: - With well-organized nucleus

How did autotrophs evolve on Earth?

- ❖ However the first organisms appeared – about 4 billion years ago – they were prokaryotes.
- ❖ They had no true nucleus.
- ❖ It seems likely also that they had RNA rather than DNA as their genetic material.
- ❖ It seems likely that they gave rise to three distinct lines of evolution leading to:
 - **Archaeobacteria** – prokaryotes including **thermophilic sulphobacteria**, **methanobacteria** and **halophilic bacteria**
 - **Eubacteria** – prokaryotes; **ordinary bacteria** and **cyanobacteria (blue-green bacteria and sometimes known as blue-green algae)**
 - **Eukaryotes** – eventually evolving into **protocists, fungi, plants, animals** (nearly all are aerobic)
- ❖ One great change affected the evolution of early life forms was shift from the reducing atmosphere to an atmosphere containing oxygen.
- ❖ This took place about 2.4 billion years ago. Where did this oxygen come from?
- ❖ The fossil record shows that cyanobacteria had been producing oxygen by photosynthesis from about 3.5 billion years ago but that for almost 1 billion years the levels in the atmosphere did not rise because the oxygen was absorbed by the vast amount of iron in the Earth – it rusted!
- ❖ But, by 2.4 billion years ago, the concentration began to rise and the rate of increase accelerated from 2.1 billion years ago.
- ❖ **Cyanobacteria** are photo-autotrophs; they use light as a source of energy, and CO_2 as a source of carbon (photosynthesis).
- ❖ They are among the earliest of autotrophs, using, not chlorophyll, but another pigment, **phycocyanin** (which gives them their blue-green appearance), to capture light energy.
- ❖ Other primitive autotrophs used not light as a source of energy but **chemical reactions** and are called **chemo-autotrophs**.
- ❖ **Chemo-autotrophs** use the energy from chemical reactions to synthesize all necessary organic compounds, starting from carbon dioxide, only use inorganic energy sources.
- ❖ Most are bacteria or archae that live in **hostile environments** such as **deep sea vents** and are the **primary producers** in ecosystems on the sea beds.
- ❖ Scientists believe that some of first organisms to inhabit Earth were **chemo-autotrophs**.
- ❖ The primitive **sulphobacteria** use **hydrogen sulphide** as the energy source.
- ❖ **Hydrothermalism**, particularly in deep sea vents, maintains the bacterial life of **sulphobacteria** and/or **methanobacteria**.

- ❖ **Bacteria** are the only life forms found in the rocks for a long time, 3.5 to 2.1 billion years ago. **Eukaryotes** became numerous 1.9 to 2.1 billion years ago fungi-like organisms appeared about 0.9 billion years ago.
- ❖ The O₂ produced by the photo-autotrophs had made it possible for aerobic respiration to evolve as an energy-releasing pathway.

4.2 Theories of Evolution

1. Lamarck's theory of evolution

✓ Lamarckism:

- use and disuse
- Inheritance of acquired traits

Use and disuse:

- The continual use of structure or process develops or enlarges the structure or the process. Conversely if not used the structure will be reduced.

E.g. use: 1. the neck of the giraffe and

2. The toes of water birds

According to Lamarck giraffes stretched their necks to reach higher branches and eventually **become long necked**. Water birds strained their toes to swim and finally became **webbed toes**.

- Disuse – e.g. the wing of penguin

Inheritance of acquired characteristics:

The traits changed or acquired during the life time of an individual's **could pass** on to its offspring.

Accordingly, Giraffe's that had acquired long necks would have **long necked offspring** rather than short necked of their parents.

These views of Lamarck were disproved after discoveries of **genetics**.

However, Lamarck believed that evolutionary change takes place **gradually** and **constantly** and this is accepted.

2. Darwin's theory of evolution

- Published his famous paper **natural selection**
- He observed different species finches in different Islands of Galapagos.
- He noticed by different finches occupied these islands and became adapted in different ways because they faced **different selection pressures**.

e.g.: - Some of them with pointed beaks adapted to eat insects.

- Some of them with strong and short beaks adapted to crush seeds.

- He explained this as descent with modification. We now call this **adaptive radiation**.

- He summarized his observations in two main ideas:-

1. All species tend to produce more offspring than can possibly survive.
2. There is variation among the offspring.

From these observations he deduced that:

There will be a struggle for existence between members of a species (because of high reproduction and resources are limited). Some members of a species Will be better adapted than others to their environment (because there is variation combining these two deductions:

Those members of a species which are best adapted to their environment will survive and reproduce in greater numbers than others less well adapted.

Therefore, the main ideas in his theories are:

- Fecundity
 - Variation
 - Competition
 - Adaptation
- leads to 'Natural selection theory'

Comparison of Lamarck's theory of use and disuse with Darwin's theory of natural selection

Aspect of theory	Lamarck's theory of use and disuse	Darwin's theory of natural selection
Variation	Environment changes, creating a need for the organism to change	There is a natural variation in features and the variations are heritable
Survival	Development of new features (e.g. longer neck of giraffe) in order to survive	Environment selects in favor of those traits that adapt the organism to the environment and against those that do not
Inheritance	new features acquired during lifetime of an individual are passed to the offspring	individuals with advantageous variations of traits survive in greater numbers and pass on these advantageous variations to their offspring
Evolution	new species over time	new species over time

3. Neo- Darwinism

- This incorporates the science of **genetics**.

Darwin didn't know the driving force behind variation and hence evolution.

Gene pool: - all the alleles of the all genes in a population.

Suppose an allele determines a feature (advantageous) to an organism in its environment.

The following will happen:

- ✓ Those with the advantageous allele of the gene will survive to reproduce than others
- ✓ They will pass these advantageous alleles to their offspring
- ✓ The frequency of the advantageous allele in the gene pool of the population will be higher in the next generation.
- ✓ This process repeats over generations and their frequencies in the gene pool increase over time.
- Mutations are important in introducing variation in to populations.
- Any mutation could produce an allele which:
 - ❖ Confers selective advantage - the frequency increases
 - ❖ Is neutral in its overall effect - the frequency may increase slowly, remain stable or decrease
 - ❖ Is disadvantageous - the frequency of the allele will be low and could disappear from the population.
- ✓ Neo - Darwinism take in to account the **genetics** and animal behavior (**Ethology**)
- ✓ Behavior can also be advantageous or not

Behavior patterns that confers a survival advantage will be selected for whilst those that do not will be selected against.

e.g.: Imprinting in geese.

Darwinism	Neo Darwinism
- Proposed by Darwin and Alfred Wallace	- It is the modified Darwinism in the light of genetics and ethnology
- Causes of variation are not included recombination the theory	- It includes causes of variations like of genes, hybridization and etc.
- Only small useful and continuous	- Genetic variations especially mutation help

Variations help in evolution	in evolution
- Unit of evolution is individual	- Unit of evolution is population

4.3. The Evidence for Evolution

- A. Evidence from fossil study (paleontology}
- B, Evidence from Comparative anatomy (body structure)
- C, Evidence from comparative embryology
- D, Evidence from comparative biochemistry
- E, Evidence from plant and animal breeding

A. Paleontology (Fossil record):-

- ✓ The word '**paleontology**' refers to the study of ancient life and comes from the Greek words *palaaios* (ancient) and *logos* (study). Fossils form the basis of this science as they are the main direct evidence about past life.
- Displays that living things have different age of fossils as they appeared on earth at different times. The most direct evidence for evolution comes from the discovery, identification, and interpretation of fossils, which are the remains or traces typically left in sedimentary rock by previously existing organisms.

- ✓ We can group fossils into two categories:

Category 1: the remains of the dead animal or plant or the imprint left from the remains, including: bones, teeth, skin impressions, hair, the hardened shell of an ancient invertebrate such as a trilobite or an ammonite, an impression of an animal or plant, even if the actual parts are missing.

Category 2: something that was made by the animal while it was living that has since hardened into stone; these are called trace fossils and include: footprints, burrows, coprolite (animal faeces)

How Fossils form?

1. Death without decomposition

- The organism must die near water
- The dead is covered with water.
- This prevents higher decomposition by bacteria but soft parts could decompose.

2. Sedimentation

- Tiny particles (solid) settle out of the water and bury parts of an organism.
- Sedimentation further insulates the dead from decomposition.
- The nature of the sediment also determines the quality of fossil.
- Sediments like clay form more detailed fossil.
- The chemical content of the sediment determine the nature of the fossil. E.g.: Iron rich Sediment makes a reddish color, whereas phosphate rich will give a grey or black color.

3. Permineralisation

- ✓ As time passes, the sediments change into rock.
- ✓ As water seeps through it, the minerals in the water glue the sediment together more (these minerals are different from the original).
- ✓ Over millions of years, these minerals dissolve the original hard parts of an organism replacing exoskeleton with molecules of Calcium carbonate or another.
- ✓ This takes the shape of an organism (now rock).
- ✓ Now, this rock is differently visible (appear) from other nearby rocks.

4. Uplift

- ✓ As the continental plates move around the earth, colliding with each other, mountains form
- ✓ Therefore, what were sea floors are lifted up and become dry land.

- ✓ The fossil becomes exposed.

How can we date fossils?

1. Stratigraphy

- Uses a strata of sediment rocks
- The lowest layers become the oldest strata and also the oldest fossil.
- The upper strata is the recent strata and also be the recent fossil
 - ✓ Used to date fossils over 10 million years old

2. Radioactive dating method.

- Radioactive Carbon dating or
- Potassium argon dating

These methods rely on the principle that radioactive atoms decay into other atoms overtime.

Half-life time ($1/2t$)

- During this period ($1/2t$), half of the radioactive element (50%) decay and 50% remains.

For example: The half-life of C^{14} is 5730 years.

- ✓ By 5730 years, half (50%) of the original C^{14} is decay into N and 50% remains radioactive.
- ✓ By the 2nd half-life (11460 years), 25% remains radioactive. Therefore, 75% already decayed.
- ✓ By 3rd half-life (17190 years) 12.5% of Carbon 14 is still radioactive and etc.

- ❖ **Potassium–argon** dating works in the same way, but the half-life in this case is 1.3 million years. This makes potassium–argon dating suitable for dating rocks millions of years old, whereas radiocarbon dating is really only accurate with rocks up to 60 000 years old.

B. Comparative anatomy: shows that organisms may have either homologous structure or analogous structure.

Homologous structure: structures which have the same origin (common ancestor) but may or may not have the same function.

- Anatomically similar structures inherited from a **common ancestor** and have a common evolutionary origin; but may have different functions.
- have different functions because of their adaptation for different habitat (divergent evolution)

Examples: - wings of birds and forelimbs of mammals

Analogous structure: structures those have different origin (have no common origin) but have the same function (same adaptation for similar habitat) what it is called convergent evolution.

Examples: - wings of birds and wings of insects -

C. Comparative embryology: similar origin and development of embryos show common origin of vertebrates.

- This shows similarities which supports common ancestry.
 - ✓ Comparative embryology provides evidence of evolution because: very different embryos show similarities in their early development

Example: All vertebrates embryo have gill slits and tails.

- Gill slits - connect throat to outside in next development in some. But in others it will be closed.
- In fishes it develops into gills.
- In humans, the tail is reduced to coccyx (tail bone).

D. Comparative biochemistry: ancestrally related species show similar biochemistry and physiology because of common origin.

- rely on DNA and proteins.

DNA:

- The base sequences of d/t organisms compared.

Isolating DNA from two species (Species A and Species B)

- Heating both DNAs to form single stranded DNA (ssDNA)
- Mixing the ssDNA of two species and cooling.
- Looking the hybridization of two ssDNA from two species
- There are also sites of mismatching (not pairing).
- This helps to calculate the percentage of similarities.

Proteins

Ex: - **Cytochrome C** (in ETC of respiration)

- **Hemoglobin**

Haemoglobin is similar in all organisms that possess it, but there are differences.

Example: In lamprey (fish like animal) is only one polypeptide chain of hemoglobin not 4.

- Most animals have 4 chains but the chains do vary.

Example: Lampreys 125 amino acid difference to humans.

- Frogs 67 amino acid differences in chain.

- Dogs 32 amino acid sequence in chain.

- Macaque 8 amino acid sequences only in the hemoglobin.

This indicates that, macaques are the close relative to humans.

E. Breeding of plants and animals: selective breeding of domestic plants and animals shows that the characteristics of species are modifiable and changeable

- This is artificial selection (selective breeding).

- These were done to obtain:

❖ High yield (like milk, seed, beef)

❖ Desired traits.

✓ If new varieties can be produced by selective breeding, then natural selection should also be able to produce new varieties, and eventually, new species.

❖ Plant and animal breeding provide evidence of evolution because they show that selective breeding can produce new varieties

4.4 The Processes of Evolution

Natural selection:-

- is the differential survival and reproduction of individuals due to difference in **phenotype**.

- favors the survival and reproduction of individuals with the best fitted and adapted genotypes while it perishes the unfavorable genotypes in a population

It is constantly changing due to mutations, and gene recombination that introduces new genes into the population.

Types:-

A. Directional selection: favors the phenotypes at one extreme over the others.

- reduces variation

Individual at one extreme could have a disadvantage whereas those at the other extreme have an advantage.

Ex: Thicker fur (longer fur) in cold climate (in foxes) is an advantage.

B. Stabilizing selection:

- Favors individuals of a population with average values (traits).

- Favors an intermediate phenotype and acts against extreme variants.

- reduces variation and improves adaptation of population to aspect of the environment that remains relatively constant.

Ex: Birth mass in human. Both over weight and under weight babies shows a higher neo natal mortality rate than those of medium mass.

C. Disruptive selection:

- **favors individuals of a population with the extreme value (trait)**
- **Intermediate phenotypes can be eliminated from the population**
- **May even split a population into two sub- populations**

Example; Darwin Finches, The medium sized beak finches neither crush the seeds unlike those with powerful and short beaked nor look for insects from cracks unlike those with very longer beaks. Therefore, overtime, both with shorter and powerful beaks and longer beaks increase in number and those with medium sized beaks number decreased in number.

Formation of new species

- ✓ This is called speciation.

Species: A group of similar, interbreeding organisms that produce fertile offspring.

There are two forms how different species form. These are:

a. Allopatric speciation

b. Sympatric speciation

a. Allopatric Speciation

- Some physical barriers must isolate the population.

E.g.: - river changing course

- Mountains
- Land mass separating two bodies of water

- ✓ **This is type of geographical isolation**

- ✓ **There is no interbreeding between the population and speciation could result.**

e.g.: Isthmus of Panama separating the Caribbean Sea and North Pacific ocean which were joined 3 million years ago. Two populations of shrimps formed as a result. Now, they will not reproduce even if they come together, rather they show an aggressive behavior.

b. Sympatric speciation

- No physical barrier.

The population inhabits the same area but prevented from breeding in different ways.

i Seasonal isolation - reproducing at different seasons.

ii. Temporal isolation - reproducing at different times of a day.

iii. Behavioral isolation - with different courtship patterns.

e.g.: palm trees growing on one island of Australia. The islands soil is partly acidic and partly alkaline.

- ✓ The palm trees growing on these soils reproduce at different seasons of a year.
- ✓ This is also an example of disruptive selection as the palms must grow on acidic or alkaline soil types.

Divergent evolution: a pattern of evolution in which species that was once the same diverges or become increasingly distinct.

- **occurs when populations change as they adapt to different environmental conditions. The pattern of speciation and adaptive radiation are examples of divergent evolution. Adaptive radiation was noticed by Charles Darwin in different species of finches found in Galapagos Islands**
- **finches have adapted to feeding on different kinds of food.**

Convergent evolution:

- **Two completely unrelated species share similar traits. Similarity arises because each species has independently adapted to similar environmental conditions.**
- **In which different species appear similar due to similar adaptations (analogous structures).**
- **Example pectoral fins of fish and flipper-like forelimbs in dolphin.**

What are Divergent evolution and convergent evolution?

Divergent evolution(adaptive radiation)	Convergent evolution
- Development of different characteristics by organisms derived from the same ancestor	- Tendency of different species to develop similar characteristics
- Occurs when similar organisms occupy different niches	- Occurs when different organisms occupy similar niches
- Evolution of different adaptations	- Evolution of similar adaptations
E.g. - the evolution of the different species of finches on the Galapagos Islands - the evolution of the different forms of the pentadactyl limb	E.g. -evolution of the giant armadillo, giant pangolin, giant anteater, and spiny anteater.

- ✓ Convergent evolution is also responsible for the wings of a bird, a bat, and the extinct pterodactyl.

Co- evolution: when two or more species depend heavily on each other for their survival and propagation that they constantly evolve together.

A population is a group of individuals of one species that live in the same geographic area at the same time.

4.5 The evolution of humans

- Human evolution shows the gradual changes of genetic make ups, physical appearance, sizes, physiology, morphology and other aspects due to different causes.
- Human evolution is caused by different factors.
- Cause of human evolution can be manmade and natural cause of human evolution without human input (effect) are natural causes of evolution like genetic disorders, natural mutation, evolution due to ultraviolet etc.
- Same are induced causes of evolution like genetic engineering (biotechnology) different therapy, medicine, processed food, food preservatives etc.

Who are we and where have come from?

- The evolution of homo sapiens is still debated a lot and remains to be studied.
- Human beings can be described as:

Homo-erectus - up righted man

Homo habilis - hand users to hold tools

In general we modern humans:

- are the latest of several human to live on the planet
- have two unique features that distinguish from other human races. These are:

1. Very huge brain

2. Bipedalism to walk truly on two legs

- Evolution has its own evolutionary lines represented by evolutionary tree.
- Evolutionary tree shows the relationship among different primates.
- **Hominine**: represents any member of genus Homo.

- **Hominid**: represent groups of species that includes all species that belong to genus **homo**.

What is significant about Lucy & Ardi?

- **Lucy** and **Ardi** are important fossils found in Ethiopia.
- Modern human and chimpanzee came from common ancestor.
- Lucy was discovered by **Donald Johansson** and **Tom Gray** in 1974 at **Hadar in Ethiopia**.
- **Lucy** is a fossil dated about **3.2 million** years ago with following characters:
 - Species **Australopithecus Afarensis**
 - she was female adult.
 - she was 25 years old.
 - her skeleton was 40% completed.
 - She was bipedal.
 - She was partly arboreal /tree dwellers/
 - Has 107cm tall.
 - She was 28kg by mass.
 - She was the oldest fossil Hominines.
 - Size is between modern human & Chimpanzee.
 - She had brain its size is like chimpanzee.
 - Bipedalism came before large brain.
- **Ardi** Fossil: was first discovered in 1992 in the afar desert in Ethiopia.
 - Research papers show **Ardi's** unique character position in human evolution.
 - It was 1.2 million years older than Lucy.
 - It was female.
 - The fossil is **4.2 million** years older.
 - It belongs to **Ardipithecus -Ramidus**.
 - She was **bipedal**.
 - Her ancestor is nearest to **humans & chimpanzee**.
 - Ancestors of chimpanzee & humans are not exactly resembled because chimpanzee is not truly bipedal (two legs).
- ✓ According to evolutionary lines human brain size increases from time to time.

- Large brain size helps people to:**
- Run faster
 - Have more upright posture
 - Plan in advance to avoid attack
 - Develop & use tools as well as weapons

Are we still evolving?

- **Homo sapiens** originated from East Africa and distributed into different environments throughout the world.
 - Due to different biological & physical factors we are still evolving throughout the world.
 - **Based on this evolutionary effect there are three human races.**
1. **African (Negroid)** includes 100 million peoples from Africa & Melanesians of the South Pacific.

2. **Eurasian (Caucasoid)** 1000 million people ranging from white to dark brown.
 - ✓ **Nordic** - often tall, blonde and narrow-headed; includes people from Scandinavian and Baltic countries, Germany, France, Britain
 - ✓ **Mediterranean** - usually lighter in body build, dark and narrow-headed; includes people from Southern France, Spain, Italy, Wales, Egypt, Jews, Arabs, Afghanistan, Pakistan, India
 - ✓ **Alpine** includes usually broad headed, square jaws, olive skin, brown hair, includes peoples from Mediterranean to Asia.
 3. **East Asian (Mongoloid)**- are most numerous of the present day populations and split into three groups:
 - a. East Serbians, Eskimos, North American Indians.
 - b. Japanese, Koreans & Chinese.
 - c. **Indonesians & Malays**
- We may still evolve into diverse species, but, at the moment, the mechanisms that usually drive speciation have been modified by our large brains.**

UNIT 5 BEHAVIOUR

5.1. What is behavior?

Behavior has many definitions as follows. Behavior:-

- is behaving bad or good.
- is observable response to any situation
- is manner of acting or conducting
- Way of behaving towards others
- Action or reaction of a person with stimuli
- The movement of organisms to some stimulus or away from the stimulus

However the better definition of behavior is coordinated response to **internal** or **external** stimuli.

- Any behavior has the following components.
 - ✓ Receptor - detect stimuli
 - ✓ Effector - produce response
 - ✓ Coordinators - influenced by receptor and influence effector
- This is represented by the following flowchart

Stimulus → **Receptor** → **Coordinating system** → **Effector** → **Response**.

- ❖ **Neuroscience** the branch of science concerned with the brain and the nervous system
- ❖ **neuroethology** the study of how behavior is linked to neural pathways
- ❖ **neural pathway** a sequence of nerve cells involved in bringing about a specific behavior
- ❖ The study of animal behavior is often called **ethology** and the biologists are known as **ethnologists**

How do plants respond to unidirectional stimuli?

- ✓ The process of elongating plant shoots towards light intensity is known as phototropism.
- ✓ Plant shoots are positively phototropic because they grow towards light.
- ✓ Plant growth towards light is maintained by plant growth hormone called **auxin**.
- ✓ Plants can respond in the following pattern

1. **Phototropism**- Provide response to light
2. **Thigmotropism** - Provide response to touch.
3. **Gravitropism** - Provide response to gravity
4. **Hydrotropism** -Provide response to water and etc.

How do simple animals respond to stimuli?

- ✓ Plants respond to stimuli by growing **towards** or **away** from stimuli but animals move away or towards stimulus.

Taxis (pl. taxes): is movement of small animals towards (positive taxis), or away from (negative taxis) a stimulus.

Positive taxis: - Move towards Intensity of Stimuli

e.g. euglena Towards Light

Negative taxis: - move away from intensity of stimulus

e.g. some animals move away from light

Kinesis (pl. kineses): is change in rate of movement due to change in stimulus intensity. It does not involve change in direction.

✓ Intensity of stimulus change threats of movement. But not directional

e.g woodlice

Importance of studying behavior

- ❖ Studying animal behavior is important because we can gain information that can be used in:-
 - **Neuroscience:** - in collecting behavioral data, determining neural pathways and displaying influences on physiology and cellular process.
 - **the environment and resource management:-** in providing early clues of environmental damage
 - **Animal welfare:** - to ensure effective standards for the care and wellbeing of research animals.
 - **science education:-** to intensify studies and students interest at higher education
 - **Human behavior:-** as basis for interpreting human society and understanding possible causes of problems in society

Types of behavior

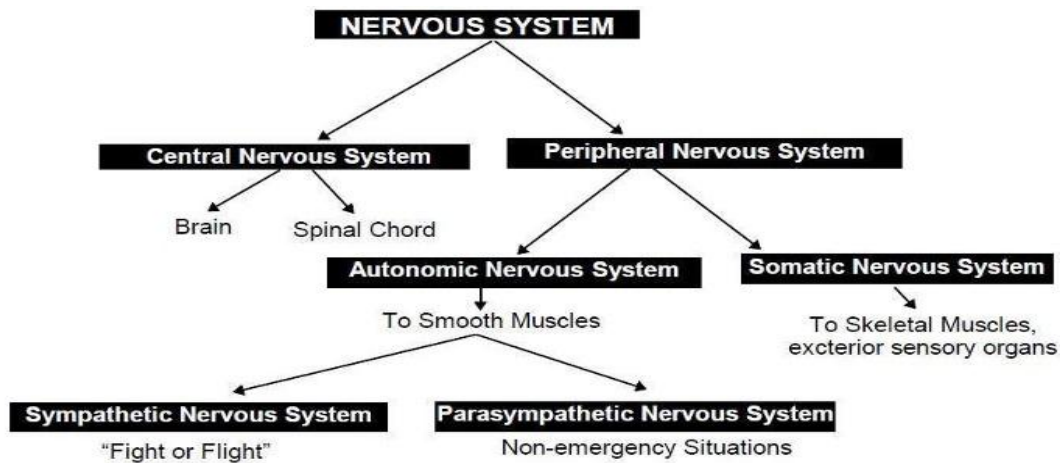
Innate behavior(inborn)	Learned behavior(acquired)
- is natural potential (software) - Programmed by nature - hard to lose or modify - has fixed action pattern	- gained by experience - easily gained and lost - can be modified - may not have fixed pattern

5.2 Innate behavior (inborn)

Instinctive behaviors have the following characteristics:

- They are common to all members of a species
- They are fully functional the first time they are performed (they require no learning)
- There is a key stimulus that triggers the behavior
- There is an innate releasing mechanism that links the stimulus to the response (this may be nervous or hormonal)
- There is a fixed action pattern in response to the key stimulus that is always the same, and
- Instinctive behaviors are adaptive – they have been retained in the species by natural selection because they confer a survival advantage.

Structure of Nervous System (NS)



5.2.1. Types of innate behavior

1. Reflex actions

- are simplest forms of behavior
- out of human control
- e.g - withdraw hand
- sneezing
- Knee jerk
- Blinking
- vomiting

2. Orientational

- eg - taxis and kinesis
- More complex behavior
- Process of moving from unfavorable to favorable conditions

3. Instinctive behavior

- Most complex behavior
- Hard to modify
- has fixed action pattern
- has key stimulus
- e.g - nest building
- weaving a web
- imprinting

How human reflex action brought about?

✓ Somatic reflex

- Controlled by skeletal muscles

e.g Knee jerk, withdraw hand from heat

✓ Autonomic reflex

- Controlled by internal organs
- eg heart beat

Biological clock

A biological clock is an internal regulatory mechanism that controls a cyclical process in an organism; it may be:-

- circadian (controls a daily cycle)
- lunar (controls a monthly cycle)
- circannual (controls a yearly cycle)

Biological clock

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➤ It can be entrained.

Imprinting is another kind of instinctive (inborn) behavior in newly born (hatched) organisms. It is the process by which animals acquire their first forms of behavior, particularly their attachment to their mother. Fixed action pattern (FAP) is for newly born/hatched/ organisms to imprint on or become attached to the first thing they see that has certain general features

E.g. In humans, Strong emotional bond (attachment) between an infant and its primary care giver (often the mother) occurs in three stages:

- **Pre-attachment** (0-2 months):- the infant prefers people to objects without discrimination.
- **Indiscriminate attachment** (2-7 months):- the infant begins to show a preference for familiar people
- **True emotional attachment to one person initially** (from 7th months onwards):- but soon multiple attachments form.

5.3. Learned behavior

It is known as acquired behavior.

- ✓ Is gained after birth.
- ✓ Gained by experience.
- ✓ Is not common to all members of the group.
- ✓ Trial and error improves their effectiveness

There are different kinds of learned behavior. These are:

- | | |
|---------------------------|---------------------------------|
| - Habituation | - associative learning |
| - Sensitization | - classical conditioning |
| - Insight learning | - latent learning |

Habituation: is a type of learned behavior in which organisms being sensitive to the stimulus and then decrease their sensitivity due to repeated response.

e.g deodorant smell into new room through time our sense of smell adapts & loses response.

Sensitization: is the opposite of habituation

- increasing sensitivity of the organism to particular stimulus
- increase response to harmless stimulus
- ✓ In higher animals, **peripheral sensitization** refers to the sensitization those results from changes in neurons of the peripheral nervous system.
- ✓ **Central sensitization** refers to the same process occurring in neurons of the central nervous system.

e.g. A person becomes more sensitive to snake sight during his adulthood proceeded by a snake bite during childhood.

Classical conditioning: Is the process of associating naturally occurring stimulus with different stimuli
example Pavlov's experiment on dogs.

It has - Unconditioned stimulus (US) - natural e.g. Food
- Unconditioned response (UR) - e.g. hunger (salivation)
- Conditioned stimulus (CS) - bell attached with food.
- Conditioned response (CR) - salivation for bell.

What is operant conditioning?

- Operant conditioning can modify more complex, voluntary behaviors by animals, person learning to associate the behavior with certain specific consequences.

Skinner identified three types of responses that he called operant that can follow behavior:

1. **Neutral operant:**-Neither increase nor decrease the probability of behavior being repeated.
2. **Reinforcer:**-Increase the probability of the behavior being repeated.
3. **Punishers:**- decrease the probability of behavior being repeated.

Example parents offering praise when their children do something positive and beating by stick when they do something negative.

Specific examples of where shaping is used include:

- Training guide dogs for the blind
- Training horses
- Training dolphins and killer whales at marine parks
- Training zoo animals

✓ **Both classical and operant conditioning** are sometimes referred to as **associative learning** because the animals learn to modify their behavior as a result of either associating two different stimuli or associating particular behavior patterns with operant responses

What is latent learning?

- ✓ It is the process of using hidden knowledge to provide response or repeated behavior
- ✓ Using the previous experience to repeat the behavior
- ✓ Latent learning happens when the brain acquires knowledge at certain time, without reinforcement, but does not use it until later, at a time when that knowledge is needed.

Example: a student studying very hard but not sure of his knowledge until he/she answers exam questions correctly.

What is insight learning?

- This one is different from trial and error in classical conditioning.
- Insight learning is the process of finding solutions for particular problems without actual experience.

Insight learning is finding solutions to problems without experience (trial and error), it involves mental "trial and error" and often the solution is learned suddenly.

Example: Wolfgang Kohler worked (experimented) with chimpanzees to demonstrate insight knowledge. A chimpanzee was placed in an enclosed room where a bunch of bananas was hanging from the ceiling out of reach of the chimpanzee. Empty boxes were also placed in the room. The chimpanzee piled up the boxes and climbed up to reach the fruits.

5.4. Examples of behavioral pattern

- Different organisms have different behavioral patterns.

What is courtship behavior?

Courtship behavior is the interaction of couple animals for the mating and reproduction purposes.

Animals have different communication styles for their courtship behavior.

Example: some use pheromones /chemicals /

- Some Use Sound /songs/

- Some Use Physical activity and other communication style.

• **Generally courtship behavior may involve:-**

- secretion of sex pheromones
- courtship vocalizations
- touch
- complex displays involving a series of fixed action patterns

Pheromones:

This is yet another term derived in part from a Greek word and translates as 'hormone bearer'. It is a chemical secreted by one animal, usually the female, to produce a behavioral response in another. There are many different pheromones, including:

- **Alarm pheromones** that are secreted by animals when attacked and produce the response of flight or aggression by others of the same species
- **Releaser pheromones** that are highly volatile and can attract a mate from a distance of two miles or more
- **Territorial pheromones** that are used to mark the boundaries of a territory by the owner; dog urine contains a powerful territorial pheromone
- **Sex pheromones** that signal the availability of a female for mating

What is territorial behavior?

Territory: is any space that an animal defends against intruders of the same species.

- Territorial behavior is found in nearly every species of animal's even humans.
- Possessing territory gives the holder's areas to forage for food and increase the chance of attracting for mating.

Territorial behavior can involve:

- marking the area
- threatening vocalizations
- threat displays (exaggerating size or displaying weapons)
- ritual fighting

- **Territorial animals usually defend areas for:-**

- ✓ **nest**
- ✓ **Den or mating**
- ✓ **Sufficient food for themselves & their young.**

- **Examples** Ethiopian wolves defend territory by urination.
- Some animals are fighting for defending their territory.
- **Ritual fighting**: is the behavior in which the acts of fighting are displayed without physical contact.

What is social behavior?

- Social behavior is the interaction between or among individuals of some species.
- It is common in social animals like honey bee.
- There are three castes of honey bees.

These are:-

1. Queen: **reproductive female**

2. Workers: **non-reproductive female**

3. Drones: **reproductive male.**

- ✓ Only 1 queen is found in one hive.
- ✓ Workers from 10,000 - 50,000 are in one colony.
- ✓ Drones are from 100 - 500 in one colony.
- **Honey bees have complete metamorphosis.**

Egg → Larva → Pupa → Adult

- ❖ Many duties are left for workers bees.
- ❖ Worker bees have different communication styles to show:-
 - ✓ Food source.
 - ✓ Distance from their hive
 - ✓ Angle & direction too.
- ❖ Honey bee make wag - dance to show food source and distance.
- ❖ Angle of dance shows angle of nectar from the sun.
- ❖ The length of the straight run is part of dance that shows proportional distance from the nest.
- ❖ Social insects have division of labor among themselves.

Benefit s of social behavior

- form stable groups and reduce intra-specific aggression
- improve the effectiveness of reproduction and/or parenting
- forage more efficiently – especially if sources of food are localized
- protect themselves against attack more effectively
- increase the chance of surviving migration
- increase the chance of surviving extreme conditions
- Communicate across long distances.

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