UNIT ONE

1. APPLICATIONS OF BIOLOGY

INTRODUCTION

- Biology is the science of every kind of life no matter where it lives, how big or small it is. Life is all around us, humans, plants, organisms which we cannot see with our eye, all are living things. As a result , Biology is broad in its scope of study.
- **Biology: -** is the science in charge **of studying all living beings**.
- **Biology:**- help us to understand **every living organism**
- Determine where some **diseases and pests** come from.
- Covers the study of the functions of **living organisms**, the **evolution of species, the factors that produce disease, as well as the discovery of new drugs.**
- Allow human beings to explore topics such as **genetic engineering, research applications with mother cells and global warming.**
- Help us to understand nature and **how humans, animals, and plants interact in life**.
- **Practical application of biology** includes:
  - Hand washing, domestication, and traditional fermentation.
  - The set of instructions given to take all the pills of antibiotics in guidelines.

1.1. Application in conservation of natural resources

After the successful completion of this section, you will able to:

- Define natural resources.
- Identify renewable and non-renewable resources
- Describe the role of conservation in protecting and preserving our natural environment.
- Discuss the role of biology in the conservation of natural resources.

Natural resources: - are resources supplied by nature.

Example: Soil, water, air, plants, animals and energy.

Conservation:-is the careful **maintenance and wise use of natural resources** to prevent them from disappearing.

Conservation biology: - is a **mission- oriented science** that focuses on how to protect and restore biodiversity (the diversity of life on Earth).

Classification of natural resources

1. **Renewable natural resources**
2. **Non-renewable natural resources**

Renewable natural resources:-

- are mainly living things and their products.
- When managed carefully, they can be used, reused, and replaced.
- The main sources of renewable resources are sun, wind; water, the earth's heat (geothermal) and biomass e.g. crop plants, trees, cattle, and chickens.

Non-renewable natural resources

- Are **NOT replaced** as same speed as those are used up.
- They are finite resources.

  E.g metals (iron and gold) fossil fuels (coal, natural gas and oils)
- Conserving **Non-renewable natural resources** and using renewable energy sources would more beneficial to the planet.

? How do Biologists conserve species?

- Through preservation of plants and animals in terms of **seed bank and zoos**.

- By stopping the destruction of their natural habitat,
- Conservation is **protecting and preserving our natural** environment so that-**Nonrenewable natural resources** are used **sparingly**, and **renewable natural resources** should be **appropriately managed**.

1.2. Food and Nutrition Security

Learning competency

- Define **food security**
- Practice school based gardening one strategy of addressing food security

Food security:-is a state in which all the **people have physical, social, and economic** access to **sufficient, safe and nutritious food** that meets their food preferences and dietary needs **for an active and healthy life all times**.

- **Food insecurity** is often rooted poverty
- **Has long term impact** on the potential of the families, communities and countries.
- **Prolonged undernourishment cause**
  - Stunt growth,
  - Slow cognitive development and
  - Increases susceptibility to illness.

Nutrition security:- is a situation whereby individuals have access to **sufficient, safe, and nutritious foods, safe water and adequate sanitation, the ability to access health care services, and knowledge of sound household and community practice in childcare food storage and preparation and hygiene**.

FOOD SECURITY IS ENSURED ONLY:-

- If enough food is available for all in a country
- If all individuals have the capacity to **buy food** of acceptable quality
- When there is NO barrier to access food

? What is the difference between Food security and Food insecurity

- **Food security: - refers to the availability and the access of food to all people.**
- **Food insecurity:- demand the intake of a wide range of food which provides the essential needed nutrients**

? What are the roles of Biology to ensure food security

- Producing **high-nutrient staple crops** and
- Developing **New products** that can **combat balance nutrition.**
- **Biotechnologists** design machinery used to produce food and drinks.
  - This allows having consistent flavor, color and texture to be produced in large quantities.

1.3. Creating Conscious citizens and Ensuring sustainable development

Learning competencies

- Define conscious citizens
- Explain the role of biology in creating conscious citizens
- Explain how sustainable development can be ensured and /or define

Conscious citizen: - one who **place value** on being fully human while connecting with a higher purpose;

- Value human life and relationship with all living things.
- Take responsibility for **transforming skills into action** through ethical decision making, to ultimate improve **life and living on the planet**.

? What is the role of Biology in creating conscious citizen?

- By expanding awareness of the social, global and environmental conditions,
- Empowers /enables/ conscious citizens to assume personal responsibility by engaging in and being committed to initiating positive impact.

- **Conscious citizens** will use **Biotechnology application** to improve life and living on the planet.
- **Conscious citizen Biologist** develop innovative and cost effective Bio-based technologies which;
    - Consume fewer resources,
    - Incorporate recycling, reused components and reduce production of wastes,
    - Use strategies for sustaining a greener earth and
    - Improving food production.

- **The conscious global citizens(Biologists)** in Ethiopia involves in sustainable development through **Protecting, managing and monitoring** the existing resource of our land including:
    - ❖ Analyzing soil, water and air for chemical pollution
    - ❖ Finding a ways to clean up pollution
    - ❖ Identifying, recording and monitoring the plants and animals that share the land we use.

➢ According to **the world conservation union**, the three dimension of sustainability (economic, social and environmental) are represented either as pillar, embedded circles or Venn diagram of three overlapping.

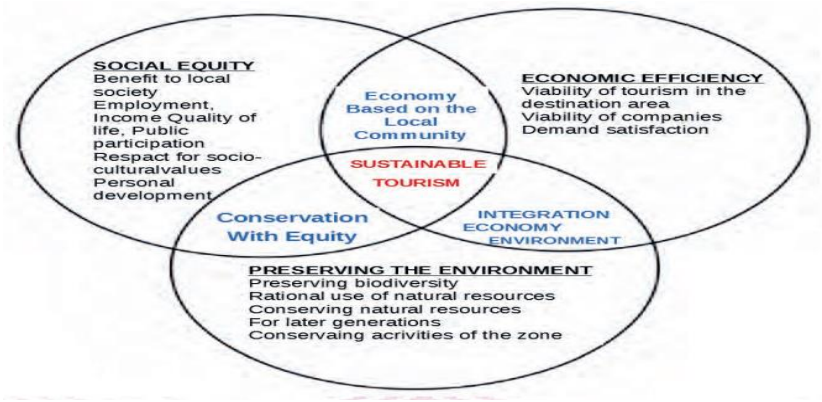


Figure 1 a model for sustainable development

1.4. Application of Biotechnology

What is Biotechnology?

- It is the **application of technologies** that involves the **use of living organisms, or their products** for the development of product that **benefits humans**.
- **GMOs** (Transgenic organisms) have received genetic materials via recombinant DNA technology.
- **Transgene**:-is a gene that introduced into a species from another species.

Biotechnology also can be used in:-

- ❖ Crops modification to make them more suitable
- ❖ Prevention and mitigation of contamination from industrial, agricultural and municipal wastes.
- ❖ Diagnosis and treatment of diseases.

1- Application of biology for food processing and production

- It involves the increasing of food productivity **<u>using microorganisms</u>**. For example:

a. Single celled protein (CSP)

➢ It produced from waste materials such as **molasses** from **sugar refining, Petroleum by-product, and agricultural wastes.**

b. Pruteen (animal feeds)

- Is produced by mass culture of the bacterium ***Methylophilus methylotrophus***

c. Mycoprotein

- Is Protein from fungus
- Is made from fungus ***Fusarium venenatum***

- Is meat substitutes for humans consumption

d. Spirulina(spiral shaped cyanobacterium)

- Is harvested from the surface of lakes and ponds
- Has become a viable **alternative to green plants** as a **primary nutrient source**.
- Can be eaten in its natural form or added to other foods and beverages.

e. Vitamins are also produced

- Vit. C was the first to be produced during a fermentation processes by bacteria
- Vit. B12(cyanocobalamin) & Vit B2 (Riboflavin) were obtained from animal liver extract
- But, now a days the production of vitamin B12 involved fermentation by **Propionic** bacteria.

f. Dairy products

- MOs are used in making a wide variety of dairy products

For example

Cultured butter milk:- is made by adding ***Streptococus cremoris*** to pasteurized skim milk and allowing fermentation to occur and other *Streptococus lactis, S. diacetylactis,* and *leuconostoc citrovotrum,L. cremoris, or L. dextranicum* make butter milk with different falvor.

Sour cream:-is made by adding one of these organisms to cream.

Yoghurt:- is made by adding *Streptococus thermophiles* and *Lactobacillus bulgaricus* to milk.

- These different bacteria give different texture and flavor.

g. Fermented meats

- Microbes such as *Lactobacillus plantarum* and *pediococus cerevisiea* add flavor by fermenting meats such as:
  - **Salami**:- produced by mixing of spice &salt
  - **Summer sausage**:- fermented & dried or smoked
  - **Lebanon Bologna**:-semi-dried beef, smoked and fermented
- The heterolactic acid fermentation helps **preserve the meat** and also gives a **tangy flavor**.

Self-test questions

Match the following items

A B

1. **Pruteen A. *Lactobacillus plantarum***
2. **Mycoprotein B. *Methlophilus methylotrophus***
3. **Vit. B12 C. *Fusarium venenatum***
4. **Butter milk D. *Streptococus thermophilus***
5. **Yoghurt E. *Propionic* bacteria**
6. **Fermented meats F. *Streptococus cremoris***

h. Production of beer, wine and spirits

- **Beer** and **wine** are made by fermenting **sugary juice**
- **Spirit** such as **whisky, gin, and rum** are made by fermenting **juices and distilling** the fermented products
- Strain of **saccharomyces** are the fermenters all alcoholic beverages.

? How to make Beer?

- **Barley are malted** (partially germinated)- to increase the concentration of starch digesting enzymes that provide the sugar fermentation.
- **Malted gain is crushed and mixed with water (about 65^0C)** Producing Mash
- **Wort (liquid extract) is separated from the mix- the most important being maltose**
- **Hops(Flower cones from the hop plant) are added to the wort for flavoring.**
- The mixture is **boiled to stop enzyme action and precipitate proteins**
- A strain of **saccharomyces** is added and fermentation produces **ethyl alcohol, CO2 and other substances (amyl and iso amyl alcohols and acetic and butyric acids)** which added to the flavor of the beer.

- After **fermentation**, the **yeast is removed** and the beer is **filtered, pasteurized and bottled**.

Wine:-is made from **juice extracted from Grapes** & it can be made from **any other fruits and even from nuts** or dandelion blossoms

- Juice is treated with **SO_2** to kill any wild yeasts
- **Sugar** and a strain of **Saccharomyces** are then added and fermentation proceeds
- Fermentation products similar to those in the **beer added to the flavor of the wine**
- Liquid wine is siphoned to separate it from yeast sediment &
- If necessary **cleaned** with agents such as **charcoal** to remove **suspended particles**
- Finally, It is bottled and aged in a cool place

Spirits:- are made from the fermentation of a variety of foods, including:

- ❖ Malted barley Scotch whisky
- ❖ Rye rye whisky, Gin
- ❖ Corn bourbon
- ❖ Wine or fruit Juice Brandy
- ❖ Potatoes Vodka
- ❖ Molasses rum

- ➢ After fermentation **distilling separates alcohol** and other volatile substances that impart flavor from the solid nonvolatile substances
- ➢ Because of distillation the alcohol content of the spirits ranges from **40-50%** much higher than the typical 12% for wine and 6% for beer.

i. Bread making

MOs accomplish three functions in bread making

1. **Leaving** the flour-based dough
2. Imparting **flavor** and **odor**
3. Conditioning the dough to make it workable

- ❖ Leaving is achieved primarily through the release of gas to produce a porous and spongy products
- ❖ Without leaving, bread dough remains **dense, flat and hard**
- ❖ The most common microbes used are various strains of the baker's yeast –***saccharomyces cerevisiea***
- ❖ Other gas forming microbes such as **coliform bacteria,certain clostridium species, heterofermentative lactic acid bacteria, and wild yeasts** can be employed depending on the type of bread desired.
- ❖ Yeast respires aerobically in bread dough and produce **CO_2 & H_2O**
- ❖ **Kneading** and microbial enzymes also contribute to bread texture,
- ❖ Kneading incorporates air in to the dough
- ❖ Microbial enzymes breakdown **flour protein** (gluten) and gives the **dough elasticity**
- ❖ Bread fermentation generate other **volatile organic acids** and **alcohol** that impart delicate **flavors and aromas**
- ❖ **Yeast & bacteria** can also impart unique flavor, depending upon the culture mixture and baking techniques used. Example
  - ➢ The **pungent flavor** of rye bread comes from in part from starter cultures of lactic acid bacteria such as ***Lactobacillus plantarum L. brevis, L.bulgaricus,Leuconostoc mesenteriods*** **and** ***Streptococus thermophiles***
  - ➢ **Sour dough bread** gets its unique tang from ***Lactobacillus sanfransisc***

1.5. Genetic Engineering

- ❖ **is the process of transferring DNA from one organism into another that result in genetic modification. The production of a transgenic organism.**
- ❖ **Is used in production of :**

- **Pharmaceutical,**
- **Gene therapy, and**
- **The development of transgenic plants and animals**

(a) Animal breeding and transgenic animals, and plants and disease, and pest management

- Animals can be genetically modified for valuable traits such as:-
  - enhancing the prolificacy and reproductive performance,
  - increasing feed utilization and milk production and or composition,
  - modification of hair or fiber,
  - increasing disease resistance
- **Gene** transfer is relatively rapid way of altering the genome of domestic livestock

(b) **Tissue culture**

- It is a method of biological research in which fragments of tissue from animal or plant are transferred to an artificial environment in which they can continue to survive and function
- Large amount of plants can be produced using this techniques
- example palm trees, orchids bananas, & carrots etc

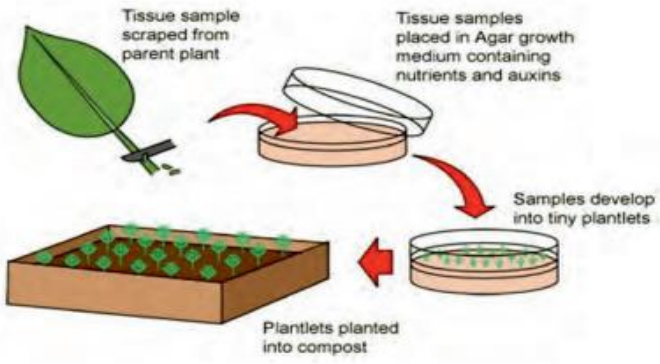


Figure 2. plant tissue culture

- the cultured tissue may be consist of a single cell, a population of cells, or parts of an organ
- tissue culture is important for **the production of disease free, high quality planting material, and rapid production of many uniform** plants.

1.6. Health and wellbeing

- ***Transgenic bacteria*** Bacteria that have received the appropriate gene from human, cow or pig can produce **insulin, growth hormone, tissue plasminogen activator (tPA)** for heart attack victims as well as animal drugs like bovine or **porcine somatotropin** (contain growth hormone)

(a) The manufacturing of antibiotics

- **MOs** can be used for the production of antibiotics (complex organic cpd)
- One of the most prolific or productive source of antibiotics is ***Actinomycetes*** (filamentous bacteria resemble mould fungi)

Example: - **Streptomyces** produce the antibiotic **streptomycin.**

- **Pencillin** –is the best known antibiotic
  - Is produced by the mould fungi **penicillium notatum.**
  - Was discovered by **Sir Alexander Fleming** in 1928
- The different mutant forms of the fungi produce different types of **penicillin**

Example:-Ampicillin, Methicillin, and Oxacillin

- Antibiotics attack bacteria in variety of ways
  - **I.** Some **disrupt the production of the cell wall** and **prevent the bacteria from producing, or even cause them to burst**
  - II. Some interfere with **protein synthesis** and thus arrest bacterial growth
- **Bacteriostatic**:- are those that **stop bacteria from reproducing**.
- **Bactericidal**:- are those that **kill** the bacteria.
- Although antibiotics may produce some side effects(such as allergic rxcs), they **do not** damage human cells because
  - **Animal cell do not have cell wall**
  - **The cell structures involves in protein synthesis are different**
- Some vaccines are also adaptive to mass production through fermentation
  - Vaccines for ***Bordetella pertussis***, ***salmonella typhi***, ***vibrio cholera***, and ***mychobacterium tuberculosis*** are produced in large batch cultures.
  - *Corynebacterium diphteriea* and *clostridium tetani* are propagated for their toxins, from which toxoids for the DT(diphtheria titani) vaccines are prepared.

(b) Biosensor

- **Is a device which uses a living organism or biological molecules, especially enzymes or antibodies, to detect the presence of chemicals.**
  - is an analytical device, used for the detection of a chemical substance that combines a biological component with a physicochemical detector.
  - Is rapidly developing area of biotechnology
  - In this field of bioelectronics, living microorganisms (their enzymes or organelles) are linked with **electrodes** and **biological reactions** are converted in to **electrical current** by biosensors.
  - They are being developed to measure specific components in beer, to monitors pollutants, and to detect flavor compounds in food.
  - Applications include the detection of Glucose, Acetic acid, Glutamic acid, Ethanol, and biochemical oxygen demand and to measure cephalosporin, nicotinic acid, and several B vitamins.
  - Recently biosensors have been developed using immunochemical –based detection system.

(c) Forensic science

- Forensic biologists inspect **crime scenes** to examine potential source of evidence using blood, saliva, and hair, and then they analyze the specimen in a laboratory, **focusing on DNA analysis**.
- **Finger prints** are also important tools to investigate crime and determine the paternity case of a child.
- This is because each individual has unique finger prints that do not change throughout life.
- Based on their investigations, they write up their findings in technical report and are called upon to testify in court.
- These days **`bioinformatics`** is widely acceptable in the field of forensic science b/c it has quite easier and reliable to gather information.
- **`Bioinformatics`** is a science that **develops methods and software tools** for understanding **biological data** such as **genetic codes**.
- The chance of two individual having the same genetic pattern by chance can be approximately **1 in 10 billion**
- **In the diagram below, individual A& C can be eliminated from further enquiries whereas B remains a clear suspect for committing the crime.**

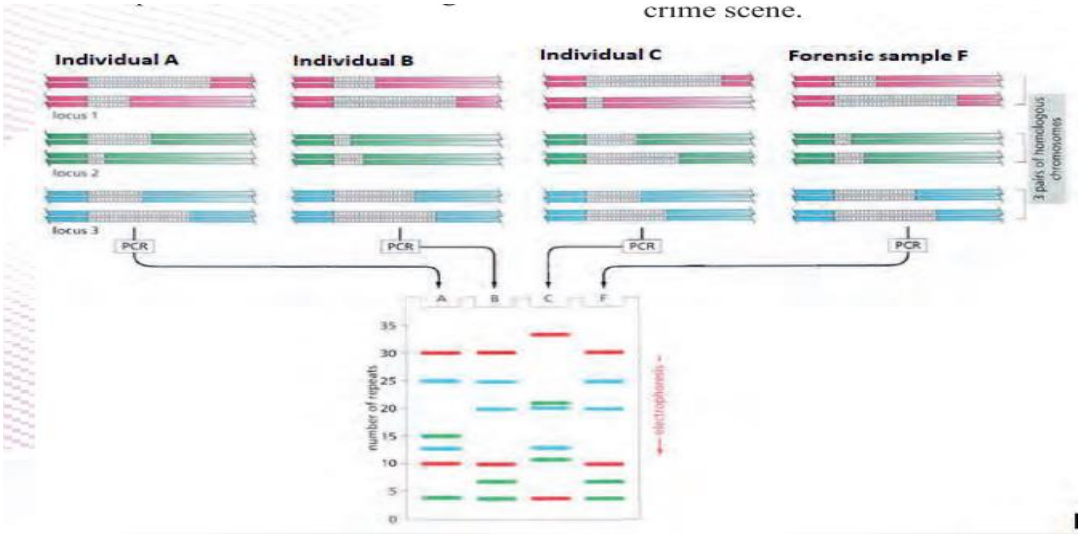


Figure 4. PCR as forensic science tools

1.7. Applications in Bio mining

- Biomining is **the technique of extracting metals from ores and other solid materials typically** using **prokaryotes, fungi** or plants (phytoextraction also known as phytomining or biomining).

1. Microbiological mining

- **Bio hydrometallurgy**: - is the use of microbes to extract metals from ores.
- Copper and metals are leached due to the action of ***thiobacillus ferrooxidants***
- This chemillithotrophic acidophilic bacterium lives by oxidizing the **sulphur** that binds **copper, zinc, lead, and Uranium** into their respecting sulfide minerals, with a result release of the pure metal.
- The bacterium doesn't use the copper; it merely converts it to a water soluble form that can be retrieved and used by us.
- **T.ferrooxidents** release oxygen from iron sulfide by the same process
- Combination of **T.ferrooxidant and T.oxidant** degrade some copper and iron ores rapidly than either one does alone.
- Combination of **Leptosprillum ferrooxidants and T. organoparus** degrades **pyrite**(FeS_2)and **chalcopyrite** ($CuFeS_2$)
- Other bacteria can be used to mine Uranium, arsenic, lead, zinc, cobalt and gold.

1.8. Applications in the environment

a) Solid waste treatment:- composting and landfill

- Biodegradable material (food waste, textiles, paper etc.) under goes a decomposition process.
- The **anaerobic** decomposition process produce **methane**(fuel)
- Organic waste items such as **vegetable peeling, and grass cuttings** are used to make compost
  - Provide a useful gardening supplement (nutrients to a soil)
  - Reduce the volume of materials that has to be disposed of by other means
- Fungi & Bacteria particularly **Actinomycetes** break down the organic matter to produce **CO_2, H_2O &Humus** (stable organic end Product).

b) Waste water treatment

- **Sewage:**-is the term used to describe **liquid waste** that contain **fecal matter** (human or animal)

- The effectiveness of the treatment process is judged chiefly by the reduction of **waste water`s biochemical oxygen demand(BOD)**
- **Biochemical oxygen demand (BOD)** is the measure of **the amount of oxygen needed by microorganism to oxidize t**he organic content.
- **A high** BOD leads to the removal of oxygen from water, a certain indicator of pollution.
  - **water treatment usually occurs in stages**

1- Primary treatment-is purely physical:-

- Involves the **removal of floating objects** followed by sedimentation
- This stage removes up to **one third** of the **BOD** value

2- Secondary treatment

- Involves microbial oxidation leading to a substantial further reduction in BOD * may take one of two forms

I. The traditional trickling filter

II. Activated sludge process (more recent)

<u>The traditional trickling filter process</u>

- The waste water is passed slowly over beds of stones or pieces of moulded plastics
- This develop a biofilm comprising bacteria , protozoans, fungi and algae
- Resulting treated water has its BOD reduced by some 80-85%

<u>Activated sludge process</u>

- Achieve a higher degree of BOD reduction
- Here the waste water aerated in tanks that have been seeded a mixed microbial sludge
- The main components of the microbial sludge is the bacterium ***zoogloea,*** w/c secrets **slime** forming aggregates called ***flocs***
- Around the ***flocs*** other microorganisms such as protozoans attach
- After a few hours 'residence in the tank, the sludge is allowed to settle, and the treated water passes out of the system
- This water then treated with chlorine to remove any pathogenic mos
- **Bulking** is the principal operating problem of activated sludge process
  - ✓ Is caused by over growth **filamentous bacteria** such as ***sphaerotilus natans***; reduce settle and compaction rates
  - ✓ And consequently passing out with treated water

- Both 2^0 treatment processes result in some surplus sludge, this surplus undergoes anaerobic digestion; result in the production of **methane** a**nd CO_2**.
- Methane can be used as a fuel to power the plant
- The remaining sludge is dewatered and used as a soil conditioner

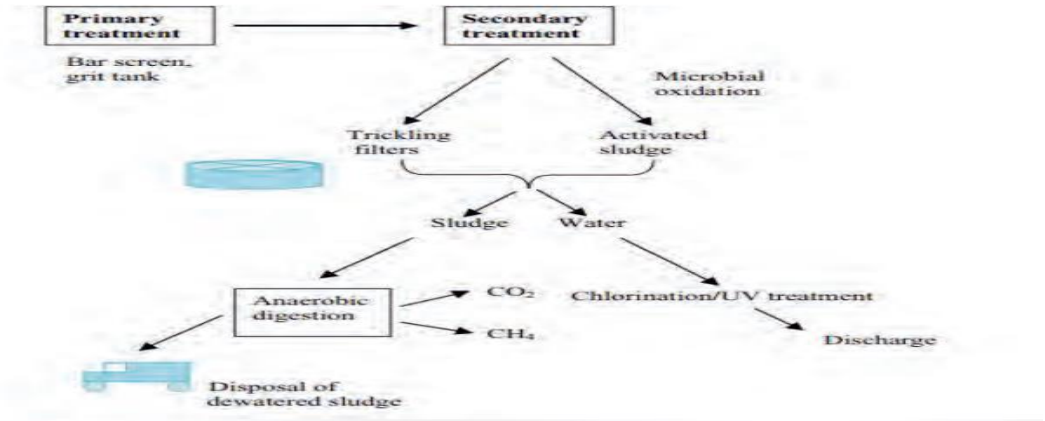


Figure 5. the role of microorganisms in waste water treatment

c) Bioremediation

- is the use of living organism or their products for **detoxification and degradation of environmental pollutants**
- pollutants are degraded with the help of saprophytic microbes; this also known as **Biodegradation**
- **genetically engineered** bacteria are used to clean up pollutants from the environment
- these bacteria metabolically breakdown toxic pollutants into harmless compounds
- **for instance** mercury resistant bacteria process metallic mercury(w/c damage the NS) in to a nontoxic cpds.
- **Enzymes** produced by a MOS modify a toxic pollutant by altering or transforming its structure>> this event is called **biotransformation**
- In many case **bio transformation results in biodegradation** i.e the toxic pollutant is degraded, were yielding less complex, nontoxic metabolites.
- Alternatively, **biotransformation** without degradation can also occur, eg toxic heavy metals can often be **rendered less toxic by oxidation or reduction** reaction carried out by mos.

d) Biofuels

- Biofuels (chiefly ethanol) is obtained by the fermentation of plant material eg. Corn
- Crop residues are the plant material that is usually left in the field after harvest.
- This material consists of **cellulose and hemicellulose** >>these polysaccharides are polymers of five d/t hexose and pentose: glucose, xylose (5), mannose, galactose, and arabinose (5).
- No microorganism naturally ferment all five sugars
- **Transgenic** *saccharomyces cerevisae* strai can ferment **xylose**
- E.g E. coli strain that expresses ***Zymomonas mobilis*** genes is able to ferment all these sugars
- Another research area focuses on degrading the cellulose and hemicellulose to release the monomers. This is done by
  - ✓ Heating the plant material and
  - ✓ Treating with acid, w/c is both expensive and corrosive

e) Biogas production

- Is a **combustible gas** produced from the an aerobic breakdown of organic matter such as **Manure**, waste plant matter from crops and house hold organic waste by activities of the mos (bacteria and archeans) in fermenters.
- It is mostly methane with some CO2,though other gases may be present
- Three d/t communities of aerobic microbes are required
  - ✓ **The 1st** group- (**eubacteria**)convert the raw organic waste into a mixture of **organic acids, alcohols, H_2, AND CO_2**
  - ✓ **The 2nd group- (eubacteria)** uses these **organic acids** and **alcohol** to produce **CO_2 & H_2**.
  - ✓ **The 3rd group-(archae called methanogens)** produce methane by one of the following reactions;

I. **CO_2+4H_2 CH_4 $+2H_2O$ Reduction of CO_2 to methane**

II. **CH3COOH CH_4 $+CO_2$ splitting ethanoic acid**

Figure methane generator:

Advantages of biogas

1. **It is a fuel to cook food, and light lamps**
2. **Slurry left after biogas production forms a soil conditioner(manure)**
3. **It is much cheaper than liquefied petroleum gas for home use**

f) Composting

- Composting is a controlled, **aerobic** (oxygen-required) process that **converts organic materials into a nutrient-rich soil amendment** or mulch through natural decomposition. The end product is compost – a dark, crumbly, earthy-smelling material.

- Is an **aerobic microbial** driven process that converts solid organic wastes into a stable, sanitary, human- like materials
- This materials->> can be safely returned to the environment
  ->> is a low moisture solid substance
- in large scale operation using largely domestic solid organic wastes, the final product is mostly useful for soil improvement, but
- in more specialized operations using specific organic raw substrates(straw ,animal manures, etc.) the final product can become the substrate for worldwide commercial production of the mushroom ***Agaricus bispores***
- composting has recently becomes a serious waste management technologies
- the primary aim of this operation is to obtain final compost with desired product quality
- **composting** carried out in a packed bed of solid organic particles in w/c the indigenous microbes will grow and reproduce
- free access to air is an essential requirement.
- The starting materials arranged in static piles(windows), aerated piles or covered tunnels or in rotating bioreactors
- Some forms of pre-treatment of the water may be required i.e. particle size reduction by shredding or grinding
- The basic biological reaction is the oxidation of the mixed organic substances with oxygen to produce CO2 and H2O and other organic by-product
- After the composting process is completed, the final product most often needs to be left for variable time periods to stabilize

1.9. Applications in industry

a) Enzymes:-

- are can be by commercial fermentation using readily available feed stock such as corn steep liquor of molasses
- the common organisms used to produce the enzymes are **fungi (e.g Aspergillus) and bacteria (Bacillus**)->> these are **non-pathogens** and do not produce **antibiotics**
- the fermentation process is similar to that described for penicillin
- if the enzymes are **extracellular** then the liquid feedstock is filtered from the organism and the enzyme is extracted.
- If the enzymes are **intracellular**, the mos have to be filtered from the feedstock
- They are the crushed and the enzyme is extracted with water or other solvents

<u>Some commercial uses of enzymes</u>

1- ***Proteases*** ->> in washing powder for dissolving strain from **egg, milk and blood**
   >> removing hairs from animals hides
   >> cheese manufacturing; tenderize meat
2- ***Lipase*** ->>flavor enhancer in cheese
   >> in washing powder for removal of fatty strains
3- ***Pectinases***->> clarification of fruit juices
   >>maximizing juice extraction
4- ***Amylases***->> production of glucose from starch

b) Biological washing powder

- ***Protease(protein digest)*** and ***lipases(fat digest)*** are used in **food** and **textile** industries
- When combined in washing powders they are effective in removing strain from protein and fats(both are large & insoluble in water)
- **The** enzymes digest and result in small, soluble molecules w/c can pass out of the clothes
- **Biological washing powder** save energy b/c they can be used to wash clothes at low temperature, so there is no needed to boil the water (NB very high T^{o}. Denature the enzymes)

1.10. Application in Agriculture

a) Bio pesticides

- **Bioinsectcides and biopesticides are** agents such as bacteria, fungi, viruses, or their components, w/c can be used to kill a susceptible insects.
- ***Bacillus thuringienesis* and *Bacillus popilliae*** are the two major bacteria of interest
- Bacteria >> ***Bacillus thuringienesis*** is used on a wide variety of vegetable and field crops, fruits, shade trees, and ornamentals.
- ***Bacillus popilliae*** is used primarily against ***Japanese beetle larvae***
- ***Pseudomonas flourescens*** w/c contain the toxin-producing **gene** from ***Bacillus thuringienesis*** is used on maize to ***suppress black cutworms***.
- ***Viruses***-three major virus groups that do not appear to replicate in warm blooded animals are used
  - ***I.*** **Nuclear poyhedrosis virus (NPV)**
  - ***II.*** **Granulosis virus (GV)**
  - ***III.*** **Cytoplasmic polyhedrosis virus (CPV)**
- **Fungi->>** ***Beauveria bassiana* and *Metarhizium anisopliae*** are used for the **Colorado Potato Beetle** and the **froghopper in sugarcane plantations**, respectively

  >> ***venticillium lecanii and Entomophthora spp*** have been associated with control of aphids in green house and field environment

b) The use of Ti plasmid as a vector

- Use of tumour inducing (Ti) plasmid of Agrobacterium tumefacies>> causes Tumours in the infected plants – to introduce glyphosate resistance into soybean crops.

Steps

1. The glyphosate resistance gene is inserted in to Ti plasmid along with an antibiotics resistance gene
2. Then this **plasmid re-inserted** in to those bacteria
3. The plant cell are then exposed to the transgenic bacterium and cultured on the plate containing antibiotics
4. The plant cells that have taken up the plasmid grow.
   The others are killed by antibiotics

c) Insect resistant Crops

- **GMP** protected against attack by insect pests.
- **Maize** is protected against the **corn borer**, which eats the leaves of the plants and then **burrow** into the stock
- **Cotton** is protected against pests such as the **boll weevil**
- Insects –resistant tobacco also exists, and is protected against the **tobacco bud worm**
  Corn borer
- The most likely determinant effects on the environment of growing an insect-resistant crop are:-
  - The evolution of resistance by the insects pests
  - A damage erect on other species of insects
  - The transfer of the added gene to other species of plant.
- However, less pesticide is used, reducing the risk of spray carrying to and erecting non-target species of insects in other areas

d) Pest resistant crops

- The genes of ***Bacillus thuringiensis*** (Bt) inserted in cotton copy in order for development of certain protein in it. The protein is very toxic to a number of different insects.

e) Transgenic Animals

- The desired genes are cloned and expressed in animals, such as sheep, goats, chickens, and mice. >> are called transgenic animals.

- ❖ Several human proteins are expressed in the milk of transgenic sheep and goats, and some are expressed in the eggs of chickens.
- ❖ Mice have been used extensively for expressing and studying the effects of recombinants and mutations.

f) Transgenic Plants

- ❖ Manipulating the DNA of plants(i.e. creating GMOs) has helped to create desirable traits, such a disease resistance, herbicide & pesticide resistance, better nutritional value, & better shelf life.
- ❖ Because GMO are not natural, they are closely monitored by government agencies to ensure that they are fit for human consumption and do not endangered other plant and animal life.
  - ➢ b/c foreign genes can spread to other spp in the environment, extensive testing is required to ensure ecological stability.

g) Herbicide resistance

- ❖ Some of the safest and most effective herbicides are those, such as glyphosate, which **kill any green plant** but become harmless as soon as they reach the soil.
- ❖ These herbicides cannot be used on crops b/c – a Gene for an enzyme that breaks down glyphosate can be introduce into a plant cell culture.
- ❖ This should lead to a reduced use of herbicides.

Cloning:- is a method of producing ***identical copies of genes, cells, or organisms***.

- ❖ The products of cloning are called a ***clone***.
- ❖ A **clone** is a group of **genetically identical organism** or **cells produced either by asexual reproduction or artificially by cloning techniques**.

<u>Advantages</u>

- ❖ They can make **large numbers of plants or animals**, which are **exact copies of a parent** with desirable characteristics.
- ❖ Sometimes cloning is used to produce skin or other tissues needed to treat patient.

h) Animal Cloning

- ❖ Animal **cannot** be cloned in the same way from parts of their bodies.
- ❖ If animal embryos are divided up at an early stage into several pieces, each piece can develop into a separate animal.
- ❖ However, it is hard to predict which embryos can develop into animals with desirable characteristics and should therefore be cloned.
- ❖ The 1st successful reproductive cloning of an adult with known characteristics is **Dolly the sheep**.

1.11. Biological Warfare

- ❖ ***Biological warfare*** **(BW)** also known as ***Germ warfare*** is the use of biological toxins or infectious agents such as bacteria, viruses, and fungi with the intent to kill or incapacitate humans, animals or plants as an act of war.
- ❖ ***Biological weapons*** include any Mos (such as bacteria, viruses, or fungi) or toxin(poisonous compounds produced by mos.) found in nature that can be used to kill or injured people.
- ❖ ***Biological agents*** may be used for an isolated assassination, to cause incapacitation or death to thousands.
- ❖ If the environment is contaminated, a long term threat to the population could be created

Review questions

Choose the correct answer from the given alternatives

1. ___is the careful maintenance and wise use of natural resources to prevent them from disappearing. A. Conservation B. Wild protection C. plantation D. all
2. ___ is a state in which all the people have physical, social, and economic access to sufficient, safe, and nutritious food A. Food security B. Security C. conservation D. none
3. ___is one who place value on being fully human while connecting with a higher purpose; one who values human life and relationship with all living things A. Unconscious citizen B. Conscious citizen C. citizen ship D. Citizen
4. ____ is also known as germ warfare is the use of biological toxins or infectious agents
   A. Biological warfare B. Bioterrorism C. Transgenic D. None
5. Which of the following is a non-renewable resource? A. Tree B. Coffee C. Gold D. all
6. Which of the following is renewable resource? A. Wood B. oil C. Gold D. Platinum
7. Modern applications of biotechnology include using A. Yoghurt making B. Genetic engineering C. Making alcohol D. Making enjera
8. Tradition application of biotechnology involve__
   A. Producing medicinal drug B. Genetic engineering C. GMO D. brewing beers

UNIT 2:

2. MICROORGANISMS

OBJECTIVES

- ❖ Categorize microorganisms based on their morphology, mode of nutrition, molecular and biochemical analysis,
- ❖ Explain the ways of transmission and prevention of pathogenic microorganisms,
- ❖ Explain the significances of Koch`s postulates for the advancement of microbiological techniques
- ❖ Apply the principle of microbiological technique
- ❖ Discuss the economic importance of microorganisms

INTRODUCTION

Microorganisms are organisms **too small to be seen** clearly by the unaided eyes.

- Must be viewed with a microscope Eg. ***Fungi***, ***Bacteria***, ***Algae***, ***Protozoa*** and ***viruses***.
- **Microbiology**;- the study of microbes.
- Based on evolutionary lines, organisms are grouped into **three domains**: these are
  - ✓ Bacteria
  - ✓ Archae and
  - ✓ Eukarya

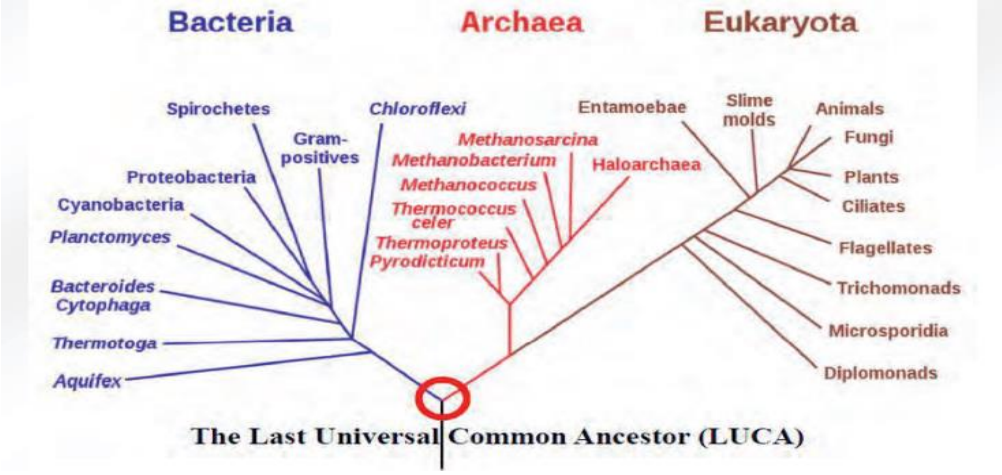


FIGURE 2.1. PHYLOGENETIC TREE OF LIFE

2.1. Eubacteria

- ❖ Literally means "**true bacteria**"
- ❖ Bacteria are relatively **simple in structure**.
- ❖ They are **prokaryotic unicellular** organisms with NO **nuclear membrane, mitochondria, Golgi bodies, or endoplasmic reticulum** that reproduce by asexual division.

General characteristics

- ❖ They are **omnipresent**; i.e. present in the soil, air & water.
- ❖ They are unicellular,
- ❖ They have **thick rigid cell wall** (peptidoglycan).
- ❖ The mode of nutrition; May autotrophic and heterotrophic.
  - Heterotrophs may be parasite, saprophyte or symbiotic

- ❖ They lack true chlorophyll but few photosynthetic bacteria have a special type of chlorophyll called **bacteriochlorophyll**.
- ❖ They lack true nucleus, mitochondria, Golgi apparatus, plastid and EPR.
- ❖ DNA & RNA are present in bacterial cell

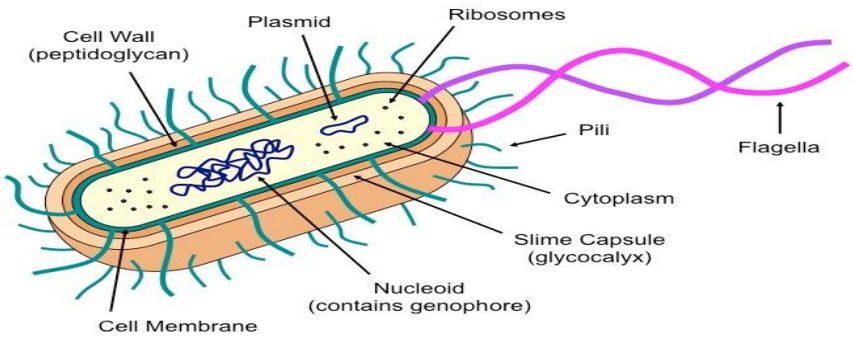
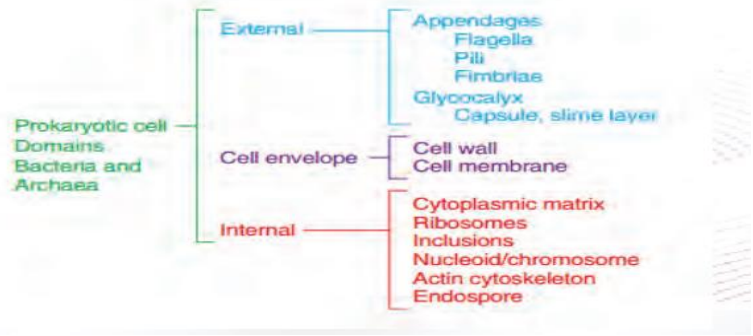


Figure 2.2. the major features of prokaryotic cell, Bacteria

The general structural plan of a prokaryotic cell can be represented wit this flow chart:



Eukaryotic microbes

- ❖ Are an extraordinary diverse group, including species with a wide range of life cycles, morphological specializations, and nutritional needs.
- ❖ Are responsible for some disease of great public health importance.
- ❖ Have a variety of complex membranous organelles, genetic material.
- ❖ A cytoskeleton composed of microtubules, microfilaments, and intermediate filaments.
  - Give cells shape; is also involved in cell movements, intracellular transport, and reproduction.
- ❖ When they reproduce, genetic material is disrupted between cells by the processes called mitosis and meiosis.

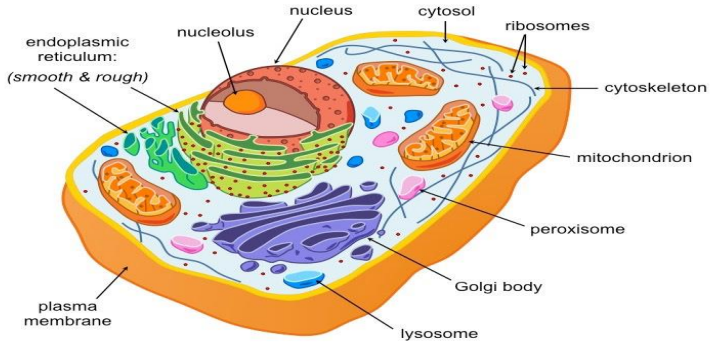


Figure2.3. Major features of Eukaryotic cell.

Bacterial shapes

- ❖ Morphologically bacteria are classified based on numerous features>> such as ***Cell shapes, nature of multi cell aggregate, motility, formation of spores, and reaction to the gram stain***.
- ❖ Bacterial cells can be grouped into the following main ***shapes***:

1. ***Cocci*** (singular, coccus) ***-spherical*** bacteria
2. ***Bacilli*** (singular bacillus)***-rod*** shaped bacteria
3. ***Spirochaetes- spiral*** or ***cork screw*** –shaped bacteria
4. ***Comma*** –vibrio cholera

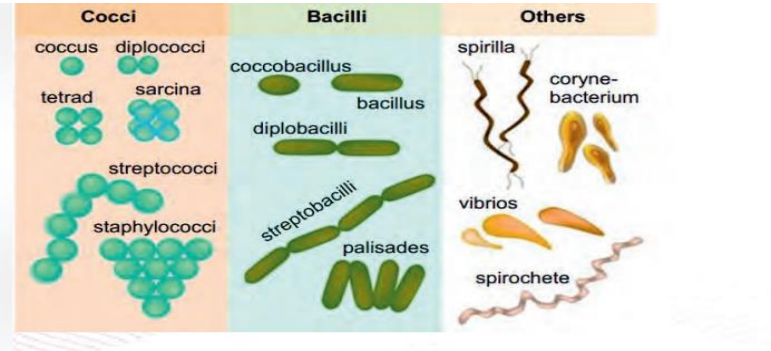


Figure 2.4. basic bacterial shape and their clustering

2.1.1. Bacterial cell wall

- Bacteria can be classified based on the types of dyes they retain.(based on gram stain)
- In this case, bacteria can be classified in to two:

1. Gram-positive bacteria

- Have a distinctive **purple appearance** when observed under light microscope following gram staining.
  - Is due to retention of **the purple crystal violet** stain in the **thick** peptidoglycan layer of the cell wall. E.g. all **staphylococci**, all **streptococci** and some **listeria** species.

2. Gram-negative bacteria

- Take the color of the **red** counter stain.
  - Have a cell wall composed of a **thin layer** of peptidoglycan

Table 2.1. comparison of Gram + and Gram _ bacterial cell walls

Characteristic	Gram-Positive	Gram-Negative
Number of major layers	1	2
Chemical composition	Peptidoglycan Teichoic acid Lipoteichoic acid	Lipopolysaccharide Lipoprotein Peptidoglycan
Overall thickness	Thicker (20–80 nm)	Thinner (8–11 nm)
Outer membrane	No	Yes
Periplasmic space	Narrow	Extensive
Porin proteins	No	Yes
Permeability to molecules	More penetrable	Less penetrable

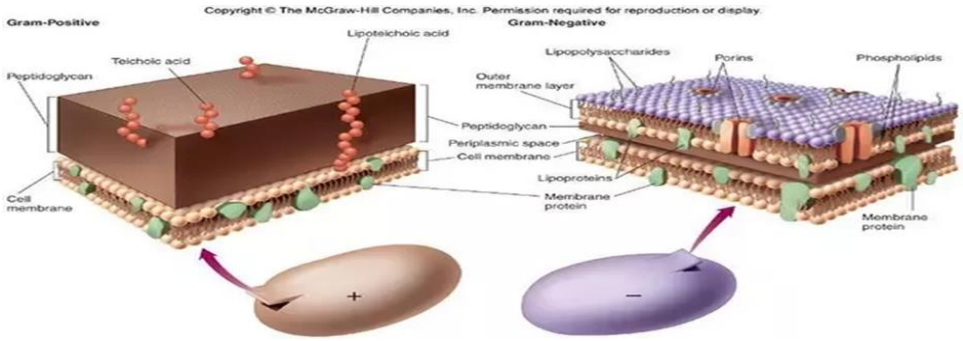


Figure 2.5. Gram + and Gram _ bacterial cell wall

- The gram staining process includes four basic steps
  1. Heat fix/attach the bacteria to the slide
  2. Applying a primary stain (crystal violet)
  3. adding a mordant (gram`s iodine),
  4. Rapid Decolorization with ethanol ,acetone or a mixture of both, &
  5. Counter staining with safranin. Then observe the color change at each level.

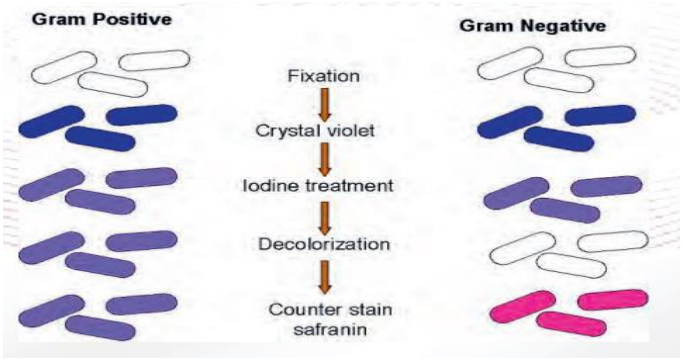


Figure 2.6 Gram staining

2.1.2. Nutritional types of bacteria

- Many are **autotrophs** – obtained their carbon from CO_2.
  i. ***Photoautotrophs***- obtained their energy from sun light
  ii. ***Chemoautotrophs***- harvest energy from inorganic chemicals
- Other bacteria heterotrophs-obtain at least some of their carbon from organic molecules
  i. ***Photo heterotrophs***- obtain their energy from sun light
  ii. ***Chemo heterotrophs***- harvest energy from organic molecules
- Source of energy includes;
  (1) Light energy---[photo]
  (2) The energy derived from oxidizing organic or inorganic molecules.[chemo]
- Bacteria also have only two sources of electrons
  i. Lithotrophs (i.e., "***rock eaters***")
  - Use reduced ***inorganic*** substances as their electron sources
  ii. Organotrophs extract e-s from reduced organic cpds
  - Based on their primary sources of ***carbon***, ***energy*** and ***electrons***, most bacteria may be placed in one of ***five nutritional classes***.
- The majority of bacteria are either ***photo litho autotrophic*** or ***chemoorganoheterotrophic***.

1- <u>Photolithoautotrophic</u>

- Often called simply photoautotrophs
- Use light energy and have CO_2 as their carbon source.
  Photosynthetic bacteria and cyanobacteria employ water as the electron donor and release oxygen.
  >>CO_2+6H_2O…..>>$C_6H_{12}O6$+6O_2
- Others, such as the purple and green sulfur bacteria, extract electrons from inorganic donors such as hydrogen, hydrogen sulfide, and elemental sulfur.

2- <u>Chemoorganoheterotrophs</u>

- Sometimes called ***chemohetrotrophs*** or ***chemoorganohetrotrophs***
- Use the organic cpds as a source of energy, hydrogen, electrons and carbon.
- Nearly all ***pathogenic*** microorganisms are **chemoorganoheterotrophs**.

3- <u>Photoorganoheterotrophs</u>

- Are photosynthetic bacteria (purple and green bacteria)
- Use organic matter as their electron donor and carbon source.
- Are common inhabitants of polluted lakes and streams.
- Some of these bacteria also can grow as photolithoautotrophs with molecular hydrogen(inorganic) as an electron donor.

4- Chemolithoautotrophs

- Oxidize reduced inorganic cpds such as iron, nitrogen, or sulfur molecules to derive both energy and electrons for biosynthesis.
- Carbon dioxide is the carbon source.

5- Chemolithoheterotrophs

- Use reduced inorganic molecules as their energy and e- source but derive their carbon from organic sources.
- Contribute greatly to the chemical transformation of elements(e.g., the conversion of ammonia to nitrate or sulfur to sulfate)that continually occur in ecosystems.

Table2. Major nutritional types of microorganisms

Nutritional Type	Carbon Source	Energy Source	Electron Source	Representative Microorganisms
Photolithoautotroph	CO_2	Light	Inorganic e^- donor	Purple and green sulfur bacteria, cyanobacteria
Photoorganoheterotroph	Organic carbon	Light	Organic e^- donor	Purple nonsulfur bacteria, green nonsulfur bacteria
Chemolithoautotroph	CO_2	Inorganic chemicals	Inorganic e^- donor	Sulfur-oxidizing bacteria, hydrogen-oxidizing bacteria, methanogens, nitrifying bacteria, iron-oxidizing bacteria
Chemolithoheterotroph	Organic carbon	Inorganic chemicals	Inorganic e^- donor	Some sulfur-oxidizing bacteria (e.g., *Beggiatoa*)
Chemoorganoheterotroph	Organic carbon	Organic chemicals often same as C source	Organic e^- donor, often same as C source	Most nonphotosynthetic microbes, including most pathogens, fungi, and many protists and archaea

2.1.3. Reproduction of bacteria

2.1.3.1. Asexual reproduction

❖ Most reproduce by an asexual process called ***binary fusion***.

1. The chromosome (DNA) replicates and the two DNA molecules separate
2. Cell fusion at mid cell involves the synthesis of a partition, or septum, that separates the mother cell into two genetically identical daughter cells.

2.1.3.2. Sexual reproduction in bacteria

❖ In conjugation, two cells of d/t mating types come together, and genetic material is transferred from one to the other.

❖ Donor cells, F+ Cells (F-fertility),& recipient cells- F-

❖ F factor → a DNA sequence in F+ cells

- Is necessary for a bacterium to serve as a donor
- Consists of about 20 genes,
- Can be in the form of a plasmid or it can be part of the DNA in the bacterial chromosomes.
- Genes encoded enzymes essential for transferring DNA.
- Certain F genes encode sex pili, long, hair like extensions hat project from the cell surface.
- The sex pilus recognizes and binds to surface of an F+ cell, forming a cytoplasmic conjugation bridge between the two cells.
- The F plasmid replicate itself, and DNA is transferred from donor to recipient bacterium through the conjugation bridge.

- F plasmids may also have other types of genes, including those that determine resistance to antibiotics.

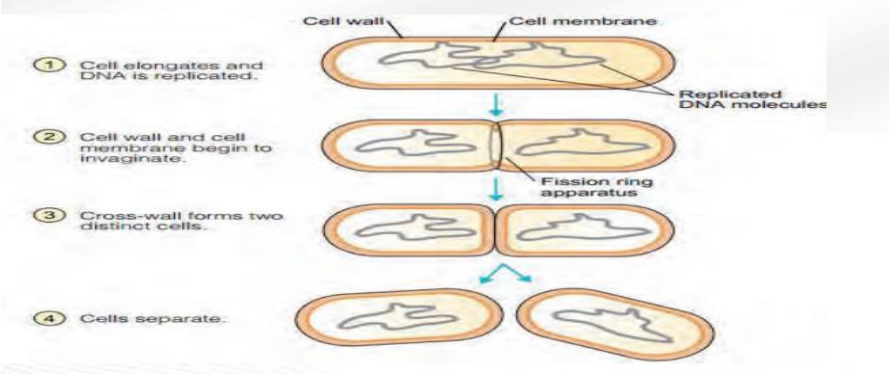


FIGURE 5. The process of Binary Fission

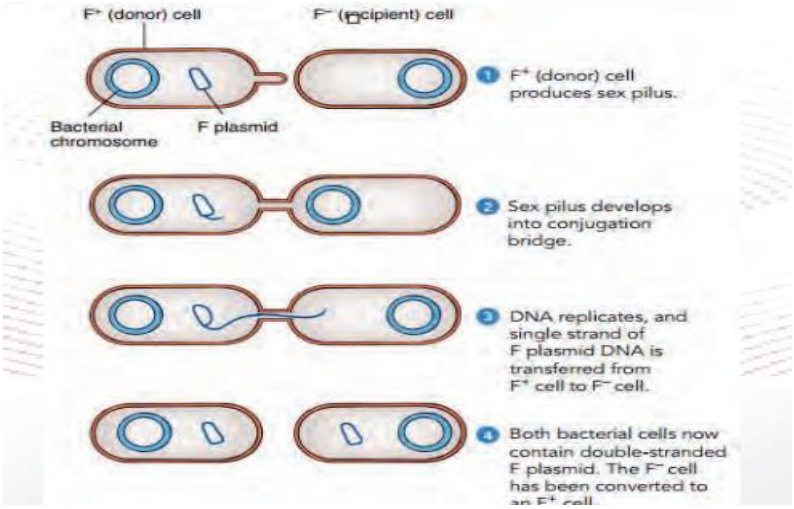


Figure 6. Bacterial Conjugation

Some diseases caused by Bacteria

S

Diseas	Causative agent	Description of agent	Organs affected	Transmission/ vector
Pertussis	Bordetella pertussis	Gram (–) rod	Upper resp. tract	air
Meningococcal Meningitis	Neisseria meningtidis	Gram (–) diplococcus	Upper resp. tract, meninges	air
Tuberculosis	Mycobacterium tuberculosis	Acid-fast	Lungs, bones, other organs	air
Typhoid Fever	Salmonella typhi	Gm(–) rod	Intestine, blood, gall bladder	Food, water
Cholera	Vibro cholerae	Gm(–) rod	intestine	Food, water
Tetanus	Clostridium tetani	Gm(+) spore-forming anaerobic rod	Nerves at synapse	soil
Syphilis	Treponema pallidum	Spirochete	Skin, cardiovascular organs	sexual
Gonorrhea	Neisseria gonorrhoeae	Gm(–) diplococcus	Urethra, cervix, fallopian tubes, epididymis, eyes, pharynx	sexual
Leprosy	Mycobacterium leprae	Acid-fast	Skin, bones, peripheral nerves	contact

2.2. Archae

- ❖ Similar to bacteria b/c these are also ***prokaryotes***
- ❖ Are unicellular, microscopic organisms that live as producers or decomposers.

Characteristics of archaea

- ❖ They are prokaryotic.
- ❖ Are single celled organisms.
- ❖ Lack membrane bound nucleus and membrane bounded organelles.
- ❖ Lack true peptidoglycan in their cell walls.
- ❖ Their cell membrane lipids have branched hydrocarbon chains.
- ❖ Many are found in extreme environments.
- ❖ Generally three major groups of archeae are recognized: ***methanogens*** (they generate methane), extreme ***halophiles***, and extreme ***thermophiles***

1. The methanogens

- Are strictly anaerobic organisms
- Are found in anaerobic environment such as water logged soils, lake sediments, marshes, marine sediments and the gastrointestinal tracts of animals, including humans.
- Degrade organic molecules to methane.

2. Extreme halophiles

- Grow in highly saline environments such as the Great Salt Lake, the Dead Sea, salt evaporation ponds, and the surface of salt preserved foods.
- Are generally obligate aerobes.

3. Extreme thermophiles (hypothermophiles)

- Are found near volcanic vents and fissures that release sulfurous gases and other hot vapors.
- With optimum temperatures usually in excess of **80^0C**
- May be either obligate aerobes, facultative aerobes, or obligate anaerobes

4. Thermophilic extreme acidophiles

- Grow in extremely acidic, hot env'ts.
- Are members of two genera, Thermoplasm &picrophilus
- The tree, based on sequences of 16S ribosomal RNA genes, reveals a major evolutionary split of archae in two phyla, the ***Crenarchaeota*** and the ***Euryarchaeota***.

❖ Scientists originally identified archae as a distinct type of prokaryotes on the bases of unique rRNA sequences.

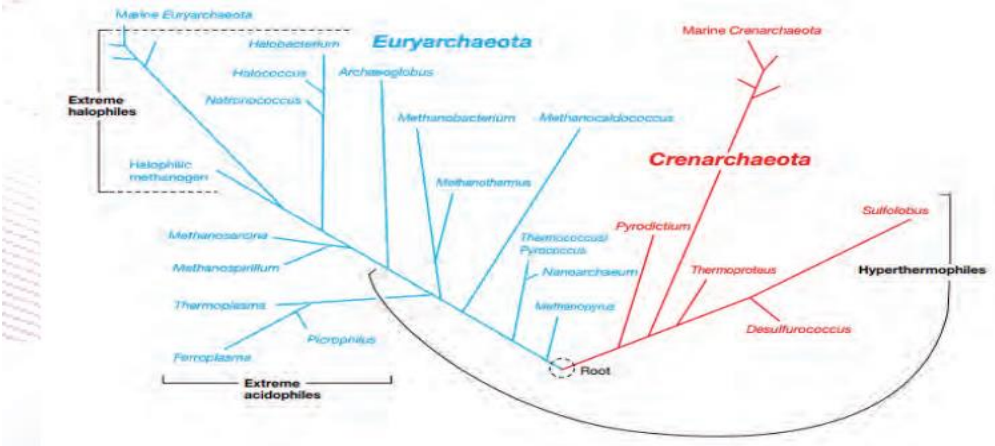


Figure 7 phylogenic tree of archaea

❖ Archae also share other common features that distinguish them from bacteria:

- Archae lack true peptidoglycan in their cell walls.
- Their cell membrane lipids have branched hydrocarbon chains.
- The initial amino acid in their polypeptide chains, coded by the AUG start codon, is methionine (as in eukaryotes and in contrast to the N- fomylmethionine used by bacteria).
- Archae multiply by ***binary fission, budding, fragmentation*** or other mechanisms.
- Nutritionally they are either aerobic, ***chemolithoautotroph*** to ***organotrophs***.

2.2.1. Beneficial Aspects of Archae

i. Source of enzymes that are usually added to detergents
   - In order to help it maintain its activity even at higher temp. and PH.
   - Proteases and lipases derived from alkaliphilic bacteria are being used as detergent addictive to increase their stain removal ability

ii. Some also bear the potential for bioremediation or help in cleaning contaminated sites.

iii. The thermos aquaticus (thermophilic),is an essential part of the development of ***molecular biology as a science***.
   - Achaeans has become the source of the enzyme harnessed as the basis for the amplification of the DNA in a technique called PCR.

2.2.2. Physical Factors That Affects Microbial Growths

❖The major physical factors which affect microbial growth are ***solutes and water activity, PH, Temperature, oxygen level, pressure and radiation*** (Figure 2.11)

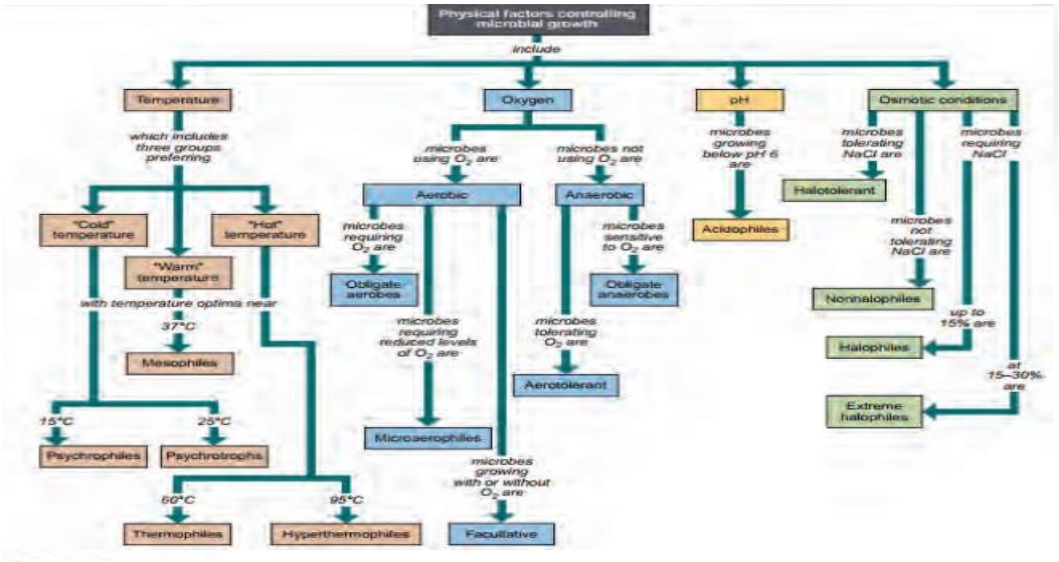


Figure 2.8 Classes of microbes based on physical factors

Test your self

Choose the best answer

1)Gram negative bacteria change the crystal violet color when treated by

A) Gram's iodine B) safranin C) alcohol D) Benedict's solution

2) Which of the following is the characteristic of gram positive bacteria? A) the presence of outer membrane B) the cell wall has thinner peptidoglycan C) it has less lipoprotein layer D) it retain the color of safranin

3)Identify the structure found in some bacteria A) cell membrane B) cytoplasm C) pili D) ribosomes

4) The characteristics unique to cocci bacteria is A) formation of diploid arrangement B) formation of chain of bacteria C) formation of cluster of bacteria D) formation of bacillus

5) The structure of vibrio bacteria is A) spherical B) rod C) spirochete D) comma

6)Which of the following is the role of staining? Staining A) increases the size of bacteria B) involves in the reproduction of bacteria C) helps to differentiate organisms D) uses as defense for bacteria

7) When gram staining procedure arranged in on order of lab activity it takes one of the following A) fixation, iodine treatment, applying crystal violet, counter staining by safranin, Decolorization B) fixation, applying crystal violet, iodine treatment, , counter staining by safranin, Decolorization C) fixation, applying crystal violet, iodine treatment, , washing with alcohol, counter staining by safranin D) fixation, iodine treatment, Decolorization, applying crystal violet, counter staining by safranin,

8)Gram positive bacteria remain purple after decolorization because A) the thicker cell wall easily loses the former color B) the thinner cell wall retain the first color C) the thinner cell wall retain the color of safranin D) the thicker cell wall retain the first color

Give Short answer

1. Imply the basic difference between photoautotrophs and chemo heterotrophs
2. How sexual reproduction does takes place in bacteria?
3. What are spores? What is their role

2.3. Fungi

- ***Mycologist***:- scientists who study fungi
- ***Mycology***:-the scientific discipline devoted to fungi
- ***Mycotoxicology***:-the study of fungal toxins and their effects
- ***Mycoses (s.***, mycosis):- the diseases caused by fungi in animals.

2.3.1. general characteristics of true fungi

- All are **eukaryotic**= possess membrane- bound nuclei(containing chrs) and a range of membrane bound cytoplasmic organelles (e.g. mitochondria, vacuoles, EPR)
- Most are ***filamentous***= composed of individual microscopic filaments called hyphae, network of hyphae called a mycelium
- Some are ***Unicellular***:- e.g. yeasts
- Protoplasm of a hyphae or cell is surrounded by ***a rigid wall*** – composed primarily of ***chitin*** and ***Glucans***, although the wall of some spp. Contain cellulose.
- Reproduce **sexually and asexually**
- Their nuclei are ***typically haploid***- although the ***Oomycota*** and some yeast possess diploid nuclei.
- All are ***achlorophllous-*** lack chlorophyll and are incapable of photosynthesis.
- All are ***chemoheterotrophic*** (***chemoorganotrophic***)
- Possess characteristic range of storage compounds- e.g***. trehalose, glycogen, sugar alcohols and lipids***.
- ***Nutritionally*** categorized into three(***saprophytic***, ***parasitic*** and ***symbiotic***)

2.3.2. Ecology of Fungi

- Are frequently found I cool, dark, moist places with a supply of decaying material.
  - Fungi are saprobes that decompose organic matter.
- ***Lichens*** are a symbiotic r/sh between a fungus and a photosynthetic organism, usually an algae or cyanobacteria. – the photosynthetic organism provides energy derived from light and carbohydrates, while the fungus supplies minerals and protection.

2.3.3. Classification of fungi

- The current classification of fungi includes:-

1. ***Ascomycota: - ascospore*** producing fungi. E.g. ***saccharomyces sereviciae***
2. ***Basidomycota***:- ***basidia*** forming fungi. E.g. rusts, smuts, and mushroom
3. ***Chytridomycota***:- ***zoospore*** producing fungi e.g. allomyces & water molds
4. ***Glomeromycota***:- e.g. ***mycorrhizal*** fungi.
5. ***Zygomycota***:- ***sporangial*** fungi, e.g. rhizopus and mucor.

2.3.4. Reproduction in fungi

❖***Sporulation***:- is the process of spore formation.

A) Asexual Reproduction

❖Asexual reproductive structures develop at the ends of specialized hyphae.

❖As a result of mitotic divisions, thousands of spores are produced, all genetically identical.

❖Many asexual spores develop within sacs or vessels called ***sporangia*** (sing sporangium; ***angio=''vessel''***)

❖Other fungi produces spores on supportive structures called ***conidiophores***. These unprotected, dust-like spores are known as conidia (sing, ***conidium***= ***dust***)

❖In yet other fungi, spores may form simply by fragmentation of the hyphae yielding ***arthropores*** (***arthro=''joint''***). The fungi that cause ***athlete`s foot*** multiply by this manner.

❖Many yeasts reproduce asexually by ***budding***. In this process, the cell become swollen at one edge, and a new cell called a ***blastospore, (blasto=''bud''***) develops (buds) from the parent cell.

B) **Sexual reproduction**

❖Many fungi also reproduce spores by sexual reproduction.

❖Opposite mating types come together and fuse.

2.3.5. Economic importance of fungi

❖ Fungi have both beneficial and harmful aspects.

i. **Beneficial aspects of fungi**

1. ***Breakdown complex organic substrates*** (recycling of carbon and other elements in the cycle of life).
2. ***Food sources***. E.g. basidiomycetes
3. In many industry processes ***involving fermentation***
4. Preparation of some cheeses, soy sauce, and sufu, enjera, tej, tela…
5. Molds (such as ***Aspergillus*** spp.)are used in the production of citric, oxalic, gluconic and itaconic acid
6. Manufacturing of many ***antibiotics*** & immunosuppressive drug the cyclosporine.
7. For studying complex ***eukaryotic events***, such as cancer and aging within a simple cell.

ii. **Harmful aspects of fungi**

1. Are major causes of plant, animal human ***diseases***.
   - ➢ Plants are particularly vulnerable to fungal diseases b/c fungi can invade leaves through their ***stomata***.
2. Molds can cause ***deterioration of fabrics, leather, electrical insulation and other manufactured goods***.
3. Spoil the agricultural produce
4. ***Mycotoxicosis*** (ingestion of toxins off fungal origin) and Mycetismus (mushroom poisoning through ingestion of fungal elements).

a. Aflatoxis: are mycotoxins produced by ***Aspergillus flavus*** and ***A. parasiticus***. The molds are found primarily in warm, humid climates, where they contaminate agricultural products such as peanuts, cereals, sweet potatoes, corn, rice, and animal feeds.

❖ Are thought to be ***carcinogenic***, especially in the liver

b. Ergotism:-

❖ Is caused a powerful ***toxin*** by from ***Claviceps purpurea***, an ascomycetes fungus

- Grows as hyphae on kernels of rye, wheat, and barley.
- Gradually consume the substance of the grain and
- The dense tissue hardens into a purple body>> ***sclerotium***.
- ***Sclerotium*** produce alkaloids (a group of peptide derivatives)
- And deposited in the grain as a substance called ***ergot***.
- Products such as bread made from rye grain may cause **ergot** rye disease, or ***ergotism***.

c. **Mushroom poisoning, or mycetism**

❖ Occurs from mushrooms that produce mycotoxins that affect the human body.

5. Superficial fungal infections
   - Infections of the **outermost** areas of the human body: hair, finger nails, toe nails, and the epidermis (the dead outer most layer of the skin).
   - Caused by any of several spp. Of filamentous fungi in the genera ***Trichophyton***, ***epidermophyton***, and ***microsporum***.
   - The various forms of dermatophytosis are referred to as ***tineas*** or '***ringworm'***
   - The tineas are classified according to the anatomic site or structure affected:

Mode of transmission

❖ Superficial mycoses (dermatomycoses)

- Transmitted directly by human contact, animal-human contact or indirectly inanimate objects (clothes, carpets, moisture, and dusts in showers, swimming pools, wardrobes, gyms).

Mode of prevention

❖ Regular disinfection of showers and wardrobes can contribute to prevention of athlete`s foot,

Some common fungal diseases

Diseases	Causative agent	Signs and symptoms	Transmission	Prevention and control
Dermatophytosis (tineas)	Epidermophyton Microsporum Trichophyton	Blister-like lesions	Fragments of skin on skin floors or surfaces	Keeping skin dry not sharing personal items
Candidiasis	Candida albicans	Itching, burning pains, "cheesy" discharge	sexually	Avoiding baths hot and tubs , Avoiding douches
Thrush	Candida albicans	White flecks on mucous membranes	Passage through the birth canal	Practicing good oral hygiene, limiting sugar intake
Aspergillosis	Aspergillus fumigatus	Bloody cough, chest pain, Wheezing Shortness of breath	Air borne spores	Staying away from sources of mold

2.4. Protozoa

❖ The term '' ***protozoa''*** (sing. Protozoan; Greek '**protos,'** First, and **Zoon**, animal

❖ Protozoology: generally refers to the study of protozoa.

Characteristics of protozoa

❖ Unicellular organisms
❖ Lacks cell wall.
❖ They are *freeing living or parasitic*.
❖ Aerobic
❖ They have true nucleus.
❖ They are *eukaryotic*.
❖ Mostly microscopic, although some are large enough to be seen with an aided eye
❖ Locomotion by *pseudopodia*, *flagella, cilia*, and direct cell movement; some *sessile*.

- Nutrition; *autotrophs, heterotrophs, saprozoic* (using nutrients dissolved in the surrounding medium)
- Aquatic or terrestrial habitat; free living or symbiotic mode of life
  - Reproduction asexually by ***binary fusion, budding and cysts and sexually by conjugation or by syngamy (union of male and female gametes to form a zygote***).

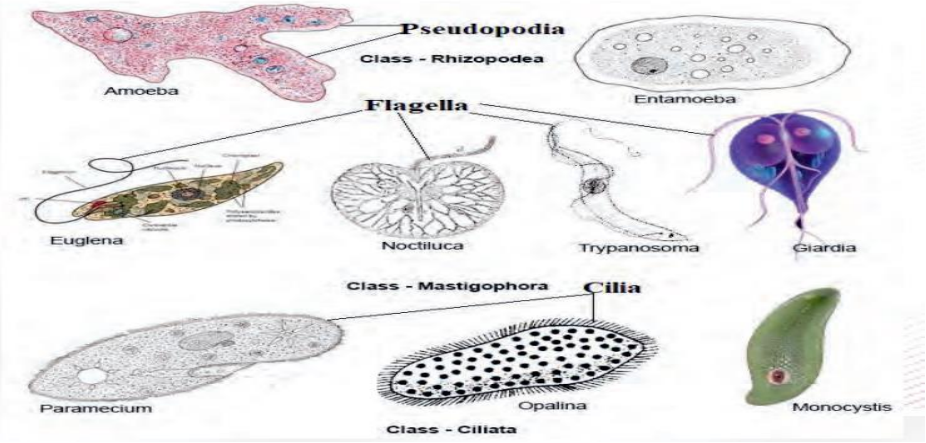


Table 2.5. Classification of protozoa

CATEGORY	MEANS OF MOVEMENT	METHOD OF ASEXUAL REPRODUCTION	METHOD OF SEXUAL REPRODUCTION	REPRESENTATIVES
Ciliates	Cilia	Transverse fission	Conjugation	*Balantidium coli, Paramecium, Stentor, Tetrahymena, Vorticella*
Amebae (amebas)	Pseudopodia (false feet)	Binary fission	When present, involves flagellated sex cells	*Amoeba, Naegleria, Entamoeba histolytica*
Flagellates	Flagella	Binary fission	None	*Chlamydomonas, Giardia lamblia, Trichomonas, Trypanosoma*
Sporozoa	Generally nonmotile except for certain sex cells	Multiple fission	Involves flagellated sex cells	*Plasmodium, Toxoplasma gondii, Cryptosporidium*

Nutrition in protozoa

- ***Heterotrophic***: receive nutrients by breaking down organic matter
- Can grow in both ***aerobic*** and ***anaerobic*** environments.
- Some protists, such as ***euglena***, receive nutrients from organic matter and through ***photosynthesis*** b/c they contain ***chlorophyll***. These protists are considered as both ***algae*** and ***protozoa***.
- Protists obtain food in one of three ways:
  1- ***Absorption*** –food is absorbed across the protists plasma membrane.
  2- ***Ingestion:*** - cilia create a wave-like motion to move food into a mouth like opening called a ***cytosome***.
  3- ***Engulf:*** - ***pseudopods*** engulf food, and then pull it into the cell using a process called phagocytosis. E.g. amoeba. Food is digested in the **vacuole** inside the cell. Waste products are excreted using a process called **exocytosis**.

Common diseases caused by protozoa

Disease	Causative agent	Organs affected	Transmission /vector	Clinical Features
Amoebiasis	Entamoeba histolytica	Intestine, liver	Ingestion of fecally contaminated food or water; disease associated with poverty, homosexual men, and migrant workers	Multiplication of the organisms and tissue destruction in the intestine and in other body tissues can result in amebic abscesses. The irritating effect of the amebas on the cells lining the intestine causes intestinal cramps and diarrhea. Due to intestinal ulceration, the diarrheal fluid is often bloody, and the condition is referred to as amebic dysentery
Giardiasis	Giardia lamblia	Intestine	Ingestion of fecally contaminated water; persono–person, in day care centers	Ingested cysts survive stomach passage; trophozoites emerge from the cysts in the small intestine, where some attach to epithelium and others move freely; mucosal function is impaired by adherent protozoa and host immune response.
Trichomon	Trichomonas vaginalis	Urogenital	Sexual contact	Vaginal discharge, odor and edema or erythema

- Some of the human diseases caused by protozoans include
  Malaria, giardiasis, African trypanosomiasis, amoebiasis, chagas disease, leishmaniosis, toxoplasmosis, crytosporidiosis

2.5. Viruses

- ❖ Is very small, ***non –cellular parasite*** of cells.
- ❖ Genome (DNA or RNA) is enclosed in a ***capsid***
- ❖ Have ***no cellular organelles*** and so ***cannot carry out any metabolic processes***; i. e. lack the chemical machinery for genetic energy and synthesizing large molecules. – they must all enter other cells to reproduce(***obligate, intracellular particles***).
- ❖ Most can be seen only with the ***electron microscope***

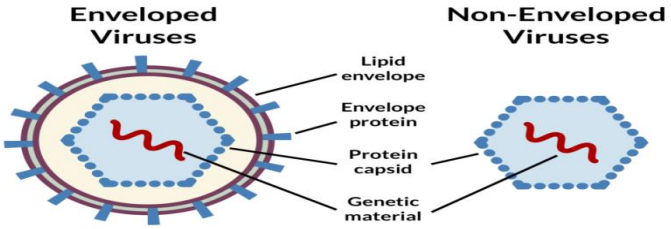
Characteristics of viruses

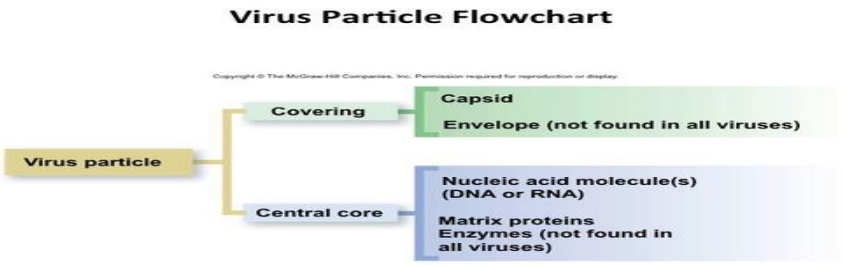
- ➢Have an ***inner core*** of ***nucleic acid*** surrounded by protein coat called ***envelope***.
- ➢***Cannot be grown*** on ***artifial cell free media*** (however, grow in animals, eggs or tissue culture).
- ➢***Do not have a cellular organization***. –do not have cell wall or cell membrane or cellular organelles including ribosomes.
- ➢***Do not occur free in nature*** but act as ***obligate intracellular parasite*** of bacteria, protozoa, fungi, algae, plants, and animals.
- ➢ ***Lack the enzymes*** necessary for protein and nucleic acid synthesis and are ***dependent for replication on the synthetic machinery of host cells***. Once it infects a susceptible cell, however, a virus can direct the host cell machinery to produce more viruses.
- ➢***Are unaffected by antibacterial antibiotics***
- ➢***Are inert*** (i.e. metabolically inactive) nucleoprotein.
- ➢Occupy a space b/n ***living and non- living***, b/c they are ***crystallizable*** and ***non-living*** outside thee, body of the host- active only inside the host cells.
- ➢***Ultramicroscopic*** size, ranging from ***20nm- 450nm*** (diameter)
- ➢Nucleic acid can be double stranded /single stranded DNA or single/double stranded RNA.

- Molecules on virus surface impart high specificity for attachment to host cell
- Multiply by taking control of host cell's genetic material and regulating the synthesis and assembly of new viruses

Structure of viruses

- Basic structures of virus
  i. ***Genome***:- central core of nucleic acid either DNA or RNA but not both
  ii. ***Capsid***:- protein coat
  iii. ***Lipoprotein layer***: - in some virus, an envelope made up of ***glycoprotein*** and phospholipid ***bilayer*** is present inside the capsid.
  Nucleocapsid- the combined formed by the core and capsid
  Capsomeres- are identical repeating subunits that build up capsids.
- Some viruses contain enzymes which play central role during infection processes.
  E. g. ***Lysozyme*** – in some bacteriophage- makes small hole in bacterial cell
  Nucleic acid polymerase- in some virus –transcribe the viral genome into mRNA
  Reverse transcriptase- in retrovirus-transcribe DNA from RNA





VIRAL SYMMETRY

1. ***Helical symmetry***

- Consists of identical protein subunits or protomers which assembled in a helical structure around the genome
- This protein subunits generally ***forms nucleocapsid***.
- The helical structure provides ***flexiblity*** to the filaments. E.g. tobacco mosaic &sendai virus

2. ***Icosahedral symmetry***
   - Refers to a type of polyhedron with 20 equilateral triangular faces and 12 vertices.
   - The rigid structure provides protection to the genome. E.g. papovavirus, picorna virus, toga virus etc
3. ***Complex symmetry***
   - Consists of complex structural components which made it different from other two groups. E.g. pox virus

Difference between DNA& RNA Viruses

- ***DNA viruses***- contain DNA. Are mostly double stranded, replicate in the nucleus
- ***RNA Viruses***- contain RNA as their genetic material. Are mostly ss, replicate in the cytoplasm

➢ ***Viruse*** – infect all cellular life forms: eukaryotes(vert. animals, plants, fungi, protozoa, algae) and prokaryotes (bacteria & archae)

Classification of viruses

➢ The primary criteria for delineating the main viral taxa are:

(1) The type and character of ***the viral genome***

(2) The ***strategy of viral replication*** and

(3) The ***type of the organism they infect***

Viral replication

- ❖ A virus ***hijack the metabolism of the cell*** to ***produce copies of it self***, and ***destroy the host cell*** when new virions are released.
- ❖ In general, viruses go through the following five steps in their replication cycles to produce more virions:

1. ***Adsorption***:- the attachment of viruses to host cell.
2. ***Penetration***:- the entry of virions(or their genome) in to host cells.
3. ***Synthesis***:- the synthesis of new nucleic acid molecules, capsid proteins, and other viral componets
4. ***Maturation***:- the assembly of newly sythesized viral components in to complete virions.
5. ***Release***:-the departure of new virions from host cells. Release generally, but not always, kills(lysis) host cells.

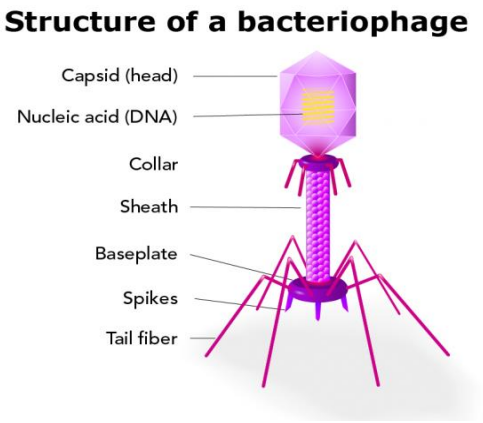
Bacteriophage/phage

- ❖ Multiply inside by making use of some or all of the host biosythesis machinery.

Major Parts

1. Capsid – protein coat that makes up most of a virus & gives it shape.
2. Nucleic Acid – genetic information in the form of DNA or RNA.
3. Envelope – an additional protective coating usually made of lipids, proteins, & carbs.

*Found only in some viruses that infect animal cells.

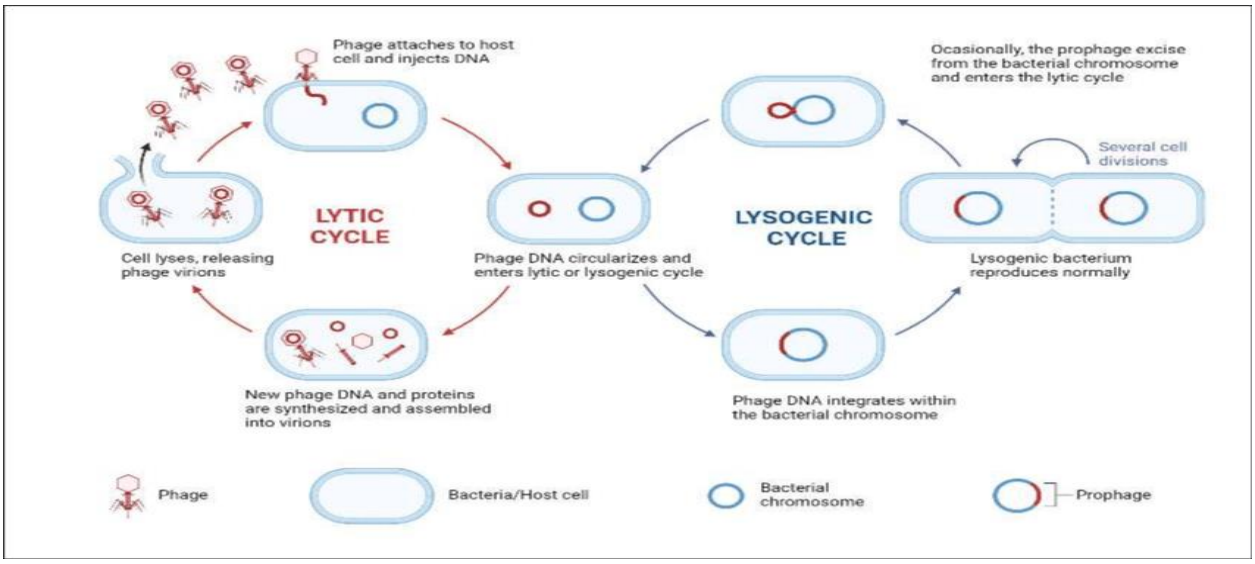


Phages exhibit two different types of life style

1- ***Lytic cycle***:- also known as ***virulent*** cycle.
Results in the ***lysis of host bacteria***, resulting in release of progeny virions
The ***enzyme lysozyme*** breaks down the cell wall, allowing viruses to escape.
e.g. phages such as T4 are called virulent(lytic) phages

2- ***lysogenic cycle***:- some phages (such as temperate phages) ***integrate into the genome of the bacterial chromosome wthout causing any lysis of the bacteria***.

- ❖ The prophage behaves likes a segment of the host chromosome and multiplies sychronously with it.



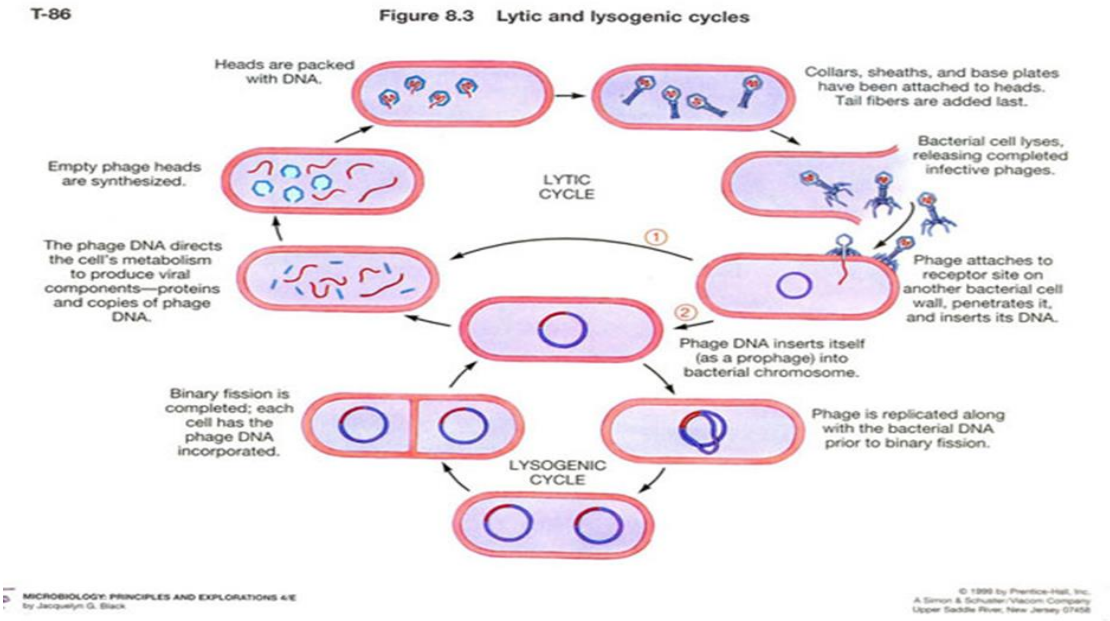


Figure lysogenic and lytic bacteriophage life cycle

EUEE 2004 E.C Questions On micro-organisms

1. In which kingdom of life are the unicellular eukaryotes grouped?
   A. Monera B. Protista C. Plantae D. Animalia
2. Which of the following is the best **collective** name for all bacteria with spherical shapes?
   A. Cocci B. Bacilli C. Spirochaetes D. Streptococci
3. Which tool of the biologist is more suitable for culturing bacteria in the laboratory?
   A. Test tubes B. Microscopes C. Petri dishes D. Beakers
4. Which one of the following types of microscopes is the best to show the details of the surface of an object?
   A. Optical microscope C. Scanning electron microscope
   B. Compound microscope D. Transmission electron microscope
5. Which one of the following is NOT one of the roles that microorganisms play in ecosystems?

A. Nutrient recycling C. Nitrogen fixation
B. Carbon fixation D. Energy recycling

6. Viruses are better characterized as:
   A. Decomposers B. producers C. carnivores D. parasites
7. In which part of the cell do Gram – positive and Gram – negative bacteria differ regarding their staining property with Gram's stain?
   A. Cytoplasm B. Cell membrane C. Cell wall D. Nucleus
8. In DNA cloning technology, which of the following molecules serves as a vector of gene of interest to be transferred to bacteria host?
   A. Bacterial DNA B. Plasmid DNA C. Nuclear DNA D. Mitochondrial DNA
9. To which of the following groups does HIV belong?
   A. Plasmids B. Retroviruses C. DNA viruses D. Bacteriophages
10. What is the main mode of transmission of diseases such as cholera and typhoid fever?
    A. Sexual intercourse C. Blood – to – blood contact
    B. Bites of animal vectors D. Drinking contaminated water
11. What are the individual strands of a fungal mycelium called?
    A. Fungus B Spores C. Hyphae D. Hydra
12. To which major area of relevance and applications of biology is the production of transgenic organism related?
    A. Agriculture B. Environment C. Biotechnology D. Medicine
13. Which of the following is true about the antiretroviral drugs currently used to treat AIDS patients?
    A. They cure AIDS C. They serve as anti – HIV vaccines
    B. They stop HIV transmission D. They slow down HIV multiplication

Biology EUEE 2005 E.C, Grade 12 on micro-organisms

1. Which of the following kingdoms of life is consisting of prokaryotic organisms?
   A. Fungi B. Monera C. Protista D. Plantae
2. What are the most frequent causative agents of food poisoning?
   A. Bacteria B. Protozoa C. Viruses D. Worms
3. Which of the following human diseases can be prevented by taking proper diets?
   A. Degenerative diseases B. Genetic diseases C. Social diseases D. Deficiency diseases
4. Which of the following practices does NOT normally transmit HIV?
   A. Sexual intercourse through anus C. Blood transfusion
   B. Sharing injection needles D. Shaking hands
5. To which of the following groups do those bacteriophages that integrate their DNA into the chromosome of their bacterial host belong?
   A. Virulent viruses C. Lysogenic viruses
   B. Lytic viruses D. Non – parasitic viruses
6. In which of the following features are eukaryotic cells distinguished from prokaryotic cells?
   A. They have mitochondria C. They have no DNA
   B. Their nuclei lack membranes D. They have smaller ribosomes
7. Which group of micro – organisms causes the disease known as athlete's foot?
   A. Bacteria B. Fungi C. Protozoa D. Viruses
8. Under which of the following groups can the fungi be more conveniently placed?
   A. Autotrophs B. Heterotrophs C. Prokaryotes D. plants
9. What is the advantage of using HAART (highly active anti – retroviral therapy) for the treatment of HIV?
   A. It gives a lasting immunity to HIV C. It prevents re – infection by HIV
   B. It prevents mutation of HIV D. It helps to break the life cycle of HIV

10. On which one of the following principles is most of the anti – HIV drugs currently in use working?
    A. Inhibition of enzyme action
    B. Degradation of viral RNA
    C. Digesting of viral particles
    D. Phagocytosis of the virus
11. If a new anti – HIV drug is to be developed to prevent the virus from entering the host cell, which one of the following processes should the drug target?
    A. Reverse transcription
    B. Binding of Gp 120 and CD4
    C. Integration of viral DNA in to host DNA
    D. Assembly of viral parts into a whole virus

Biology EUEE 2007 E.C Grade 12 On micro-organisms

1. What color do **gram-positive** bacteria stain with Gram's stain?

A. Red B. Pink C. Purple D. White

2. Which group of organisms in the ecosystem release nutrients locked up in dead bodies of organisms?

A. parasites B. decomposers C. Autotrophy D. Carnivores

3. Among the following organisms, which one belongs to the prokaryotes?

A. paramecium B. streptococcus C. Spirogyra D. Tape worm

4. What is the process called when two bacteria directly contact cell to cell and exchange their genetic information?

A. conjugation B. transformation C. co-transformation D. Transduction

5. What does it means when biologists express the cell membrane as a unit membrane?

A. a cell is covered by a single membrane.
B. A membrane is only one lipid layer thick.
C. All cells have essentially similar membrane
D. A membrane is covered by a single layer of protein

6.In which of the following ways do retroviruses differ from other RNA viruses?

A. Their genetic material is DNA.
B. Their genetic material is RNA
C. They copy RNA to DNA molecule.
D. They copy RNA from DNA molecule

7. Which of the following groups of micro- organisms does not contain parasitic members?

A. Bacteria B. Algae C. Fungi D. protozoa

8. Which one of the following is the smallest of all?

A.A red blood cell B. A virus C. A bacterium D. An amoeba

9. Which one of the following shows the feeding method of decomposers?

A. Saprophytic nutrition
B. Autotrophic nutrition
C. parasitic nutrition
D. Intracellular digestion

10. Which stage in the life cycle of HIV is disrupted if AIDS patients are treated with a drug that has a protease inhibiting activity

A. Entry of the virus into the host.
B. conversion of viral RNA to DNA
C. Integration of viral DNA into host DNA.
D. Assembly of viral parts into whole virus

11.The T-lymphocyte cells of AIDS patients are destroyed by

A. multiplication of HIV inside the cell
B. infection of opportunistic organisms

C. the immune system of the host organism itself

D. the CD4 receptors on the cell surface

12.One of the following is true about bacteriophages that have lysogenic life cycle.

A. They are RNA viruses

B. They integrate their nucleic acid in to that of the host

C. The multiply in the host immediately after infection

D. progeny viruses are released by chronic release method

Biology EUEE 2008 E.C Grade 12 On micro-organisms

1. Which of the following diseases is correctly matched with its causative agent ?

A. Malaria- fungus C. Ringworm- protozoa

B. AIDS- virus D. Syphilis- worm

2. Which step in the HIV life cycle is disrupted by an anti- retroviral drug that competitively inhibits the reverse transcriptase enzyme ?

A.Entry in to the host cell C. Formation of DNA from RNA

B. Assembly of viral parts in to a virus D. Integration of viral DNA in to host DNA

3.In what way would AIDS patients benefit from treatment with anti- retroviral drugs ?

A.Reductiion of HIV replication C. Immunizing against HIV

B. Provision of cure for AIDS D. Killing of opportunistic infectious agents

4.Which of the following is the best collective name for all bacteria with spherical shapes?

A. Spirochaetes B. Bacilli C. Cocci D. Streptococci

5.Which of the following diseases is transmitted by mosquitoes?

A. Diabetes mellitus C. Rabies

B. Kaposi’s cancer D. Malaria

UNIT THREE

ENERGY TRANSFORMATION

Introduction

- ✓ ***Energy transformation***: - conversion of one form of energy into another form of energy.
  E.g. light energy to chemical energy as in photosynthesis
- ✓ ***Metabolism***: - sum of chemical reactions that takes place within each cell of an organ.- is divided in to two:-
- ✓ ***Anabolic reaction***:-led to synthesis of larger biomolecules.
  - ❖ It helps in the construction of molecules from smaller units.
  - ❖ helps in the building of macromolecules like ***protein, nucleic acid, and polysaccharide***
  - ❖ is a constructive process
  - ❖ absorb energy (endergonic)
- ✓ ***Catabolic reaction***:-convert nutrients to energy by breaking them down
  - ❖ Involved in the breakdown of complex molecules or breakdown of monomers into carbon
  - ❖ Is a destructive process
  - ❖ Release energy(exergonic)

Comparison of Anabolism VS Catabolism

No	**Anabolism**	**Catabolism**
1.	It is the ***constructive*** phase of metabolism	It is the ***destructive*** phase of metabolism
2.	It is the process whereby ***simpler substances are joined together*** to form complex macromolecules	It is the process whereby ***macromolecules are broken down to form simpler substances*** or monomers
3.	The process ***requires energy*** to construct substances	The process **release** energy as a result of the breakdown of molecules
4.	It is ***endergonic*** (energy absorbing) reaction	It is ***exergonic*** (energy releasing) reaction
5.	It occurs during ***photosynthesis***	It occurs during ***cellular respiration***

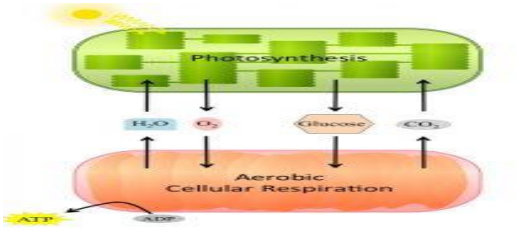
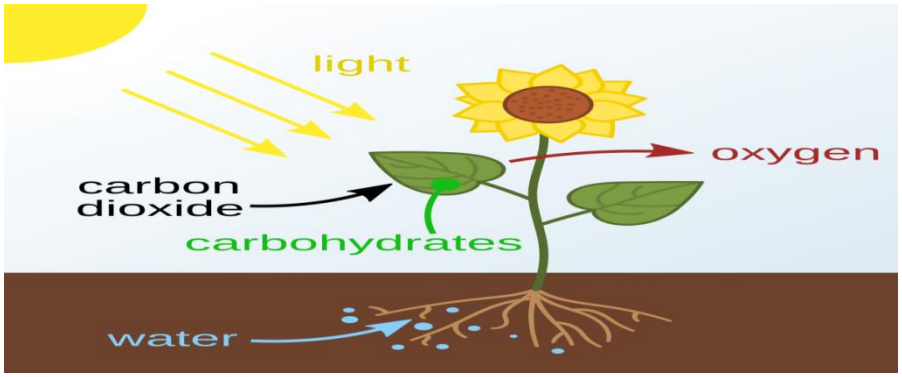


Figure 3.1. Metabolic path ways

3.1. Photosynthesis

- ❖ Conversion of light energy(from sun) into chemical energy(glucose)
- ❖ Light energy is used to assemble CO_2 into ***glucose*** and other molecules
- ❖ Water is used in the process and oxygen released as by product



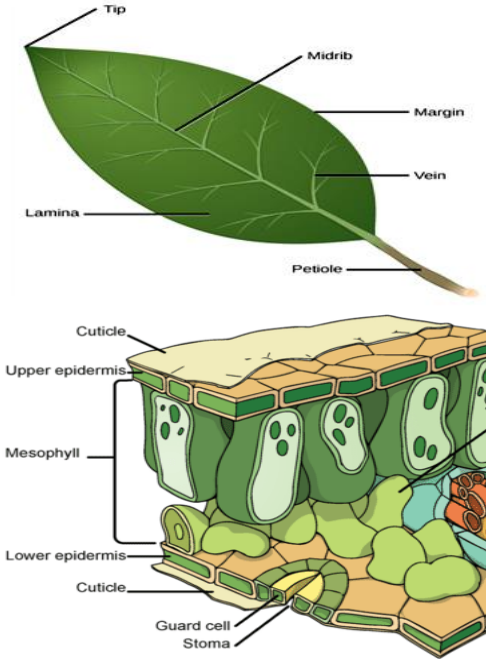
Photosynthesis

- ✓ Provide food for plants
- ✓ Provide energy(raw material) and O_2 to heterotrophs
- ✓ Is a source of oxygen in the atmosphere
- ✓ Contributes to carbon cycle
- ✓ Contributes to symbiotic relationship among plant, animal and humans. E.g. photoautotrophs:- plants, multicellular algae, some protists, cyanobacteria, purple sulfur bacteria

Question NO 1. Which of the following is **not** necessary for photosynthesis to take place?

A. Chlorophyll B. CO_2 **C. O_2** D. Water

External structure of a Leaf



A/ Outer layer (epidermis)

- ➢ Upper and lower epidermis
- ➢ Consists of cuticle, guard cells and stomata
- ➢ ***Waxy cuticle***:- water proof upper surface layer found in many types of leaf
- ➢ ***Lower epidermis***:- surface layer of a leaf containing stomata

- ***Stomata***:- pores mostly on the lower surface of leaves that can be opened or closed to control gas exchange and water loss
- ***Guard cells:-*** pairs of a cells which surround and control the size of stomata by altering their shape

B/ Middle layer (mesophyll)

- Includes tissues that are directly or indirectly involved in photosynthesis
- There are two regions in the mesophyll layer; the ***palisade*** layer & ***spongy*** layer
  - ***Palisade mesophyll***:- the main photosynthetic tissue of a leaf;

✓ It is regularly arranged and closely packed columnar(vertically elongated)cells
✓ Largest number of chloroplast per cells
✓ In best position to capture most of the sun light

- ***Spongy mesophyll***:- main gas exchange tissue of a leaf

✓ Lies below the palisade cells
✓ Irregularly shaped with fewer chloroplasts
✓ Very loosely arranged with numerous air spaces which are very close to the stomata
✓ Allow the diffusion of O_2 Water vapor & CO_2.

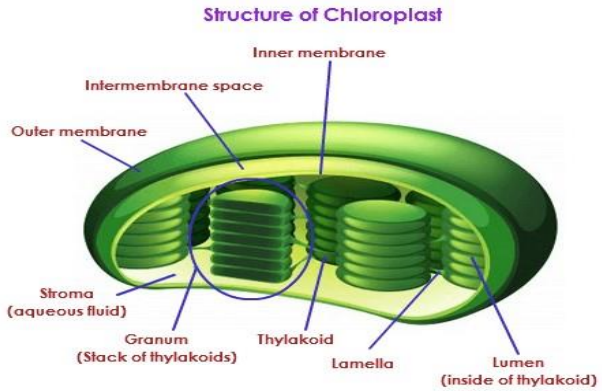
Question 2 which leaf part or layers contain the largest number of chloroplast?
A. Epidermis **B. Palisade** C. Cortex D. Spongy

The site of photosynthesis

- Photosynthesis takes place in the ***chloroplast***
- Mesophyll cells of leaves have highest density of chloroplast.
- Chloroplast have double membrane; the ***outer*** and ***inner*** membrane
- ***Intermembranic space*** :- a fluid filled space between outer and inner membrane
- ***Stroma:-*** fluid filled matrix covered by inner membrane
- ***Thylakoid:-***membranous disk like shaped compartment in ***stroma***

✓ Interior of thylakoid is called ***lumen***

- ***Grana***:- stacks of up to 100 thylakoid
- ***Outer membrane***:- separates b/n cell cytoplasm and intermembrane space
- ***Inner membrane***:- separates b/n intermembrane space and stroma



- Photosynthesis has two reactions: ***Light dependent and light independent reaction***

♥ ***Light dependent reaction***:- takes place on the membrane of ***thylakoid***
♥ ***Light independent reaction***:- (Calvin cycle):- takes place in the ***stroma*** of chloroplast

3.1.1. Photosynthetic pigments

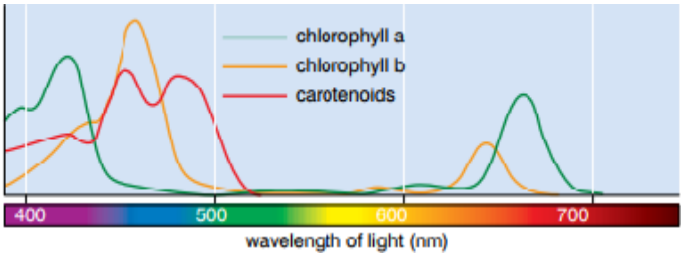
- ❖ Are pigments having a response to light (i.e. they can absorb light energy)
- ❖ Different pigments respond to different wave length of visible light i.e. they absorb certain wave length
- ❖ Are useful to plants and other autotrophs because they absorb light energy
- ❖ Since every pigment reacts with narrow range, there are several kinds of pigments in each for different color to capture more solar energy
- ❖ There are three basic classes of pigments:
  - ➢ ***Chlorophylls***
  - ➢ ***Carotenoids***
  - ➢ ***Phycobilins***
- ❖ ***Chlorophylls***:- are greenish pigments with ***porphyrin*** ring – there are several kinds of chlorophylls
- ❖ ***Chlorophyll" a"***:- the most important and found in all plants, algae, and cyanobacteria
- ❖ ***Chlorophyll "b"***:- found only in green algae and in plants
- ❖ ***Chlorophyll "c"*** :- found only in photosynthetic chromista and dinoflagellates

Question3. Which molecule in plant cells first captures the energy from sun light during photosynthesis?
A.ATP **B. Chlorophyll** C. CO2 D. Glucose

Question 4. Which of the following is the most important pigment during photosynthesis?
A. **Chlorophyll 'a'** B. chlorophyll 'b' C. Carotenoids D. Xanthophyll

- ***Carotenoids***: - are usually red, orange or yellow and contain the compound carotene. Are called accessory pigment because they don't pass light energy directly to photosynthetic pathway but transfer it to chlorophyll. E.x. ***fucoxanthin***
- ***Phycobilins***: - are water soluble pigments. Therefore found in stroma and cytoplasm. Occur only in ***cyanobacteria*** and ***rhodophyta***
- Absorption spectrum the range of wave length a molecule absorbs as recorded by spectrophotometer

Figure 3.5



- The pigments absorb most wave length of visible light-except ***500nm to 600nm***- green!
- Plants are green because these wave lengths are reflected, no absorbed
- ***Chlorophyll "a"*** absorb ***violet-blue and reddish-orange red*** wave length
- ***Chlorophyll "b"*** absorb mostly ***blue*** and ***yellow*** light
- ***Carotenoid*** absorb the **blue green** region

Question 5. What is the advantage that a photosystem containing molecules of d/t types of light sensitive pigments have? **A. To absorb light of d/t wave lengths** B. To increase the size of photosystem C. To increase the complexity of the photosystem D. To increase the surface area for light absorption

Light dependent and light in-dependent reactions

- ***Light dependent reactions***:-

✓ takes place on the membrane of ***thylakoids***
✓ water is split
✓ use light energy to `drive` the synthesis of ***two molecules*** that drive the light independent reactions. These are

- ✓ ***ADP***- this provides the ***energy*** for the reactions.
- ✓ ***NADPH***- this provide the ***hydrogen*** ions for a reduction reaction

 Light independent reactions

- ✓ Takes place in the ***stroma***
- ✓ Synthesis ***glucose***.

Note: - NADPH-=REDUCED NADP (gain H)

Question NO 6. Where does the light dependent reaction of photosynthesis occur in the chloroplast? (2005)

A. In the thylakoid membrane B. In the fluid of the stroma C. In all parts of the chloroplast D. In the stomatal opening

Question 7. Which of the following is true about the 1st stage of photosynthesis?

A. Light dependent B. temperature dependent C. ATP driven D. Glucose driven

Oxidation is	Reduction
Accepting oxygen	Losing oxygen
Loosing hydrogen	Gaining hydrogen
Losing electron	Gaining electron

What happens in the light-dependent reactions?

- ❖ Light-dependent reactions use energy from light (photon) to drivesynthesis of two molecules that drive the light independent reactions.

These reactions are:-

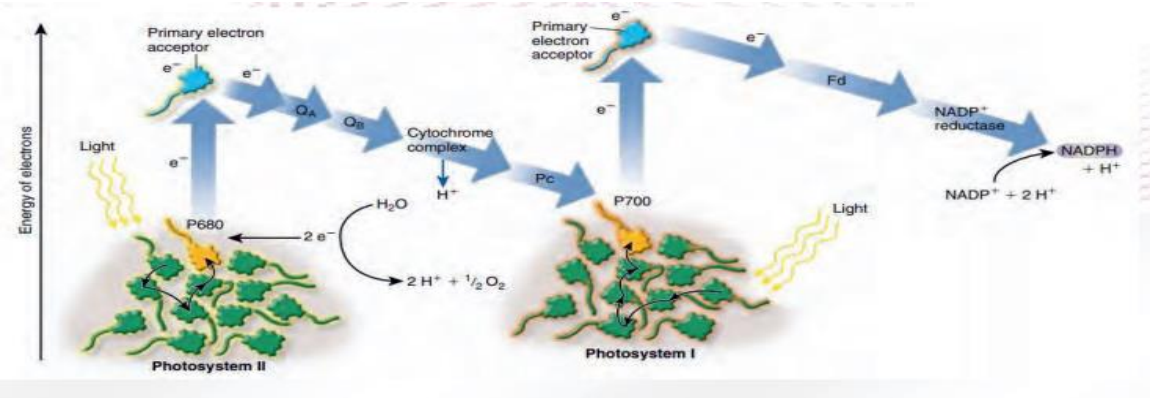
1. photolysis of water (light dependent splitting of water

$2H_2O \rightarrow O_2 + 4H^+ + 4e^-$

2. Phosphorylation reaction to synthesis ATP that provides the energy for the laterreactions, and

3. Produces reduced NADP which is similarly used to transporting hydrogen ions as NAD in respiration. It provides the hydrogen ions for later reduction reaction

Z-scheme representation of light dependent reactions.



Question 8. The molecule of which pigment is located at the reaction center of photosynthesis?

A. **Chlorophyll a** B. Chlorophyll b C. Carotenoid D. Accessary pigment

Steps of light dependent reaction

i. In photosystem ***II electrons (e-) in chlorophyll*** excited by the energy in photons of light, become energetic and escape from the chlorophyll and pass to ***primary electron acceptor***.

ii. Light dependent splitting of water (photolysis) occur in chloroplast, $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$
The electrons replace those lost from the chlorophyll molecule of photosystem II.

iii. Primary electron acceptor passes electron to electron transport chain ***(plastoquinone [pq]), cytochromes, plastocyanin(pc***) ; the electrons lose energy as they passed from one carrier to the next.

iv. A proton (Hydrogen ion) pump in cytochromes complex moves and accumulates protons from the stroma to thylakoid lumen which drives the ***chemiosmotic*** synthesis of **ATP**.

v. In photosystem I electron in chlorophyll are excited and escape from the molecule. They are replaced by the electrons from photosystem II

vi. The electron then pass along a second electron transport chain involving ***ferredoxin*** (Fd) and ***NADP reductase***. At the end they react with protons (hydrogen ion) and NADP to form reduced NADP (in the stroma)

Question 9. Which of the following is NOT true about photosystem II?

a. Its reaction center molecule is p680.

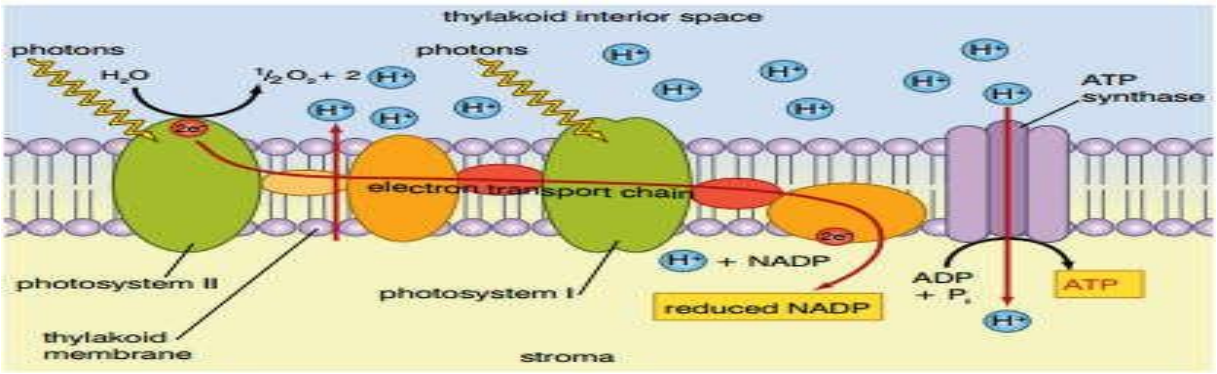
b. It passes its excited electrons to photosystem-I

c. The energy lost from its excited electrons reduced NADP.

d. It replenishes its lost electrons from photolysis of water

Question 10. Which of the following processes of photosynthesis does NOT require the presence of light to take place? A. The splitting of water B. ATP formation C. Reduction of NADP **D. Carbon fixation**

Question no. 11. Which process of photosynthesis can occur in the presence as well as in the absence of light? A. Photolysis of water B. ATP formation **C. Carbon fixation** D. Release of free energy



Products of light dependent reaction

- O2- Produced in the thylakoid lumen
- NADPH- produced in stroma
- ATP- produced in stroma by ATP synthase. ATP is formed from ADP and Pi by process of non-cyclic photophosphorylation.

Cyclic and non-cyclic phosphorylation

- ***In non-cyclic photophosphorylation***

✓ The electrons lost from the chlorophyll are not recycled in any way

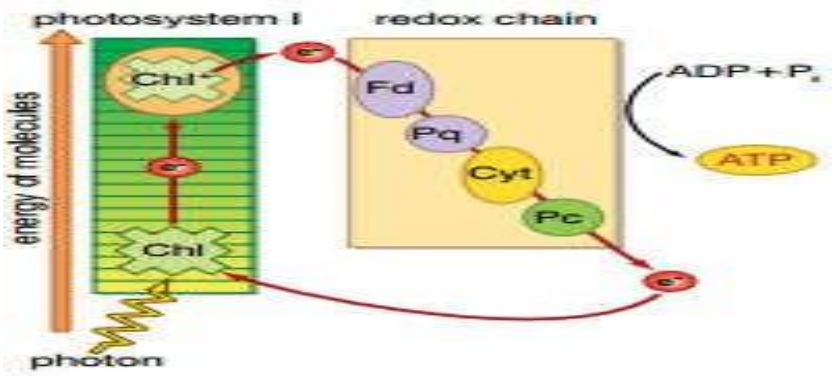
✓ Both photosystem I and II used to generate ATP

- ***In cyclic photophosphorylation***

✓ Electrons lost from the chlorophyll molecule are returned to it

✓ Only photosystem I is used to generate ATP

✓ NO oxygen and no reduced NAD are formed



Comparison of No-cyclic and cyclic photophosphorylation

	Non-cyclic	Cyclic
Pathway of electrons	Non-cyclic	Cyclic
First electron donor(source of electrons)	Water	photosystemI(P700)
Last electron acceptor destination of electrons)	NADP	Photosystem I(P700)
Products	Useful:ATP, reduced NADP oxygen (byproduct).	Useful:ATP only
Photosystem involved	I and II	I only

Question no 12. In cyclic photophosphorylation, what is the source of the recycled electron? (2004)

A. Reduced NADP **B. Chlorophyll molecule** C. ATP D. Photolysis of water molecule

Question no 13. What is the source of the oxygen that is produced during the process of photosynthesis by high plants?

A. CO2 **B. H2O** C. ATP D. Chlorophyll

Question no 14. One of the following is NOT part of the light reaction of photosynthesis

A. Photosystem I B. photosystem II C. Electron carrier **D. Calvin cycle**

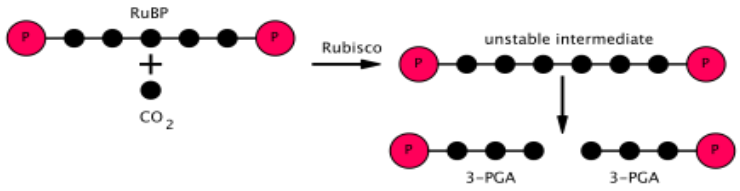
The light independent reaction (Calvin cycle)

- Also known as dark reaction because doesn`t require light
- It takes place in the stroma of chloroplast
- In dark reaction ***carbohydrates (glucose)*** are formed from ***CO_2*** using ***ATP*** and ***NADPH*** from light dependent reaction
- The light independent reaction can be organized in to three stages
  - Carbon fixation
  - Reduction
  - Regeneration

a.Carbon fixation stage

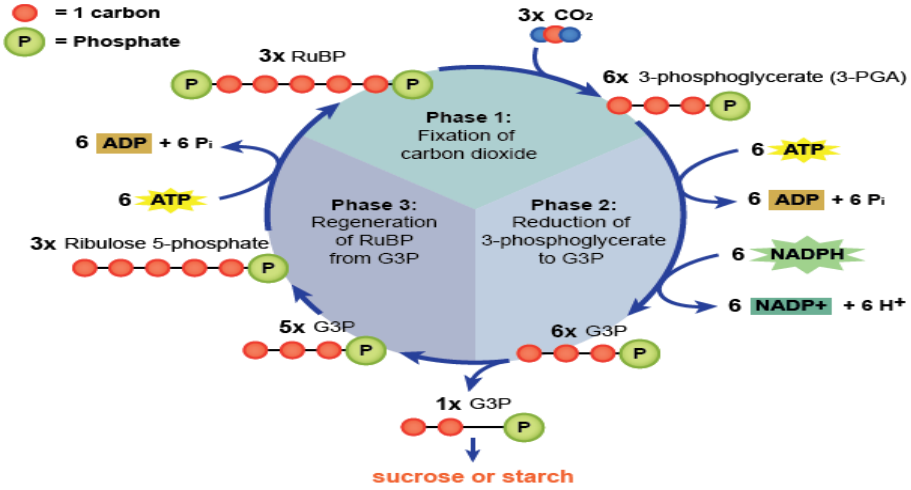
- Is a beginning stage of Calvin cycle when carbon dioxide react with **pre-existingfive carbon** molecule ***ribulose bisphosphate*** (**RuBp**) in stroma of chloroplast.
- Form an immediate carbon six molecule Phosphoglyceric acid (PGA)
- Is catalyzed by **Rubisco** enzyme (RuBp carboxylase/oxygenase).
- This step gives six carbon cpd that disintegrate into two molecule of ***3-PGA*** (3-Phosphoglyceric acid) –a 3 carbon

compound



b.Reduction

- Second stage of light independent reaction
- ATP & NADPH are used to change 3- PGA to G3P(Glyceraldehyde-3- phosphate)- a 3 carbon sugar
- This step is called reduction because ***NADPH*** donates electrons to form ***G3P***



c.Regeneration

- Some G3P molecules form while others recycled to regenerate RUBP(Ribulose bisphosphate)
- Regeneration needs ATP and a series of reaction called '***carbohydrate scramble'***
- In the dark reaction CO2 is fixed to glucose and RUBP is regenerated
- In the Calvin cycle **12 NADPH** and **18 ATP** are used to fix **6CO2** molecule in to one hexose sugar (fructose-6-phosphate) which is then converted to glucose

➢ Calvin cycle needs ***six turns*** to produce two G3P (**TP**, *Triose phosphate*) which is enough to make one glucose molecule.

- ➢ One turn of Calvin cycle needs 3ATP and 2 NADP to produce one glucose molecule.
- ➢ RuBp (ribulose bisphosphate)= CO2 Acceptor

Question no 15. How many ATP and reduced NADP molecules used up during reduction of carbondioxide respectively?

A. 6 ATP and NDP C. **18ATP and 12NADP**

B. 24ATP and 12NADP D. 3ATP and 2NADP

Question no 16. Which of the following processes of photosynthesis does not require the presence of light to take place (2004)

A. The splitting of water B. ATP formation C. Reduction of NADP **D. carbon fixation**

C3,C4,and CAM Photosynthesis

C3 Photosynthesis and photorespiration

 What we have just described previously is called C3 photosynthesis- because the first compound formed in the

light independent reactions is 3-PGA, which contains three carbon atoms

- Approximately 95% of plants on the earth are C3 plants
- Example : wheat, rye, oats, orchards grass
- C3 plants have leaves that are adapted to this method of photosynthesis

Leaves of C3 plants have the following major adaptation for photosynthesis:

- ❖ Have broad leaves to capture more light
- ❖ Palisade cell has chloroplast at upper surface of leaves to absorb more light.
  - Their stomata are mainly at lower surface.
- ❖ To minimize water loss (has waxy cuticle)
- ❖ They open their stomata mainly at day time, to allow entry ofCO_2 and close if water loss is great on hot day.
  - Spongy mesophyll has air space.
- ❖ That allows easy diffusion of CO_2 and O_2 between palisade and stomata.

➢ But Plants in tropic have problems because on very hot day the leaves close their stomata to minimize water loss and this leads to **photorespiration**

What is photorespiration?

In hot days plants close their stomata, this leads to

- ❖ Decrease in concentration of CO2 in leaves and
- ❖ Rubisco shows unusual behavior
- ❖ Normally Rubisco bind with CO2 but if the concentration of CO2 in leaves decrease it binds with O2 to form GPA and phosphoglycolate
- ❖ Rubp+O2→GPA + Phosphoglycolate
- ❖ This oxidation of organic compound(carbon) in the presence light
  - ➢ Like ordinary respiration CO2 is produced but ATP is not
  - ➢ Instead ATP is consumed in this process
  - ➢ The GPA can inter the Calvin cycle but phosphoglycolate must be converted in GPA to inter Calvin cycle
- ❖ This requires ATP and the reactions takes place in mitochondria ,peroxisome, chloroplast
- ❖ It seems wasteful but,
- ❖ It may have function which are still unknown
- ❖ Photorespiration occurs in C3 Plants, greatly reduced in C4 plants and absent in CAM plants

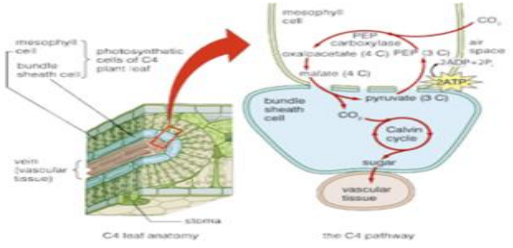
Question no 17. Which of the following statement is **not true** concerning C_3 plants?

A. The first compound formed in the dark reaction contains three carbon atoms.
B. The stomata are mainly on the lower surface to minimize water loss.
C. The cell of bundle sheath contains many chloroplasts
D. The palisade cells are nearest the upper surface of the leaf

Question no 18. Which of the following processes mainly reduce efficiency of photosynthesis?

A. Photophosphorylation
C. Chemiosmosis
B. Fixation of CO_2
D. **photorespiration**

C4 Path way



C4 PHOTOSYNTHESIS

- C4 plants ; maize, crabgrass, sorghum and sugar cane
- the first compound formed by carbon fixation is a C4 compound
- The light-dependent reactions are the same as in the C3 plant
- Bundle sheath cells

✓ contain chloroplast without thylakoid
✓ Calvin cycle occurs here because calvin cycle enzymes are present
✓ light dependent reaction doesn't take place because they don't have thylakoid(site of light dependent reaction)
✓ If light dependent rxn not occur O2 won't be produced and this prevents photorespiration from occurring in bundle sheath cells

- mesophyll cells

✓ Contain chloroplast with thylakoid
✓ Calvin cycle doesn't occur in mesophyll cells b/c they doesn't have Calvin cycle enzyme
✓ Light dependent reaction takes placeb/c they have thylakoid
✓ The basic C4 cycle consists of ***four stages*** which occur partly in mesophyll cells and partly in bundle sheath cells

1. Carbon dioxide reacts with PEP(C3) to form oxaloacetate(C4) in mesophyll cells

✓ this is catalyzed by the enzyme **PEP carboxylase**.

2. Oxaloacetate is converted into malate(C4) which then passes from the mesophyll cell into a bundle sheath cell.
3. In the bundle sheath cell, malate is converted to pyruvate with the release of a molecule of carbon dioxide, which starts the reactions of the Calvin cycle by binding with RuBp
4. The pyruvate is converted back to PEP; this reaction requires ATP.

✓ Overall, the C4 cycle uses two more molecules of ATP to deliver a molecule of carbon dioxide to Rubisco than does the C3 cycle.
✓ C4 plants separate the two stages of photosynthesis by carrying them out in different cells to reduce the effect of photorespiration

Question no 19. Which of the following is NOT true about C4 plants such as tef (Eragrostistef)? EUEE 2007 E.C

A. CO2 is harvested during the night time.
B. The bundle sheath cells contain chloroplasts.
C. Light-dependent reaction occurs in mesophyll cells.
D. Chloroplasts of bundle sheath cells lack thylakoids

Question no. 20. Which of the following is the adaptation by C4 plants that helps them to avoid photorespiration? EUEE 2008 E.C

A. Harvesting of carbon dioxide at night
B. Storing carbon dioxide in the vacuole
C. Using separate cell for light & dark reactions
D. Keeping the stomata closed during the day

Crassulacean acid metabolism (CAM) photosynthesis

- Example of CAM plant ; ***pineapple***
- They undergo the same set of reactions as C4 plants, but they separate the two stages by carrying them out **at different times.**
- They close their stomata during the day to reduce water loss and open them at night when temperatures fall

The CAM photosynthesis cycle

1. At night, the plants open their stomata to allow in CO_2 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 pyruvate releasing carbon dioxide for the reactions of the Calvin cycle.

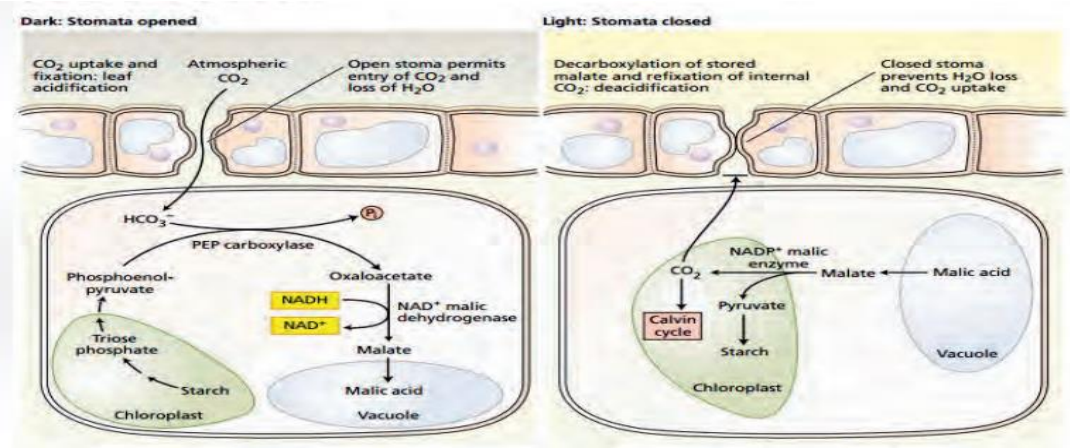


Figure 3.10 CAM Cycle

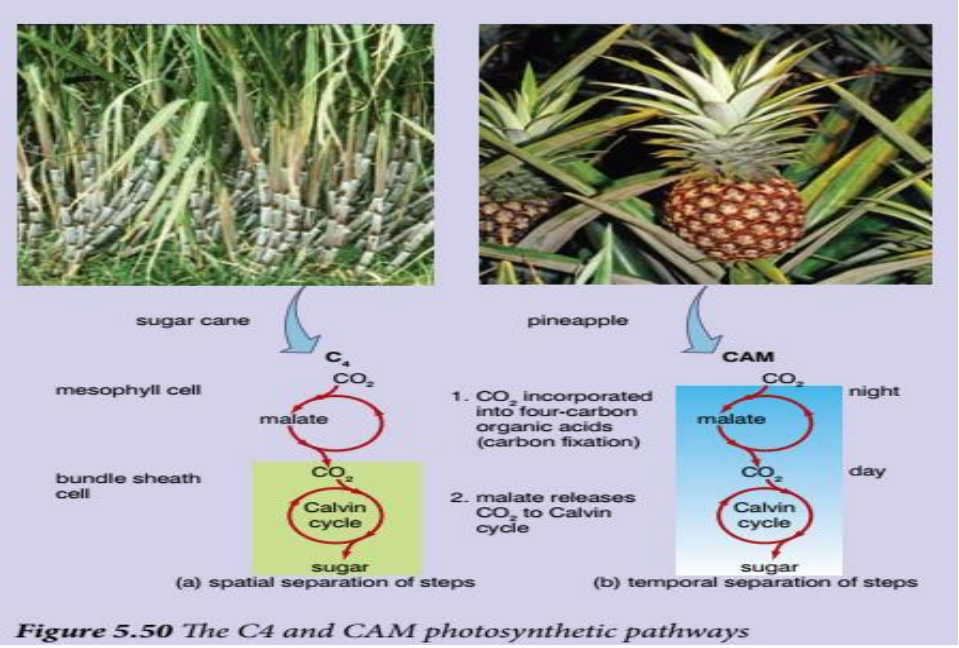
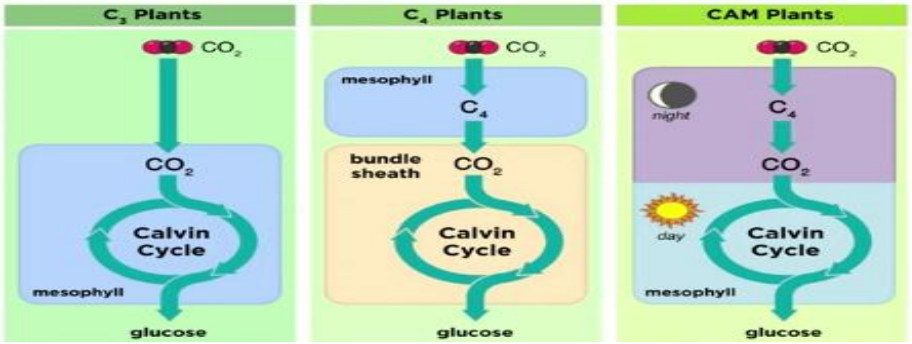


Figure 5.50 *The C4 and CAM photosynthetic pathways*



Self-test question

Answer the following multiple choice questions. Don't visit key before you try it on yourown. Refer relative sources and contact your teacher where necessary.

1. From the following identify the **wrong** statement about PsII and PsI?
   A. Each photosystem linked with different ETC
   B. PsI linked with '**fd'** to transfer exited electron to NADP
   C. PsII involved in both cyclical and non-cyclical phosphorylation
   D. Each photosystem have reaction center and antenna complex
2. Which one of the following pairs of plants is **NOT** photosynthesis by **C4** and **CAM** pathway respectively?
   A. Sugar cane and pineapple C. Maize and Cacti
   B. Sorghum and Cacti D. cacti and sorghoum
3. All of the following are generally true about photorespiration **EXCEPT** one?
   A. It involves RuBP binding with oxygen
   B. It lower photosynthetic efficiency
   C. It is reductive process that consume ATP and NADP
   D. It is a condition in low [oxygen] and common in C_3 plants
4. Which one of the following pairs of photosynthetic pigment has maximum absorptive spectrum at which rate of photosynthesis is effective than else?
   A. Violet and Blue B. Blue and Red C. Green and Red D. Yellow and Red
5. Which one of the following is **NOT** generally true about Non-cyclical phosphorylation?
   A. Chlorophyll molecule is initial and final donor and acceptor of a chain
   B. It involves one way electron flow from water to NADP
   C. It involves both PSII and PSI
   D. It ends up with generation of ATP, NADP and O_2
6. Which one of the following pairs of factors directly influences light dependent and lightindependent reaction respectively and indirectly influences each other viseversaly?
   A. Light intensity and Carbon dioxide concentration
   B. Temperature and chlorophyll molecule
   C. Carbon dioxide concentration and light intensity
   D. Temperature and light intensity
7. Which one of the following pigment in a photosystem is referred as a reaction center where light dependent reaction starts?
   A. Xanthophylls B. Chlorophyll b C. Chlorophyll a D. Carotenoids
8. Which one of the following is **NOT** true about CAM pathway?
   A. Is adapted to desert (arid) condition with high temperature and low moisture
   B. They open and close their stomata at different circadian rhythm.
   C. They have needle leaved and long rooted plant with thick bark
   D. They has no role in sugar production
9. Among the following reaction in C3,C4 and CAM Pathway , one similarly takes place in mesophyllcell:
   A. Fixation of carbon dioxide C. Generation of ATP and NADP
   B. Calvin cycle D. Sugar production
10. In light dependent stage of photosynthesis light is essential for:

A. Fixation of carbodioxide from the atmosphere
B. Synthesis of ATP and proton carrying coenzyme
C. Regeneration to ribulose biphosphate
D. Combination of carbodioxide and water

11. Which one of the following reactions commonly occurs in both Cyclical and Non-cyclical phosphorylation of photosynthesis in thylakoid membrane of chloroplast?
    A. Production of reduced NADP
    B. Generation of ATP
    C. Generation of O2 and water photolysis
    D. Involvement of both PsII and PsI
12. In what way chloroplast in bundle sheath cell of C4 plants adapted for the pathway?
    A. Absence of Calvin cycle
    B. Presence of thylakoid membrane
    C. Absence of thylakoid membrane
    D. Dependence on high oxygen concentration
13. Which one of the following organelles involved in photorespiration to convert phosphoglycolate into glycolate to be re-used in Calvin cycle respectively?
    A. Chloroplast, Mitochondria and Perixosome
    B. Ribosome, Nucleus and Mitochondria
    C. Chloroplast, Perixosome and Mitochondria
    D. Nucleus, Ribosome and Golgi body
14. What is the main advantage that a photosystem containing molecules of different types light sensitive pigments have?
    A. To increase amount/number of photosystem.
    B. To absorb light of the different wave length
    C. To increase amount of ATP in cell
    D. To Increase number of chlorophyll molecule in the cell
15. Which of the following is true regarding cyclic photophosphorylation?
    A. Only photosystem II involved
    B. The flow of electron is from PSI to PSI
    C. It produces oxygen & red. NADP
    D. There is ATP production
16. Under what conditions do C4 plants have more photosynthetic efficiency than C3 plants?
    A. Low temperature
    B. Low CO2 concentration
    C. low light intensity
    D. high CO2 concentration
17. Which of the following reaction represents photo respiration?A. 6 $CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$
    B. $CO_2 + RUBP \rightarrow 2G3P$
    C. $O_2 + RUBP \rightarrow 1G3P +$ phosphoglycolate
    D. CO_2 + phosphoenolpyruvate → Oxaloacetic acid
18. Which one of the following molecules initially combines with CO_2 in stroma of chloroplast?
    A. Glycerate phosphate
    B. Oxalo acetate
    C. Phosphoenol pyruvate
    D. Ribulose biphosphate
19. Which of the following plants carryout light dependent and primary CO_2fixation in separate time?
    A. C-3 plants B. C-4 plants C. CAM plants D. Both CAM and C4 plants
20. Which of the following is the correct sequence of the reaction in Calvin cycle of photosynthesis?
    A. Regeneration of RuBP, reduction reaction and CO_2 fixation.
    B. Regeneration of RuBP, CO_2fixation and reduction reaction.
    C. CO_2fixation, regeneration of RuBP and reduction reaction.
    D. CO_2fixation, reduction reaction and regeneration of RuBP

Answer Key

1. C	**11. B**
2. D	**12.C**
3. C	**13. C**
4. B	**14. B**
5. A	**15. D**
6. A	**16. B**
7. C	**17.C**
8. D	**18.D**
9. A	**19.B**
10. B	**20.D**

3.2. CELLULAR RESPIRATION

At the end of the unit students will be able to:

- Describe the structure of ATP and its role in cellular metabolism.
- Explain how ATP is adapted to its role as an energy transfer molecule within a cell.
- Describe in detail each stage of aerobic respiration.
- Explain the processes of alcoholic fermentation and lactate production.
- Appreciate the importance of lactate production during running and other sports.

Cellular Respiration

➢ Is the process by which energy is produced by **breaking down of organic molecules** such as glucose

There are two types of respiration:

a. Aerobic respiration - this requires the presence of **oxygen**

b. Anaerobic respiration - this can take place in the **absence of oxygen.** ex .***fermentation***

Question no 1. What is the correct equation for cellular respiration? EUEE

A. $6CO_2 + 6H_2O + Energy = 6O_2 + C_6H_{12}O_6$

B. $6O_2 + C_6H_{12}O_6 = 6CO_2 + 6H_2O + Energy$

C. $6O_2 + C_6H_{12}O_6 + Energy = 6CO_2 + 6H_2O$

D. $6CO_2 + C_6H_{12}O_6 = 6O_2 + C_6H_{12}O_6 + Energy$

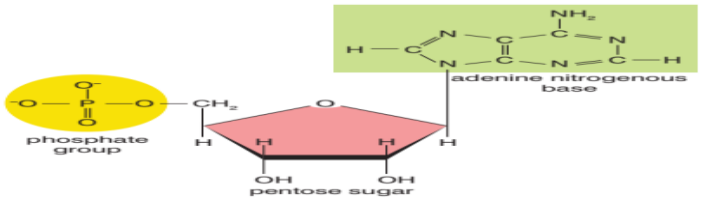
What is ATP molecule like?

- ❑ The full name for ATP is **A**denosine **T**ri-**P**hosphate
- ❑ All nucleotides contain:
  - ✓ a nitrogenous base
  - ✓ a pentose sugar
  - ✓ a phosphate group
- ❑ there are 5 types nucleotides
  - ✓ Adenine nucleotide
  - ✓ Guanine nucleotide
  - ✓ Cytosine nucleotide
  - ✓ Thymine nucleotide
  - ✓ Uracil nucleotide

Nucleoside =nitrogenous base + pentose sugar

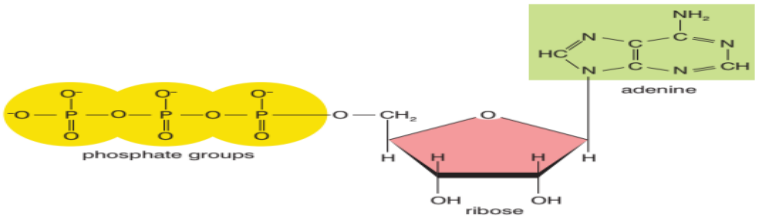
Nucleotide=Nucleoside + phosphate group

- ✓ ATP is based on Adenine nucleotide



- ❑ ATP is the adenine nucleotide with two extra phosphate groups
  - ✓ hence called **phosphorylated nucleotide**

➢ **phosphorylation:-** adding one or more phosphate groups to a molecule



- The Three Phosphate Groups Are Linked To One Another By A High Energy **Phosphoanhydride** Bonds.
- **That Means ATP is an Energy Storing Compound**
- **Hydrolysis :-**breaking a bond by adding water
- **Condensation:-** forming a bond by removing water
- *breaking of phosphoanhydride bond is a hydrolysis reaction*:-
- If one phosphate is removed from ATP ,it is changed to ADP and Pi releasing energy

  ATP + H2O → ADP +Pi +Energy
- If one phosphate is removed from ADP ,it is changed to AMP and Pi releasing energy

  ADP + H2O → AMP +Pi+ Energy
- AMP can be recycled back to ADP or ATP to store energy

  AMP + Pi +ENERGY → ADP +H2O

  AMP + 2Pi +ENERGY → ATP +H2O

Pi=inorganic phosphate

Question no 2. Which of the following defines ATP?**EUEE**

A. Adenine + adenosine + a phosphate

B. Adenosine + ribose sugar + double phosphate

C. Adenine+ ribose sugar + triple phosphate

D. Nitrogen + sugar + monophosphate

Question no 3. Which phosphate bond of the ATP is broken when the energy it contains is needed for cellular activity?

A. The first bond

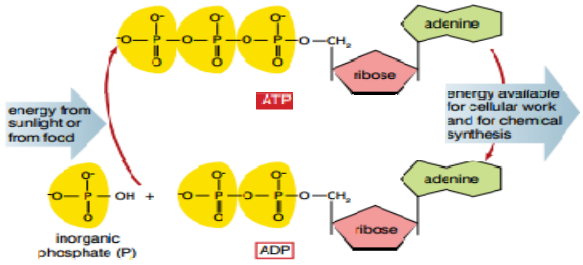
B. The C- C bonds

C. **The second bond**

D. The third bond

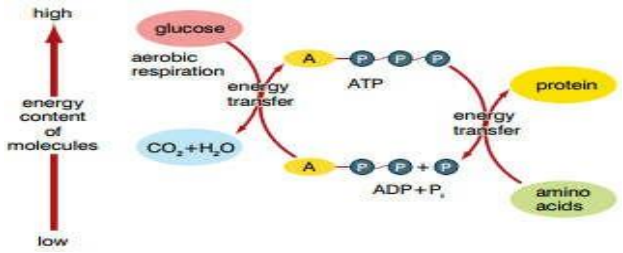
Hint:

- Adding the extra phosphates (third) requires energy, as energy is stored in the ATPmolecule and when the bonds that hold third phosphate are broken energy is released again.



How ATP adapted as an energy transferring molecule in the cell?

- The energy from sunlight or glucose cannot directly used to drive available cellular process rather used to produce ATP. We say that it is coupled processes as the process takes place simultaneously at the same time



Coupled reactions transfer energy in cells

ATP is adapted to its role because of the following:-

- It releases energy in small amount that matches biological process of the cell.
- It releases energy only in single step only, **Hydrolysis**.
- It able to move around the cell easily, but not escape from the cell.

The following major process requires energy from ATP

- ❑ Synthesis of macromolecules E.g Protein, polysaccharides
- ❑ Active transport across plasma membrane
- ❑ Muscle contraction
- ❑ Conduction of nerve impulses
- ❑ Initial step of respiration, Glycolysis

How is ATP produced in respiration?

- ❑ ATP is produced by phosphorylating ADP i.e. by adding phosphate group to ADP

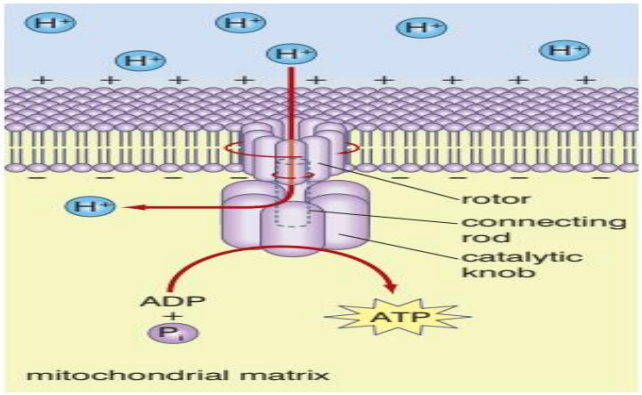
ADP + Pi → ATP

- ❑ This can be done in two ways

1) **<u>Oxidative phosphorylation</u>**

- ➢ The formation of ATP involves an enzyme called **ATP synthase**

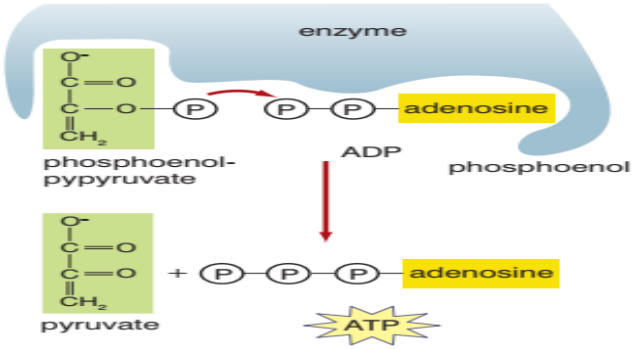
When the rotor of ATP synthase is made to spin **by *hydrogen*** ions passing through it, the energy of the spinning is used to activate sites in the catalytic knob that convert ADP and Pi to ATP.



2) **<u>substrate level phosphorylation</u>**

- ➢ In this process, another molecule such as ***phosphoenol pyruvate*** is able to transfer a phosphate group directly to ADP

The process isn't catalyzed by **ATP synthase** but by another enzyme



Stages and The site of cellular respiration

Stages

- ***Glycolysis***
- ***link reaction***
- ***Krebs cycle***
- ***electron transport and chemiosmosis***

Sites

- ***in eukaryotic cells*** only glycolysis occur in ***cytoplasm***, the remaining steps takes place in the ***mitochondria***
- **In prokaryotic cells** all the steps are carried out in the **cytoplasm**, because prokaryotes ***doesn't have mitochondria***

#NOTE also * only ***glycolysis*** can occur both in the presence and absence of O_2

*the remaining steps occur only in the presence of O_2

Therefore **Glycolysis** occurs in ***aerobic and anaerobic respiration*** but the remaining steps occur only in ***aerobic respiration***

Question no 5. Which of the following steps in cellular respiration can take place in the absence of oxygen? **EUEE**

A. Electron transport

B. Glycolysis

C. Krebs cycle

D. Acetyl COA formation

Question no 6. Which of the following is true for cellular respiration? **EUEE**

A. Restricted to plant cells

B. Restricted to animal cells

C. Occurs in all eukaryotic cells

D. Occurs in prokaryotic cells only

Question no 7. Which of the following stages of aerobic respiration occurs outside mitochondria?

A. Glycolysis

B. Chemiosmosis

C. Krebs cycle

D. Link-reaction

Question no 8. Which of the following happens during cellular respiration but **NOT** during photosynthesis?

A. Fixation of carbon dioxide

B. Release of carbon dioxide

C. Release of free oxygen

D. Formation of ATP

Glycolysis

- Means glucose splitting

- It is the first stage of cellular respiration.
- It takes place in cytoplasm (Cytosol) of a cell.
- It is a process of anaerobically breakdown of carbon six glucose molecules into two carbon three molecules.

Glucose (C6) ——————→ ***2 pyruvate (2C3)***

Glycolysis has two phases with ten steps.

a. ATP utilized stage and glucose converted to **2G3P**.
b. ATP production phase and **2G3P** converted to pyruvate.

Glucose doesn't enter into mitochondrial membrane because of:-

- It is medium sized and not lipid soluble.
- There is no carrier protein to transport glucose across membrane.
- But pyruvate and coenzyme can enter mitochondrial membrane.

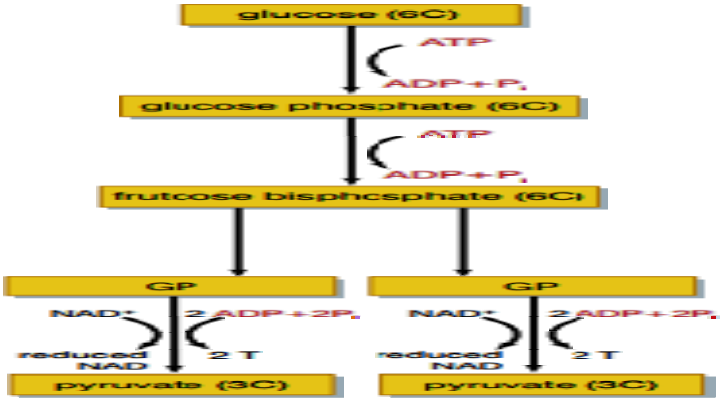
The following reactions take place in glycolysis?

- There is ten steps in glycolysis that are catalyzed by different enzyme
- In phosphorylation process, glucose converted to another carbon six sugar (Fructose,1-6, biphosphate).
- Fructose, 1-6, bisphosphate split into two carbon three sugar ***glyceraldehyde –phosphate***(G3P)
  - Each **G3P** converted to pyruvate
  - Two ATP molecules used up to make glucose more active.

End product of glycolysis per glucose molecule

- Four total ATP molecule by SLP {two ATP used to activate glucose and two netATP gain}.
- ***Two pyruvate*** molecule ***Two reduced NAD molecule***
- Then **pyruvate** and coenzyme enter into mitochondrial membrane

Main stages of Glycolysis

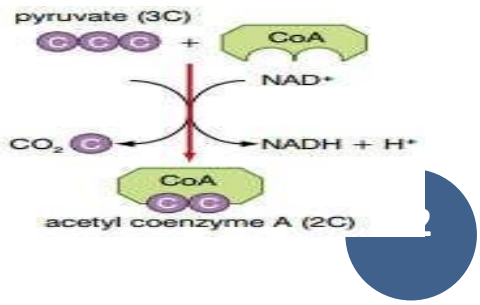


Summary of overall reaction of Glycolysis:-

$$C_6H_{12}O_6 + 2ATP + 4ADP + 2Pi + 2NAD \rightarrow 2C_3H_6O_3 + 2ADP + 4ATP + 2NAD\ red. + 2H^+ + 2H_2O$$

Link reaction(pyruvate oxidation)

- Is act as a transition or link step between glycolysis and Krebs cycle.
- It takes place in fluid matrix of mitochondria and involves aerobic process.
- Then pyruvate reacts with coenzyme A (**CoA**) to form carbon two molecule acetyl-coA (**acetyl CoA**). **Hint**. CoA is derived from **Vit. B** panthonic acid which is needed for respiration.



Two main reactions takes place in link reaction are:-

- **Dehydrogenation** -hydrogen is lost from a molecule and red.NAD formed.
- **Decarboxylation** - a carbon atom is lost in form carbon dioxide.
- **End product of this reaction**

  $2CO_2$, 2acetyl CoA, and 2NADH

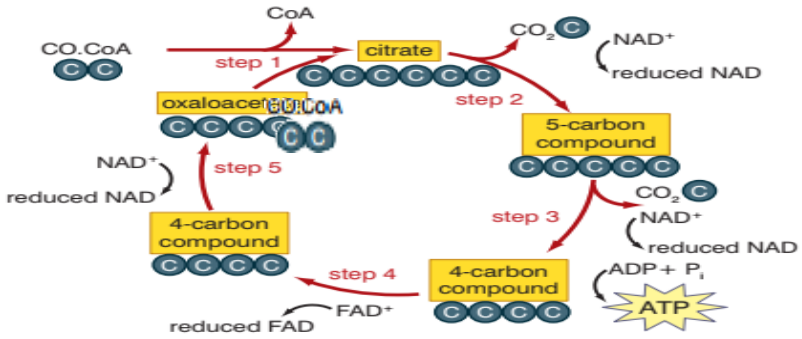
- The Acetyl-coA molecules enter the Krebs cycle
- NADH goes to the electron transport chain to produce ATP
- Carbon dioxide diffuses out of the cell as a waste product

KREBS CYCLE (Citric acid cycle) / Tricarboxylic acid

- It is takes place in fluid matrix of mitochondria and aerobic process.
- In all glycolysis, link reaction and Krebs cycle hydrogen atom transferred to NAD and FAD molecules.

What happens in the Krebs cycle?

- Two-carbon group acetyl-coA reacts with the four-carbon compound **oxaloacetate** to form a six-carbon compound called **citrate.**
- Citrate decarboxylated to form a five-carbon compound (**Isocitrate**) and CO2.
- Five-carbon compound further decarboxylated to form a four-carbon compound and CO2, ATP molecule by **SLP**.
- Four-carbon compound regenerate the original four-carbon compound (oxaloacetate)and begin reacting with another molecule of acetyl CoA.
- After citric acid forms, it goes through a series of reactions that release energy
- The energy is captured in molecules of NADH, FADH2 and ATP
- Carbon dioxide is also released as product of these reactions
- The final step of the Krebs cycle regenerates OAA



End of Krebs cycle as regeneration is:

- Six reduced NAD
- Four carbon dioxide
- Two ATP molecules produced by SLP
- Two reduced FAD

➢ Two turns are needed because glycolysis produces two pyruvate molecules when Glucose splits

	NADH	FADH2	ATP
GLYCOLYSIS	-	-	2
LINK REACTION	-	-	-
CREB CYCLE		2	2
TOTAL		2	4

In ETC 1NAD=3ATP, 1FAD= 2ATP

A summary of the overall reaction of the Krebs cycle is:-

$$CH_3CO.CoA + 3NAD + FAD + C_4H_2O_5^{2-} \rightarrow 2CO_2 + 3NADH + FADH + CoA + C_4H_2O_5$$

Question no 9. If a cell contains **10NADH** + **10 $FADH_2$** molecules, a total of how many ATP molecules would it produce from them? A.20 ATP **C. 50 ATP**

B. 30 ATP D. 60 ATP

Question no 10. During the Krebs cycle, which of the following molecules temporarily stores most of the energy released from food molecule?

A. ADP B. ATP C. **NADH** D. FADH

Question no 11. What happens in the first reaction of the Kerbs cycle during energy transformation?

A. a 2-C compound is produced

B. a 6-C compound is produced

C. a 4-C compound is produced

D. a 5-C compound is produced

Electron Transport Chain (ETC) and Chemiosmosis

Define and Explain how these two reactions takes place?

- ❖ Together makes up oxidative level phosphorylation (**OLP**).
- ❖ It is an aerobic process involving ATP synthase enzyme.
- ❖ It takes place in mitochondrial inner membrane, **Cristae.**

The following events take place on Cristae:

- ➢ Hydrogen atoms carried by red.NAD and red.FAD are released and split into protons and electrons.
- ➢ The electrons pass along electron carriers from one carrier to next that form, ETC.
- ➢ They loss energy as they pass from one carrier to next.
- ➢ Where energy lost is used to empower the pump (makes the process more energetic) from mitochondrial matrix into the inter-membrane space.

Three molecules that act as electron carriers in the ETC are:

- Red. NAD dehydrogenase (also a proton pump)
- Ubiquinone (also a proton pump), and
- Cytochrome (proteins that contain iron).

Where reduced NAD is dehydrogenated by the NAD dehydrogenase complex, reduced FADis dehydrogenated by Ubiquinone.

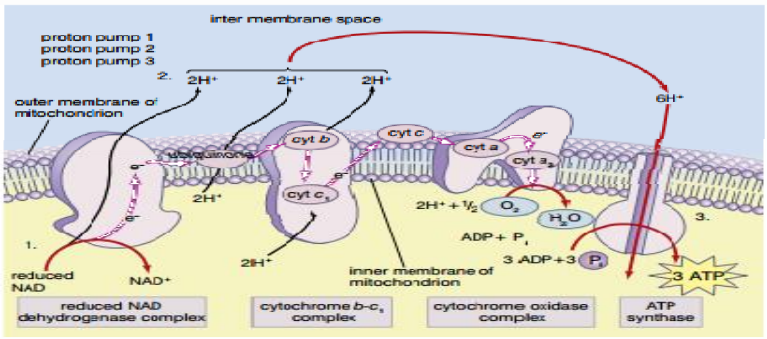
At the end of ETC, electrons combine with protons and with oxygen to form molecules of water.

$4e^- + 4H^+ + O_2 \rightarrow 2H_2O$, oxygen is termed as the **terminal electron acceptor of the chain**.

Because of the action of the proton pumps,

- ❑ Protons accumulate in the inter-membrane space creating a higher concentrationthere than in the matrix.
- ❑ This proton gradient results in protons diffusing through the ATP synthase.
- ❑ This makes rotor 'spin' of synthase and produce ATP from ADP and Pi, phosphorylation

Chemiosmosis is diffusing of hydrogen ions through the ATP synthase

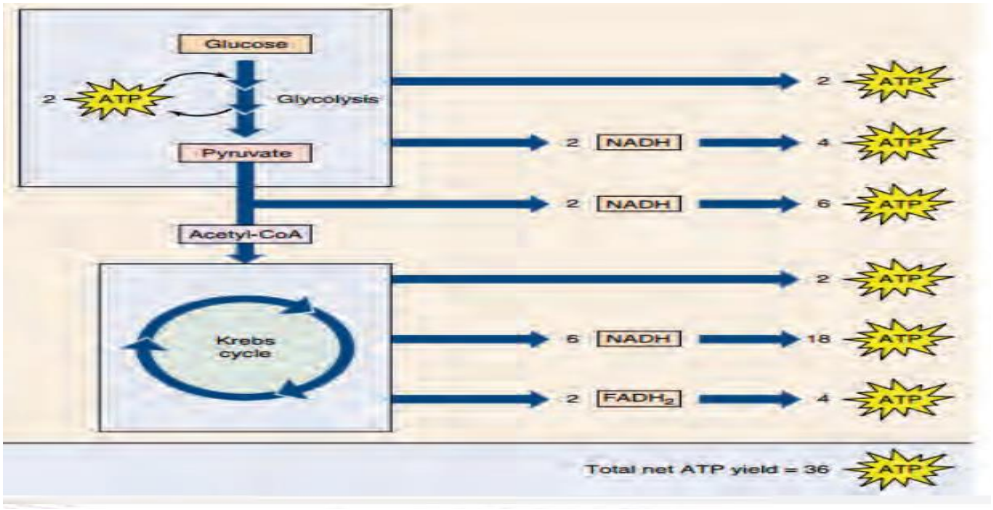


- The oxidation of one red. NAD molecule results in six protons passing through ATPsynthase and so leads to the synthesis of 3ATP molecules.

1red. NAD → pump six proton → three ATP

- The oxidation of one of red. FAD molecule results in four protons passing throughATP synthase and leads to the synthesis 2ATP molecules.

1red. FAD → pump four proton → two ATP



Energy from non-carbohydrate source

- We obtain most of our energy in the form of fats, proteins, disaccharides, and starch
- All these organic molecules in food can be used by cellular respiration to make ATP
- Glycolysis can accept a wide range of carbohydrates for catabolism.
- ***In the digestive tract***
- ✓ starch is hydrolyzed to glucose
- ✓ Glycogen stored in the liver and muscle cells, can be hydrolyzed to glucose between meals as fuel for respiration
- ✓ Disaccharides are hydrolyzed to glucose and other monosaccharaides
  - Sucrose=glucose + fructose
  - Maltose=glucose + glucose
  - Lactose =glucose + galactose
- ✓ Glucose is broken down in the cells by glycolysis and the citric acid cycle. Galactose and fructose also inter glycolysis
- **Proteins** can also be used for fuel, but first they must be digested to amino acids.
- ✓ Many of the amino acids are used to build new proteins
- ✓ Amino acids present in excess are converted to intermediates of glycolysis and the citric acid cycle by removing their amino group **(i.e. deamination**.)
- **fats** obtained either from food or from storage cells in the body can be used for fuel
- ✓ fats are digested to glycerol and fatty acids,
- ✓ The glycerol is converted to glyceraldehyde 3- phosphate, an intermediate of glycolysis.
- ✓ Most of the energy of fat is stored in the fatty acids
- ✓ By a process of **beta-oxidation fatty** acids are broken down to acetyl-coA which enters the citric acid cycle.
- ✓ NADH and FADH2 are also generated during beta oxidation; they can enter the electron transport chain, leading to further ATP production.
- ✓ A gram of fat oxidized by respiration produces more than twice as much ATP as a gram of carbohydrate.

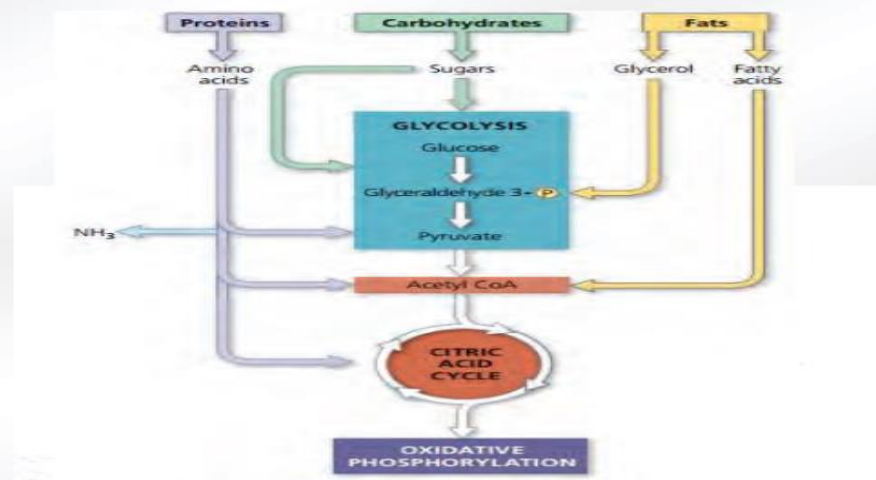


Figure 3. 20. The cataboism of various molecules from food.

Fermentation

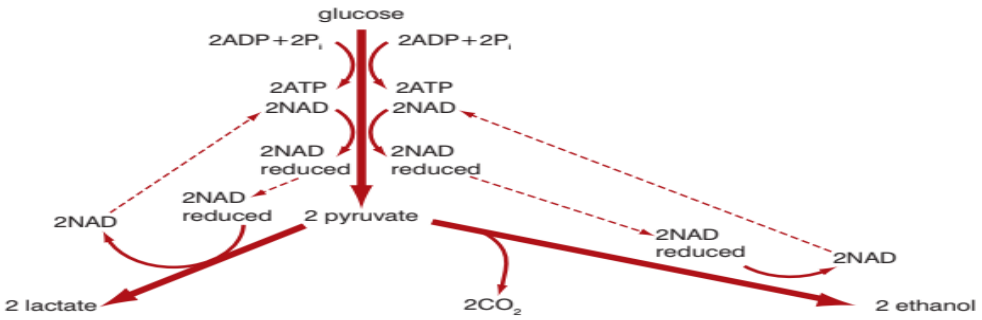
What happens in the anaerobic pathway?

- ❑ **In the process of glycolysis**
- ✓ net profit of 2 ATP produced
- ✓ 2 NAD+ reduced to 2 NADH
- ✓ Glucose split into 2 pyruvate

Anaerobic respiration = glycolysis + fermentation

- ❑ During aerobic respiration ,the NADH formed in glycolysis is oxidized to reform NAD+ for use in glycolysis again. And pyruvate enters Krebs cycle
- ❑ **When oxygen is not present**
- ✓ the final reaction of oxidative phosphorylation cannot take place . As a result, the electron transport chain comes to a halt
- ✓ Very quickly, **the Krebs** cycle and **the link reaction** come to a halt as both NAD and FAD are required in their oxidized forms for this reaction
- ✓ However, glycolysis *can* continue even though it also requires NAD .i.e pyruvate undergo **fermentation**

Fermentation replenishes NAD+ from NADH produced in glycolysis



Fermentation process in animal cells and yeasts.

Alcohol Fermentation

- ✓ First, Pyruvate is decarboxylated to form acetaldehyde.
- ✓ Hydrogen atoms released from NADH are then used to convert acetaldehyde to ethanol. NAD+ is then recycled back and used in glycolysis
- ❖ **Facultative anaerobes** are organisms that can undergo fermentation when they are deprived of oxygen

Example: - Yeast

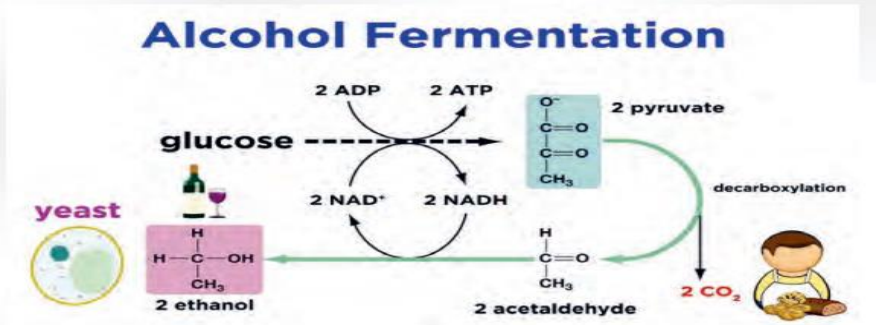


Figure 3.22. Alcohol fermentation

Lactic acid fermentation

- ❑ is the process by which **pyruvate** molecules are converted to **lactic acid** in the muscle cells of humans, and cells of some bacteria.
- ❑ the pyruvates are used to oxidize NADH and convert it back to NAD".
- ❑ During the process, lactic acid or lactate is produced as a byproduct.
  - ✓ Only 2ATP are from anaerobic respiration which isn't enough to power the entire organism, but can be used to supplement

The ATP levels in tissues (like muscle) where oxygen levels may drop quickly.

- ✓ the products of bacterial lactic acid fermentation have been used to produce food products such as yogurt, sour cream, and buttermilk.

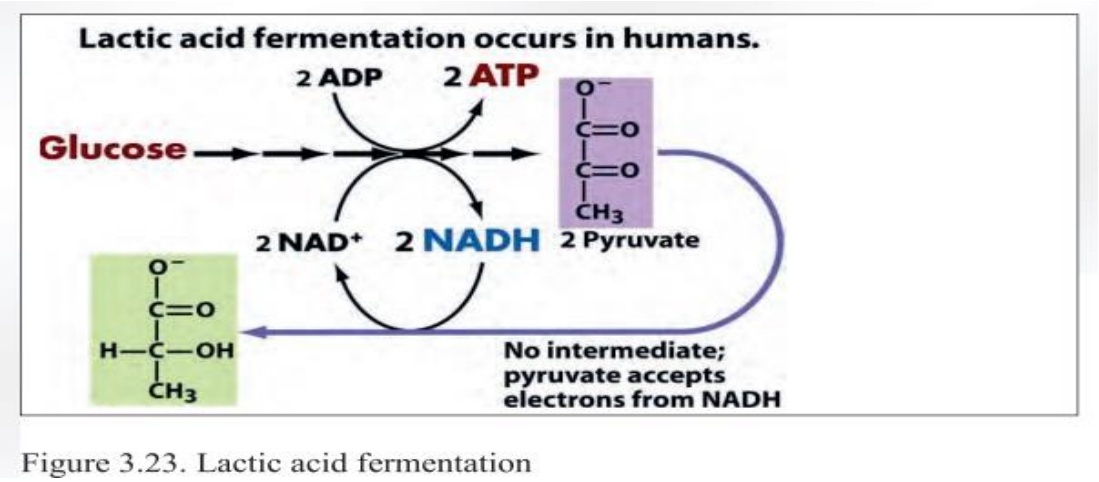


Figure 3.23. Lactic acid fermentation

Lactate formation during exercise

- ➢ During exercise, the energy demand of muscle cells increases greatly.
- ➢ Sometimes, aerobic respiration is insufficient to meet this energy demand.
- ➢ Fermentation of glucose supplies the extra energy.
- ➢ Although fermentation yields only 2 ATP per molecule of glucose, it is a much faster process than aerobic respiration and can produce a lot of ATP quickly, over a short period of time.
- ➢ It also produces lactate which causes ***fatigue*** when accumulated in the body
- ➢ The ATP used in sprints and short-distance runs is nearly all generated anaerobically. But, due to muscle fatigue, this cannot be sustained
- ➢ Longer races must be run slower to allow aerobic respiration to produce the ATP at its slower rate.

Lactate can be used to regenerate glucose in the liver by **Cori cycle**

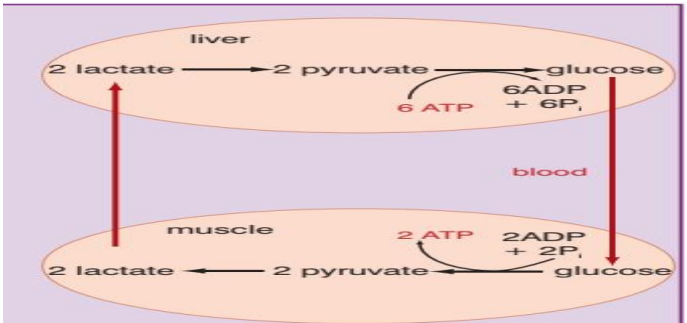


Figure 5.23 The Cori cycle

Question no 12. What does the fermentation of glucose by yeast normally yield?

A. Lactic acid ,CO_2, and 2ATP

B. Alcohol, CO_2 ,and 2ATP

C. CO_2,H2O, and 36 ATP7

D. Alcohol,CO_2 ,and 36ATP

Question no 13. When athletes take part in short distance running , how do the cells generate most of energy that is quickly needed?

A. Aerobic respiration in muscle cells

C. Mitochondrial respiration in any cells

B. Anaerobic respiration in muscle cells

D. Yeast fermentation in the stomach

Question no 14. If present in the fermentation system, which one of the following would negatively affect alcohol production by yeasts?

A. Water

B. Oxygen

C. Glucose

D. Fermentation enzyme

Question no. 15. How many net ATP molecules are generated through anaerobic respiration, when a single glucose molecule is changed to pyruvate in the human body?

A. Two

B. Three

C. Four

D. Six

Give your correct answer for the following multiple choice questions. Refer relativesources where necessary.

1. Which of the following reactions represents cellular respiration?
   A. $6\ CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6\ O_2$
   B. $CO_2 + RUBP \rightarrow 2G3P$
   C. $O_2 + RUBP \rightarrow 1G3P +$ phosphoglycolate
   D. $C_6H_{12}O_6 + 6O_2 \rightarrow C_6H_{12}O_6 + 6\ O_2$
2. During which of the following pairs of respiration stage carbon dioxide is produced as an endproduct?
   A. Electron transport chain and Krebs cycle
   B. kreb cycle and Link reaction
   C. Link reaction and chemiosmosis
   D. Glycolysis and Link reaction
3. Among the following identify one that bestly explains respiration?
   A. Reductive ,catabolic and exergonic
   B. Reductive ,endergonic and anabolic
   C. Oxidative, exergonic and catabolic
   D. Oxidative ,exergonic and catabolic

4. Which phosphate group bond of ATP is broken when energy it contains needed for cellular process?
   A. The second bond B. C-C bond C. The first bond D. The third bond
5. As electron passes down the electron transport chain of the mitochondria:-
   A. They produce reduced NAD to the next process
   B. Carbon dioxide is produced & FAD^+ is reduced
   C. They lose energy as they pass from one electron carrier to next.
   D. They gain energy as they pass from one electron carrier to the next.
6. In which of the following pair's cellular respiration does substrate level phosphorylationoccur?
   A. Glycolysis and Chemiosmosis
   B. Electron transport chain and Chemiosmosis
   C. Krebs cycle and Glycolysis
   D. Krebs cycle and Chemiosmosis
7. What does the fermentation of glucose by yeast normally yields:-
   A. $2CO_2$, 2ATP & lactic acid C. $2CO_2$, 2ATP & ethyl alcohol
   B. $2CO_2$, 36ATP& ethanol D. 2ATP and lactate
8. Which one of the following is NOT component of nucleotide during phosphorylation process?
   A. Phosphate group C. Nitrogenous bases
   B. Pentose sugar unit D. Amino acid sequence
9. How many ATP molecules is produced per complete oxidation of single glucose moleculeduring cellular respiration?
   A. 4ATP B.24ATP C.30ATP D. 36ATP
10. Starting with two molecules of acetyl CoA and oxaloacetate, kreb cycle after regeneration endswith:
   A. 1ATP , $2CO_2$,1FADH2and 3NADH
   B. 2pyruvate, 2ATP and $2CO_2$
   C. 10NADH,34ATP and 2FADH2
   D. 2ATP, $4CO_2$,2FADH2 and 6 $FADH_2$
11. During kreb cycle, to which one of the following coenzyme does most of energy released fromglucose molecule is transferred?
   A. NAD B.NADP C.FAD D.AMP
12. What is role of oxygen in the aerobic respiration? It:-
   A. Combines with CoA to form acetyl CoA
   B. Used as final electron acceptor in the electron transport chain.
   C. Combines with pyruvate to form acetyl CoA
   D. Transfer proton from one carrier to next
13. During which one of the following processes of cellular respiration is most of ATP produced?
   A. Glycolysis B. Kreb cycle C.Link reaction D.Chemiosmosis
14. What chemiosmosis represent during aerobic respiration pathway?
   A. Passing of electron from one carrier to next
   B. Splitting of glucose anaerobicaly
   C. Diffusing of proton down concentration gradient
   D. Regeneration of coenzymes under glycolysis
15. Among the following cellular process one releases carbon dioxide to the surroundingatmosphere:
   A. Assimilation B.Photosynthesis C.Respiration D. Feeding
16. Which one of the following is **NOT** true about oxidative level phosphorylation?
   A. It comprises ETC and chemiosmosis
   B. It is catalyzed by ATP synthases enzyme
   C. It depends on proton passing through rotor spin of ATP synthases
   D. It produces ATP by substrate level phosphorylation

17. When athletes take part in short distance race, how does the cell generate energy needed? By:
    A. Aerobic respiration in muscle cell
    B. anaerobic respiration in muscle cell
    C. alcoholic fermentation in cytoplasma
    D. aerobic respiration in inner membrane
18. When the muscle cells are in short supply of oxygen, which of the following compounds wouldbe accumulate in them?
    A. Ethanol B. Acetic acid C. Pyruvic acid D. Lactic acid
19. One of the following molecule acts as a final/terminal electron acceptor of a respiration?
    A. NADP B. $FADH_2$ C. Water D. Oxygen
20. The first molecule produced when Acetyl COA combines with oxaloacetate in fluid matrix of mitochondria?
    A. Citrate B. Malate C. Isocitrate D .Succinate
21. Starting with two molecules of pyruvate and two coenymeA, link reaction results which of the following end products?
    A. 2Acetyl COA , 2CO2 and 2NADH
    B. 2Acetyl COA, 2ATP and 2CO2
    C. 2Acetyl COA, 2ATP and 2NADH
    D. 2Acetyl COA, 2CO2 and 2FADH2
22. From the oxidation of **10NAD** and **10FADH2** molecule, how many proton pumped through ATPsynthase and how many ATP synthesized in rotor spin respectively?
    A. $54H^+$ and 27ATP C. $60H^+$ and 30 ATP
    B. $100H^+$ and 50 ATP D. 70 H^+ and 35 ATP

UNIT 4
EVOLUTION

Unit learning outcomes: After completion of this unit, you will able to:

- Define evolution
- Debate on different thoughts of the origin of life
- Compare Lamarck VS Darwinian theory
- Explain how comparative anatomy, embryo, fossil records, and biochemistry provide evidence for evolution
- Define natural selection
- Describe the type of natural selection with examples
- Appreciate the struggle among organisms for survival
- Outline human evolution
- Define mutation
- Examine the different type of mutations with examples
- Describe the cause of mutation
- Appreciate the effects of mutations on living things
- Discuss genetic drift and gene flow
- Describe the roles of immigration and emigration on gene flow and speciation
- Explain the causes of species extinction

- **Evolution** is a change in genetic composition of a population over successive generations
  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*
  - The theory of evolution describes how the various forms of life (including humans) on earth emerged and evolved

4.1. Theories of the origin of life

There are five main theories of the origin of life on Earth:

1. Special **Creationism**
2. Spontaneous Generation
3. Eternity Of Life
4. Cosmozoan Theory
5. Biochemical Origin

a. Special Creationism

- **Creationism:-** *a theory claiming that the different forms of life on Earth* were created by ***a supreme being(GOD)***
- There are many different versions of special creation, linked with different religions

<u>Young Earth creationism</u>

- ✓ suggests that the Earth is only a few thousand years old
- ✓ believe the Earth was created in six 24-hour days.
- ✓ While they agree that the **Earth is round and moves around the Sun**, they interpret all geology in the light of Noah's flood.

Old Earth creationism

✓ accepts the evidence that the Earth is very old but still maintain that all life was created by God

Day-age and gap creationism

✓ Both believe that creation have taken much longer than **six Earth days**.

Gap creationism :-

- a large gap between the formation of the Earth and the creation of all the animals and humans

The gap could be millions or billions of years

Day-age creationism :-

- the six 'days' as really meaning a billion years or geologic time
- the 'days' are just symbolic

Progressive creationism.

✓ accepts the Big Bang as the origin of the Universe

✓ It accepts the fossil record of a series of creations but each is seen as a unique creation

✓ Modern species are not seen as being genetically related to ancient ones.

Theistic evolution/Evolutionary creationism

✓ This view of evolution maintains that God 'invented' evolution and takes some form of an active part in the ongoing process of evolution

Intelligent design

✓ is the newest version of creationism

✓ maintains that God's handiwork can be seen in all of creation if one knows where to look **intelligent design** offer sophisticated arguments, often based on cell biology and mathematics

b. spontaneous generation (abiogenesis)

❑ **Spontaneous generation** suggests that life can evolve 'spontaneously' from non-living objects

❑ it was once believed that life could come from non-living things such as :-

✓ Mice from corm

✓ Flies from bovine manure

✓ Maggots from rotting meat

✓ Fish from mud of previously dry lake

❑ **Francisco Redi**(1668)

✓ Disproved spontaneous generation by an experiment

✓ He placed fresh meat in jars . One jar was left open and the others were covered by a cloth

Days later ,the opened jar contained maggots whereas the covered jars contained no maggot ,but maggots appeared on **the exterior surface** of the cloth

❑ Redi successfully demonstrated that the maggots came from fly eggs



❑ **John needham** (1748)

✓ is the **proponent** of spontaneous generation

✓ He boiled mutton broth and then cooling the mixture in an open container to room temperature
✓ And then tightly stoppered the flasks
✓ Many of the flasks become **cloudy** and **contained microorganisms**

He thought that organic matter contained a vital force that produced spontaneous generation**.**



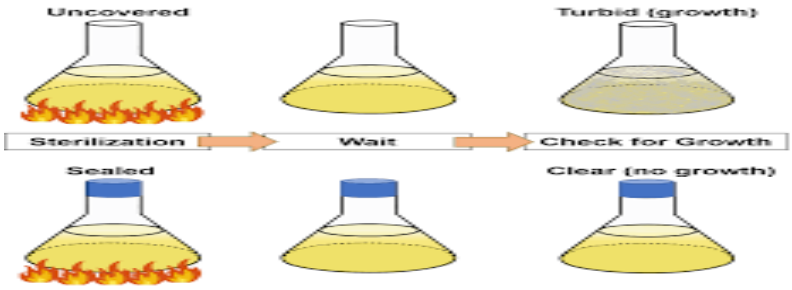
Draw backs

❖ The equipment may not be sterile
❖ There is not heated enough

❑ **Lazzaro spanllanzani** (1729-1799)

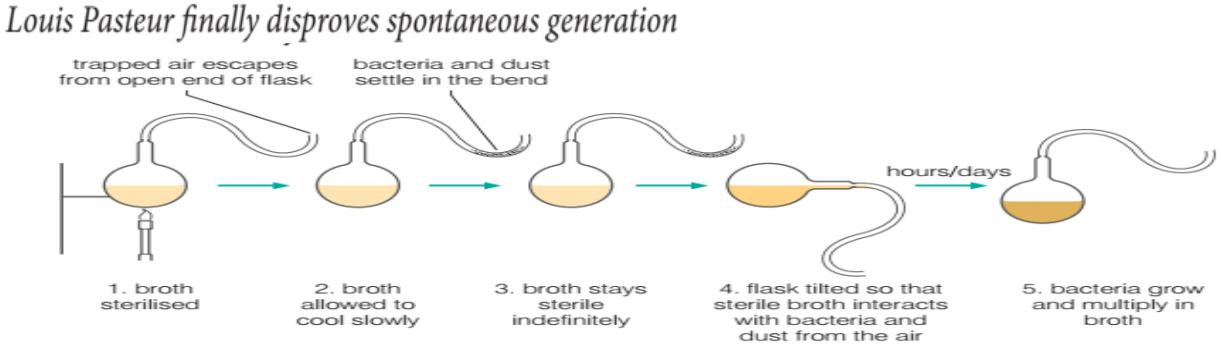
Experiment design

✓ Sealing Flasks that contained water and seeds
✓ Placed in boiling water for ¾ of an hour
✓ No growth took place as long as the flasks remained sealed
❖ ***Conclusion*** Air carried germs to culture medium
✓ Also commented external air might be required for growth of animals already in the medium
✓ The supporters of spontaneous generation maintained that heating the air in the sealed flasks destroyed its ability to support life
✓ this research paved the way for the downfall of spontaneous generation



❑ **Louis Pasteur**

✓ showed that broth (or wine) only went sour if micro-organisms were allowed to enter.
✓ Also no micro-organisms appeared in the broth unless they were allowed to enter from the outside – they were not formed from the broth itself.



❖ These two scientists showed that both macro-organisms (Redi and micro-organisms (Pasteur) can only arise from pre-existing organisms, disproving the theory of spontaneous generation

c. **Eternity of life**

❑ According to this theory there is no beginning and no end to life on Earth
❑ so it neither needs special creation nor does it need to be generated from non-living matter.

d. **Cosmozoan theory**

❑ According to this theory, life has reached this planet Earth from other cosmological structures, such as meteorites, in the form of highly resistant spore
❑ *claims that life on Earth originally came from elsewhere in the Universe (possibly from another planet)*
❑ strongly linked to the 'eternity of life' theory

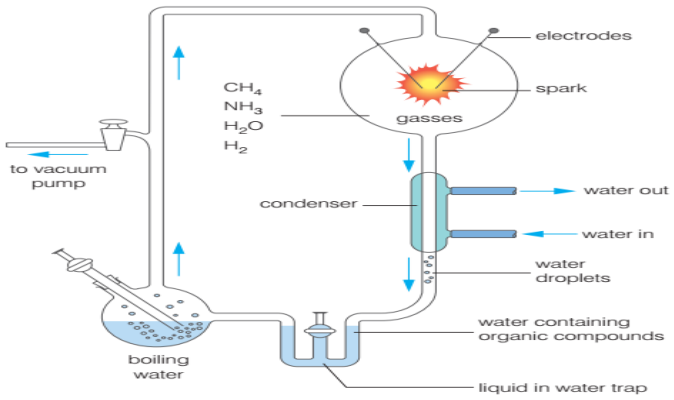
Other versions of the cosmozoan theory

❑ **Panspermia:-** proposed that bacterial spores were propelled through inter-planetary space by radiation pressure and reached Earth

Pseudo-panspermia:- that organic compounds arrived from outer space and added to the chemicals on Earth that gave rise to the first life.

e. **biochemical theory**(abiogenesis)

❑ *suggests that life on Earth originated as a result of a number of biochemical reactions producing organic molecules which associated to form cells*
❑ life evolved from non-biological molecules which reacted together and eventually formed pre-cells
❑ Two biologists (**Aleksandr Oparin** and **John Haldane**) proposed that ;
✓ Common gases in the early earth atmosphere combined to form organic chemicals by the energy of ultra violate light
✓ organic molecules form more complex molecules
✓ The complex molecules acquired some characteristics of living organisms
❑ later **Stanley Miller** approved the oparin-Haldane model by spark-discharge experiment
✓ he passed electric sparks repeatedly through a mixture of gases(CH4,NH3,H2O ,H2).
✓ he analysed the liquid in the water trap and found it contained a simple organic molecules such as (HCN)
✓ by leaving the equipment for longer periods of time, more complex organic molecules such as (amino acids ,pentose sugars **,**hexose sugars) were formed



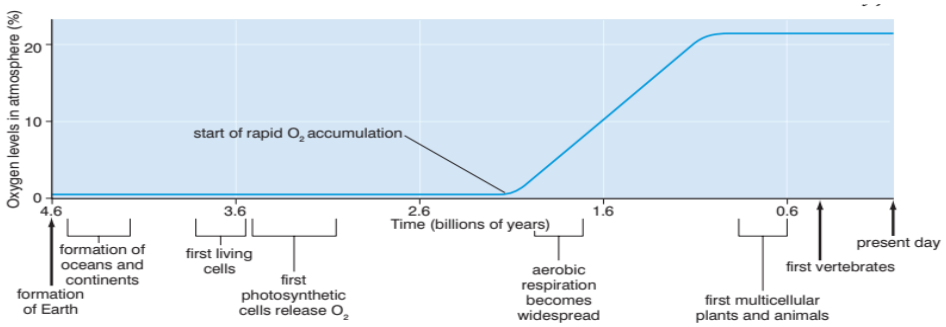
Stanley Miller's spark-discharge *experiment*

Question no 1. In the miller and Urey's stimulation experiment to study organic molecules formation in primeval atmosphere of the earth, all the following gases were used except which? EUEE

A. Ammonia B. Hydrogen **C. Oxygen** D. Methane

Autotrophs

- ❑ **Autotrophs** :-are organisms that produce organic molecules from inorganic material
- ✓ Autotophs are bases for all food chain ;they produce sugar, proteins, lipids and other materials for life
- ❑ **Prokaryotes:-** the first organisms which appeared 4 billion years ago
- ✓ prokaryote is an organism consisting of a prokaryotic cell(a cell without a nucleus)
- ✓ They give rise to three distinct line of evolution; **archaebacterium ,eubacterium, eukaryote**
- ✓ **archaebacterium :-** consists of thermophilic sulfobacteria,methanobacteria,halophilic bacteria
- the first bacteria (and thus the first living organisms) to develop on Earth.
- They are now only found in extreme conditions
- ✓ **Eubacterium:- ordinary bacteria** and **cyanobacteria(**blue-green algae**)**
- any bacteria that is not an archaebacterium is a eubacterium
- ✓ **Eukaryote:-** proctists ,fungi, plants and animals
- All organisms other than bacteria are eukaryotes
- ❑ One great change that affected the evolution of early life forms was the shift from the reducing atmosphere to an atmosphere containing oxygen
- ❑ This took place about 2.4 billion years ago.



- ❑ The two major types of autotrophs are **chemoautotrophs** and **photoautotrophs**
- ❑ **chemoautotrophs**
- ➢ Use chemical energy and inorganic carbon to produce organic molecules
- ➢ Source of energy **:- chemical reaction**(ferrous iron,hydrogen , hydrogen sulfide wtc)
- ➢ Source of carbon **:-** CO2
- ➢ All chemoautotrophs are prokaryotes (archea or bacteria)
- ➢ Found in extreme environments such as deep-see vents and acidic environments
- ➢ Ex . Chemolithoautotrophs
- ❑ **Photoautotrophs**
- ➢ Use light energy and inorganic carbon to produce organic molecules
- ➢ Source of energy **:- light**
- ➢ Source of carbon **:-** CO2 Ex. Cyanobacteria(prokaryote) ,Green plants (eukaryote)

QUESTION NO 2. Which of the following came first in the course of organic evolution? EUEE

A. Photosynthetic organisms
B. Free oxygen in the atmosphere
C. Land plants
D. Multicellular organisms

QUESTION no 3. Which of the following groups are believed to be the first photosynthetic organisms to evolve on earth?EUEE A. Green plants B. green algae **C. blue green algae** D. lichens

Question no 4. Which of the following is NOT true about the nature of the first form of organisms on earth? They are
A. prokaryotic B. unicellular **C. aerobic** D. anaerobic

4.2. Theories of evolution

4.2.1. Lamarckism

✓ *claimed that organisms passed on to subsequent generations traits acquired during their lifetime*
✓ The two parts of his theory are:
- Use and disuse, and
- Inheritance of acquired traits.

a. Use and disuse

✓ Lamarck suggests that by continually using a structure that structure will become enlarged or more developed.
✓ any structure that is not used or is little used will become reduced in size or less developed.
✓ **classic examples**
- a giraffe could, over a lifetime of straining to reach high branches, develop an elongated neck.
- from years of straining their toes to swim through water, **water birds** gained elongated, webbed toes
- penguins wings would have become smaller than those of other birds because penguins do not use them to fly.

However, Lamarck could not explain how these might happen.

b. Inheritance of acquired traits

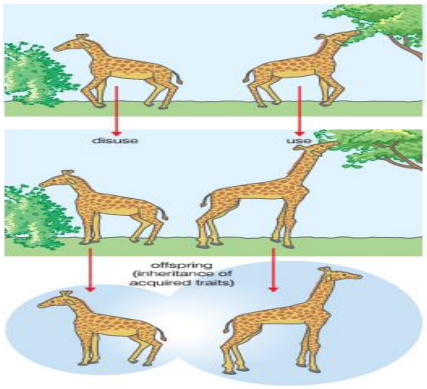
Lamarck believed that
✓ traits changed or acquired during an individual's lifetime could be passed on to its offspring.
✓ Giraffes that had acquired long necks would have offspring with long necks
❖ **Lamarckian inheritance** has been disproved by the discoveries of genetics

significance of Lamarckism

✓ Was the first comprehensive theory of evolution
✓ It nicely explains the existence of vestigial organs
- **vestigial organs** parts of organism that are no longer in use .this can be used to determine relatedness of species

Ex. front flippers of whale contain bones of limbs that exist in mammals (cow)

✓ It explains the development of strong jaw and claws in carnivores due to continued use
✓ It stimulated other scientists



Question no 5. According to Lamarck's theory of evolution, what is the origin of new structures that are necessary for evolution?

A. Mutation
B. Gene recombination
C. Natural selection
D. Use and disuse of body parts

4.2.2. Darwinism(theory of natural selection)

- ❑ Some of Darwin's evidence came from a visit to the Galapagos Islands.
- ❑ Darwin studied the finches found on the different islands and noted that there were many similarities and differences between them
- ❑ He concluded that an 'ancestral finch' had colonized the islands and adapt to the different conditions on the islands and, eventually, evolve into different species.
- ✓ Some of the finches had evolved into insect eaters, with pointed beaks.
  Others had evolved into seed eaters with beaks capable of crushing the seeds.
- ❑ **Basic postulates of Darwinism**
- ➢ **Geometric increase**:-
- all species tend to produce more offspring than can possibly survive
- ➢ **Struggle for existence**:-
- There will be competition between members of a species (because they over-reproduce, and resources are limited).
- ➢ **Variation under nature**:- difference between member of species
- ➢ **Natural selection and survival of the fittest** :-
- Some members of a species will be better adapted than others to their environment (because there is variation).
- *Those members of a species which are best adapted to their environment will survive*
- ➢ **Origin of species** :-
- the later descendants after several generation become distinct from their ancestors.
  On this way new species appear

Questin no 6. Which of the following ideas is NOT **a part of Darwin's theory of Evolution?EUEE**

A. Over reproduction
B. Use-and disuse of body parts.
C. Existence of heritable variation
D. Competition for scarce resources

Question no 7. Which of the following expression is more related to the phrase " survival of the fittest"?EUEE

A. Natural selection
B. Mendelian inheritance
C. Gene mutation
D. Inheritance of acquired characteristics

Question no 8. In his theory of evolution, the cause of which of the following concepts was MISSING in Darwin's explanation?EUEE

A. Over-reproduction C. **Hereditary variation**
B. Struggle for survival D. Survival

Question no 9. According to the theory of evolution as proposed by Charles Darwin, Which one of the following is the most important driving force of evolution?EUEE

A. Natural selection C. Genetic recombination
B. Over-reproduction D. Mutation

4.2.3. Neo-Darwinism theory

- ❑ It is the revised version of Darwin's theory
- ❑ combines Darwin's original theory ,genetic theory and animal behavior

Gene pool of population- the sum of all alleles(genes) available in the population

❑ <u>postulates of neo-Darwinism</u>

➢ <u>Genetic variability</u>

- genetic variation exists within a population due to mutations, genetic recombination, and other processes
- This variation provides the raw material for natural selection to act upon

➢ <u>Natural selection</u>

- individuals with advantageous traits are more likely to survive and reproduce ,passing on their beneficial traits to the next generation

➢ <u>Reproductive isolation</u>

- new species can arise when populations become reproductively isolated from each other, preventing gene flow between them
- This can occur through mechanisms such as **geographic isolation**, **behavioral differences**, or **genetic incompatibility**, ultimately leading to the evolution of distinct species.

QUUESTION NO 10. Which of the following theories explains evolutionary change of living things in terms of changes in their allele frequencies? EUEE

A. Darwin's natural selection C. Inheritance of acquired characteristics

B. Spontaneous generation **D. Neo-Darwinism**

QUESTION NO 11. which of the following is the idea contained in Neo- Darwinism which was not present in the original version of Darwin′s theory of evolution?EUEE

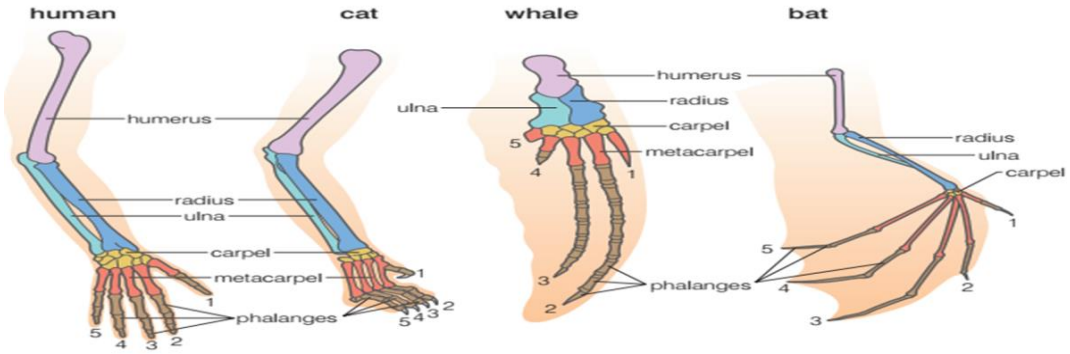
A. Organisms tend to over-reproduce **B. Hereditary variation is caused by alleles**

C. Organisms compete for scarce resources D. Fit individuals survive and produce more offspring

4.3. The evidence for evolution

<u>I. comparative anatomy</u> :-is one of the strongest forms of evidence for evolution

- ✓ looks at structural similarities of organisms and uses these to determine their possible evolutionary relationships
- ✓ It assumes that organisms with similar anatomical features are closely related evolutionarily, and that they probably share a common ancestor.
- ✓ **<u>homologous structures</u> :-** structures that are very similar in form, but very different in function.
  - Because they are so similar, they indicate an evolutionary relationship and a common ancestor of the species
  - **Example** - the forelimb of mammals. the forelimbs of humans, whales, cats and bats are all very similar in structure and possesses the same number of bones but different external features and function
  - arm for manipulation in humans
  - leg for running in cats
  - flipper for swimming in whales
  - wing for flying in bats



❖ **pentadactyl limb**(*a limb with five digits*) must have evolved just once and that all organisms with this kind of limb share a common ancestor.

✓ **Analogous structures:**-*struactures having the same function but different anatomy*

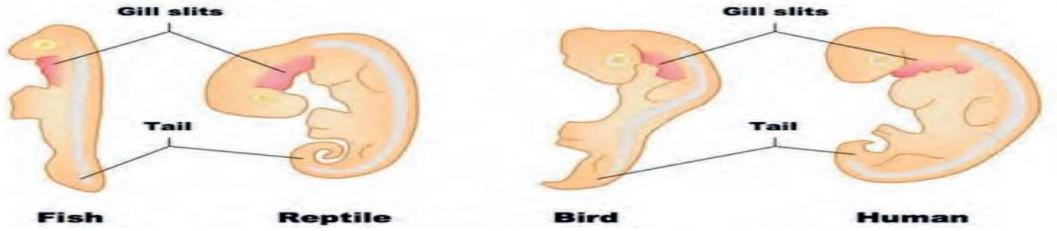
- Because they are so different structurally, even though they have the same function, they cannot indicate that two species share a common ancestor
  Example -the wings of a bird ,butter fly and a mosquito



II. **Comparative embryology :**-studies the way in which the embryos of vertebrates develop before they hatch or are born

- early in development, all vertebrate embryos have gill slits and tails
- The embryonic tail does not develop into a tail in all species. In humans is reduced to the coccyx(**tailbone**)
- in many species the 'gill slits' close later in development. However, in fish and larval amphibians they contribute to the development of **gills.**

The more similar the pattern of embryonic development, the more closely related species are assumed to be.



Question no 12. The bones in human hands, fippers of the whale and wings of the bats are known as what?EUEE

A. Linker fossils
B. Analogous structures
C. Homologous structures
D. Vestigial structures

Question no 13. Which of the following characteristics can show the evolutionary relationship?EUEE

A. Structure having similar functions
B. Presence of analogous structures
C. presence of homologous structures
D. structure having different origins

Question no 14. Which of the following characteristics can show the evolutionary relationships among organisms?EUEE

A. Structures having similar functions C. Structures having different origins
B. Structures having same size **D. Structures having common origin**

Question no 15. Which of the following pairs are analogous structures?EUEE

A. Wing of a bird & wing of a butterfly C. Wing of a bird & wing of a bat
B. Front leg of a horse & a human arm D. Front leg of a frog & wing of a bat

Question no 16. What do you call structures that have same evolutionary origin even though they may now have different structural make ups or functions? EUEE

A. Endemic B. Analogous **C. Homologous** D. Indigenous

Question no 17. Which of the following embryonic structures do the embryos of all vertebrates develop during their early development?EUEE

A. Gill slits B. Teeth C. Gill D. Fins

III. Palaeontology :-is the study fossils

- ✓ Fossils are the remains or traces of animals, plants and other organisms from the remote past
- Formed when certain parts of organisms or plants embedded in the soil or water and preserved for many hundreds of years
- ✓ We can group fossils into two categories:

Category 1: the remains of the dead animal or plant or the imprint left from the remains . can be the actual organism or part of an organism

- 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,

Category 2: something that was made by the animal while it was living that has since hardened into stone; these are called trace fossils

- footprints
- burrows
- coprolite (animal faeces)

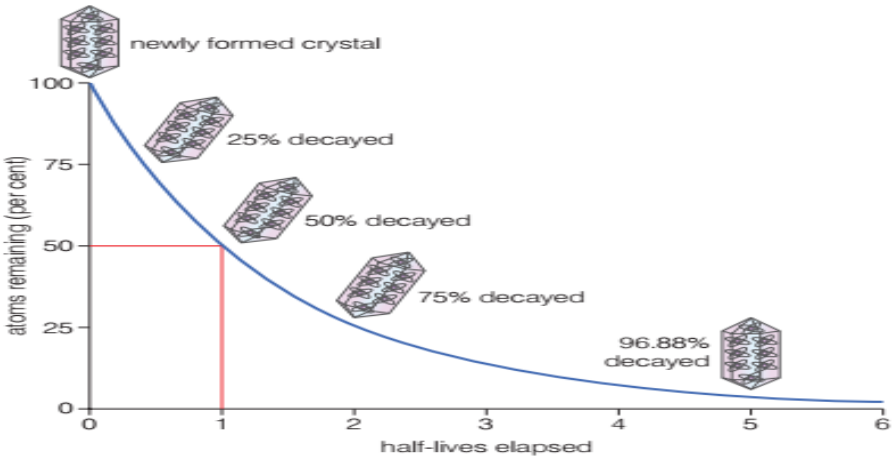
Dating fossils

- ✓ sedimentary rocks are laid down in layers (strata)
- ✓ **stratigraphy :-** using the sequence of the strata and the fossils that occur in them to deduce how the organisms have changed over time
- ✓ The depth of the strata is related to their age
  - The oldest strata and the oldest fossils, will be in the **lowest layers**
  - most recent strata and fossils will be nearest to the surface
- ✓ To find out how old each layer is scientists use one of two techniques

1. **radiocarbon dating**
2. **potassium–argon dating**

- radioactive atoms decay into other atoms over time
- Radioactive carbon atoms (C14) decay into non-radioactive nitrogen atoms (N)
- Radioactive potassium atoms (K40) decay into argon atoms (A40)

- ✓ **half-life** - *the time needed for half the atoms of a radioactive substance to decay*
- ✓ starting with a certain number of radioactive atoms, after one half-life, **50%** will still be radioactive
- ✓ After a second half-life, 50% of this **50%** will have decayed and **25%** of the original number will still be radioactive.
- ✓ After a third half-life 50% of the remaining **25%** will have decayed and 12.5% original number will still be radioactive



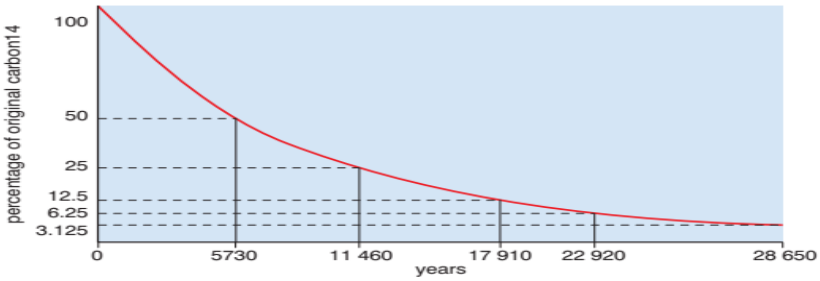
Half-life of a radioactive element

one half-life of carbon 14 is **5730 years**

- ✓ In living things the ratio of carbon 14 (radioactive carbon) to carbon 12 (ordinary carbon) is about 1 to 1 trillion
- ✓ living things lose carbon 14 (as CO2) and gain it in the food they eat or (produce)
- ✓ 5730 years after a living things die only 50% of the original carbon 14 atoms will remain and the ratio of C-14 to C-12 will be 1 to 2 trillion (or 0.5 to 1 trillion)
- ✓ After 11 460 years, 25% of the original carbon 14 atoms remain and the ratio is 1 to 4 trillion (or 0.25 to 1 trillion)
- ❖ The percentage of carbon 14 atoms and the ratio of carbon 14 to carbon 12 keeps halving with each half-life that passes
- ✓ half-life of radioactive Potassium is 1.3 million years. This makes potassium–argon dating suitable for dating rocks millions of years old
- ✓ radiocarbon dating is really only accurate with rocks up to 60 000 years old

QUESTION NO 18. Suppose a piece of wood initially contains 100 grams of a radioactive substances , how many grams remain radioactive after 30 000 years provided that its half life is 10 000 years?EUEE

A. 50 grams B. 25 grams C. 12.5 grams D. 6.25 grams



Converting the percentage of carbon 14 in a fossil to an age

IV. **Comparative biochemistry**

- ✓ Various chemicals have been studied in order to find evidence of evolutionary relationships
- ✓ organisms that share very similar molecules and biochemical pathways are closely related evolutionarily
- ✓ Chemicals that have been used in such analyses include:

• DNA

• proteins such as: cytochrome c and haemoglobin

✓ Species that are closely related have the most similar DNA and proteins; those that are distantly related share fewer similarities

example :-98% of our DNA is the same as that of chimpanzees which confirms that chimpanzees are closest relatives of humans



(evolutionary) tree of some animals based on differences in DNA

haemoglobin **:-is** *the molecule found in red blood cells that carries oxygen and has* four polypeptide chain

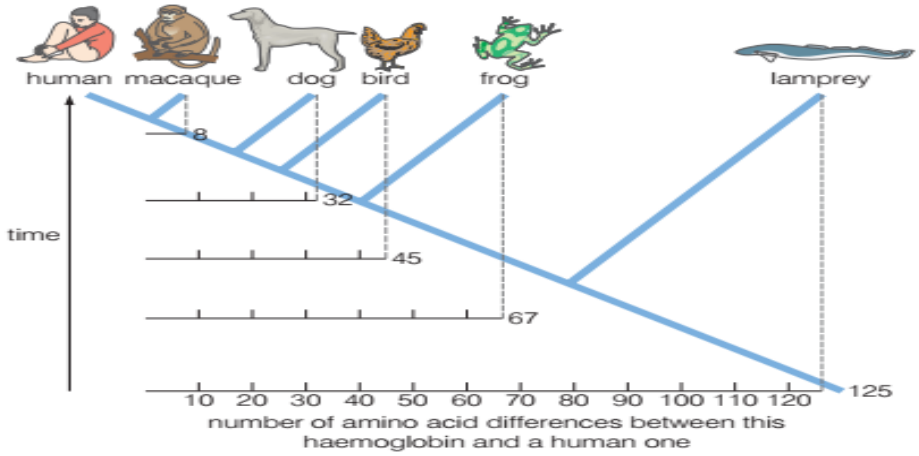
✓ The **haemoglobin** molecule is similar in all animals that possess it, but there are differences

✓ For example, the haemoglobin of the lamprey (a primitive fish-like animal) has only one polypeptide chain

✓ Most animals have haemoglobin with four chains, but the chains do vary

haemoglobin analysis cannot be used to include plants and algae in any phylogenetic tree

Species	Alpha-hemoglobin (141 amino acids)	Polypeptides chains Beta-hemoglobin (146 amino acids)	Y-hemoglobin
Human	+	+	+
Chimpanzee	+	+	+
Gorilla	1	1	1
Gibbon	3	3	2



The evolutionary relationships of some animals shown by differences in haemoglobin

QUESTION NO 19. If the DNA of the following animals is hybridized to human DNA, with which one of them would human DNA hybridize more?EUEE

A. Horse B. Fish **C. Chimpanzee** D. Mice

QUESTION NO 20. Which of the following pairs of molecules can give information about how much two species are evolutionary related to one another? EUEE

A. DNA and proteins B. Lipids and carbohydrates

C. starch and cellulose D. carbohydrates and proteins

QUESTION NO 21. a fossil initially contains 100,000 atoms of a contain radioactive element whose half life is 10,000 years , after how many years would the number of atoms be 12500?

A. Ten thousand years B. Twenty thousand years C. Thirty thousand years D. Forty thousand years

QUESTION NO 22. Carbon 14 has a half life of about 5730 years. Suppose a fossil contains only 12% of the amount of Carbon 14 normally present in living organisms, how old is the fossil?

A. 5730 years B. 17190 years C. 11460 years D. 22920 years

4.4. Natural selection: Definition, Types and Examples

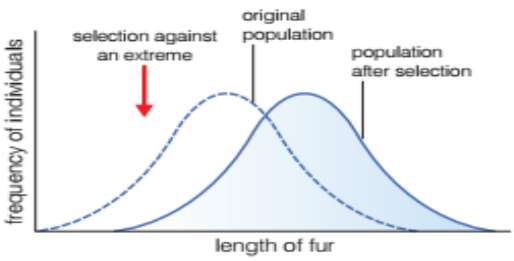
- **natural selection** is the theory that explains the origin of species in terms of survival of those best adapted to a specific environment
- is the 'driving force' behind evolution
- It is the process that brings about changes (over time) in populations that can lead to **speciation** (the formation of new species)
- **species is *a group of related organisms that can reproduce with each other so that they produce fertile offspring***

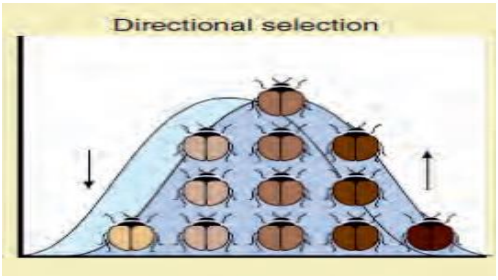
  current definition of a species is:
  - *A group of similar organisms with **a similar biochemistry, physiology and evolutionary history that can interbreed to produce offspring that are fertile.***
- The different types of selection include:
  - ✓ **directional selection**
  - ✓ **stabilising selection**
  - ✓ **disruptive selection**

A. directional selection

A feature(Ex. fur type) may show a range of values. Individuals at one extreme could have a disadvantage whereas those at the other extreme have an advantage

- ✓ thicker fur (longer hair) in foxes is an advantage in a cold climate.
- ✓ Thinner fur in foxes is an advantage in a hot climate
- ✓ If the environment became significantly colder, there would be a selection pressure in favour of the foxes with long fur(one extreme) and against those with short fur(disadvantaged extreme)
- ✓ Directional selection shifts the curve in one direction ,changing the average and range value of the curve





Directional selection

QUESTION NO 23. What kind of natural selection results in the removal of members of the population that are found just at one end of the range?EUEE

A. Stabilizing selection C. Disruptive selection

B. Directional selection D.Normalizing selection

B. **Stabilising selection**

- ✓ individuals at both ends of the range of values for a feature are the least well adapted and Selection operates against both these extremes to reduce the variability in the population
- ❖ Stabilising selection trims of extreme phenotypes and reduces variation about the mean

  Ex. Birth mass in humans. Babies who are very heavy or very light show a higher neonatal mortality rate than those of medium mass.

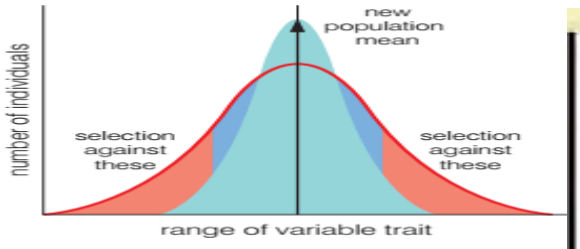
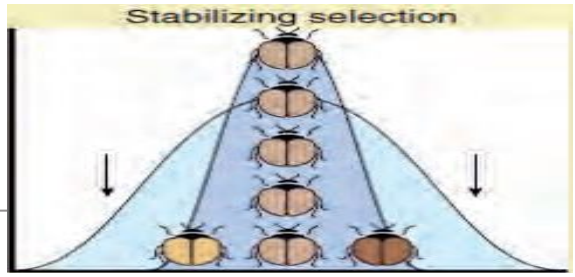


Figure 4.31 Stabilising selection



Question no 24. When a bell-shaped curve results from the analysis of a certain variable in a population, what type of natural selection is probably taking place in the population with regard to the variable?

A. Disruptive selection B. Directional selection C. Divergent selection **D. Stabilizing selection**

Question no 25. What kind of selection does a bell shaped curve in a variable indicate?

A. Disruptive selection B. Unidirectional selection C. Divergent selection **D. stabilizing selection**

C. **Disruptive selection**

- ✓ Disruptive selection is the converse of stabilising selection
- ✓ individuals at both extremes of a range have some advantage over those displaying the mean value
- ✓ As a result, the frequency of individuals at the extremes of the range will increase over time and those in the middle of the range will decrease
  - ❖ Disruptive selection trims off intermediate phenotype, result in two or more peaks
  - ✓ Eaxample . evolution of Darwin's finches
  - ▪ A finch with an 'average' length beak :-not be able to obtain insects out of cracks in the bark of trees and not be able to crush seeds
  - ▪ A finch with longer beak _ able to obtain insects out of cracks in the bark of trees
  - ▪ A finch with shorter beak_ able to crush seeds
  - ▪ Over time, those with average length beaks will decrease in numbers

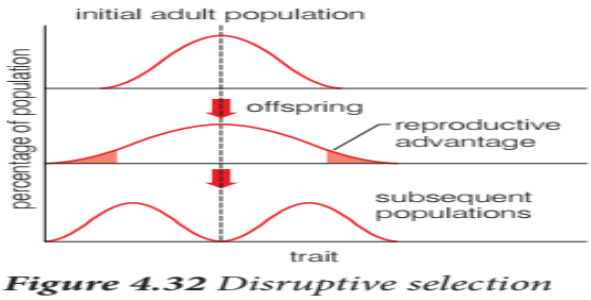
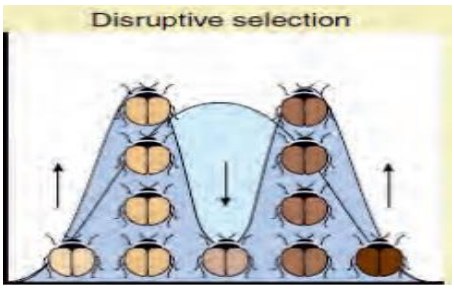


Figure 4.32 Disruptive selection

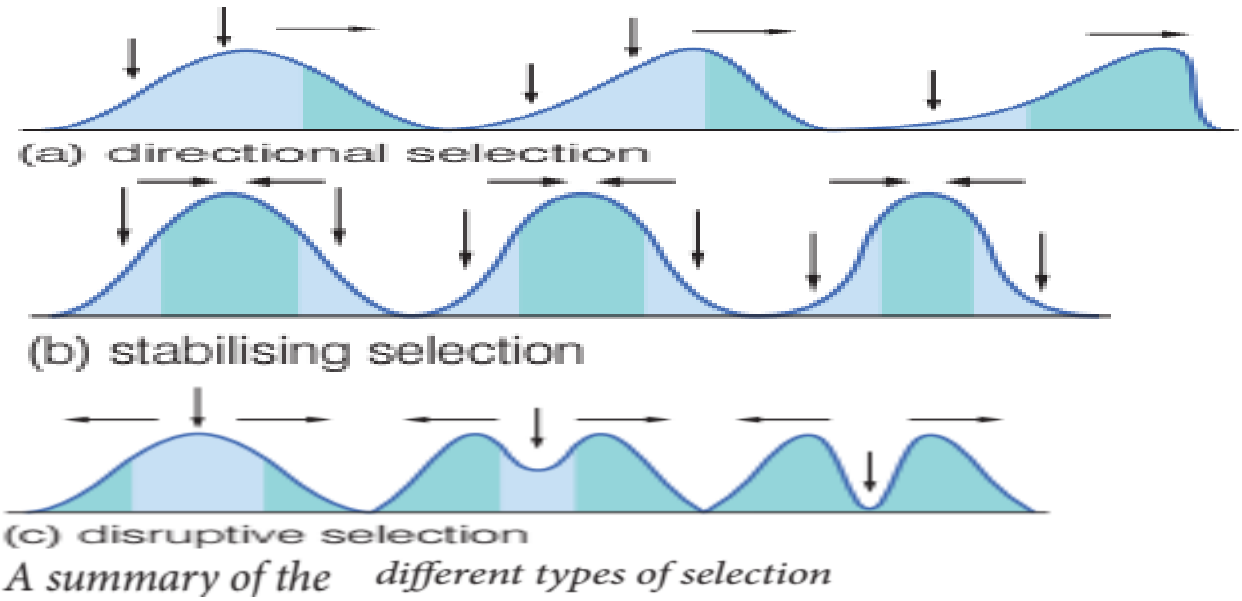


Question no 26. What does an evolutionary selective pressure that acts around the mean do?EUE

A. It stabilizes B. It terminates C. It converges **D. It disrupts**

Question no 27. Which of the following descriptions is true about the action of selective pressures in populations?
Selective pressure that acts:

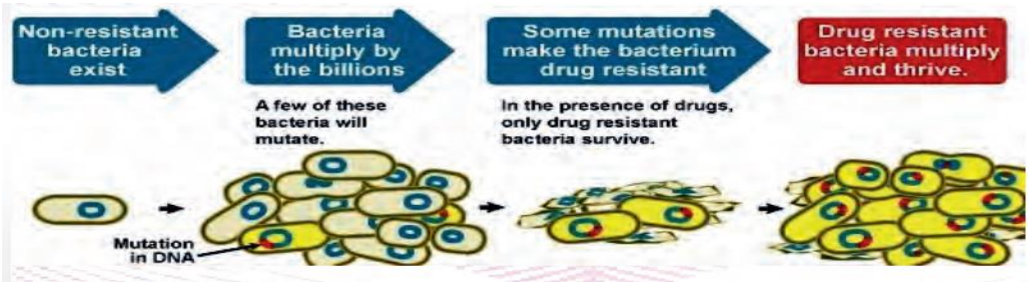
A. Around the mean value is stabilizing
B. **Around the mean value is disruptive**
C. At both ends of the distribution is directional
D. At one ends of the distribution is stabilizing



A summary of the different types of selection

About antibiotic resistance – a modern example of selection in action

- ✓ Bacteria can be resistant to antibiotics through mutations(<1 in a million bacteria) that alter the cellular targets of antibiotics.
- ✓ Resistant bacteria continue to grow and reproduce under antibiotic treatment that affectively paralyse or kill their antibiotic susceptible neighbours



4.5. Pattern of evolution

- ✓ Thaere are 3 main types of evolution*; <u>divergent</u> ,<u>convergent</u> and <u>parallel evolution</u>*
  - ❑ ***<u>Divergent evolution</u>***
    - ✓ Divergent evolution leads to the development of a new species.
    - ✓ Often occurs when closely related species diversify to new habitat

<u>Examples of divergent evolution</u>

- ✓ On a large scale , the creation of the current diversity of life on earth from the first living cells
- ✓ On a smaller scale, evolution of humans and apes from a common ancestor
- ✓ the evolution of the different species of finches on the Galapagos Islands
- ✓ the evolution of the different forms of the pentadactyl limb

❑ **<u>Convergent evolution</u>**

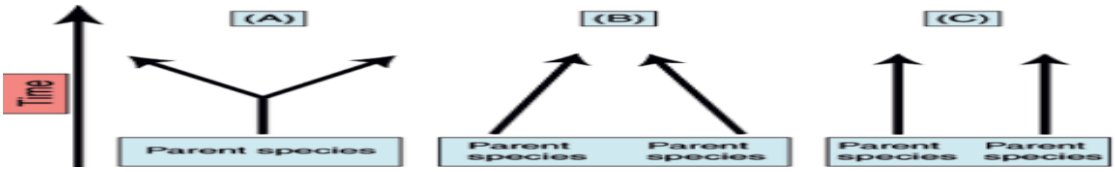
- ✓ *the process by which unrelated organisms evolve similar structures, adapted for the same function*
- ✓ Takes place when species of different ancestry begin to share analogous traits because of a shared environment

Example convergent evolution

- ✓ Fishes and whales have some similar characteristics since both had to evolve methods of moving through the same environment(water)

❑ **Parallel evolution**

- ✓ Occur when two species evolve independently of each other,maintanig the same level of similarity
- ✓ Usually occurs between unrelated species that don't occupy the same niches in a given habitat



Types of evolution; A) Divergent B) Convergent C) Parallel

QUESTION NO 27. Animals without close evolutionary relations are sometimes seen to have similar structures adapted for the same function. Which evolutionary principle is illustrated by this observation?

A. **Convergent evolution** C. Sympatric evolution
B. Divergent evolution D. Allopatric evolution

QUESTION NO 28. Which of the following the result of similarity observed between the wings of bird and a pterodactyl?

A. convergent evolution C. stabilizing selection
B. directional selection D. divergent evolution

QUESTION NO 29. Which of the following is an evolutionary requirement for two sub-population of a species to evolve into independent species?

A. Free exchange of genes C. Free migration between population
B. Geographical isolation D. Absence of natural selection

QUESTION NO 30. Which of the following types of evolution would occur when unrelated populations happen to occupy similar niche in different geographic area?

A. Divergent evolution C. Sympatric evolution
B. Convergent evolution D. Adaptive evolution

Types of speciation

- ✓ Natural selection provides a mechanism by which new populations of a species can arise
- ✓ Species:- *a group of similar, interbreeding organisms that produce fertile offspring*
- ✓ different species cannot interbreed to produce fertile offspring
- ✓ As long as two populations are able to interbreed, they are unlikely to evolve into distinct species.
- ✓ To evolve into distinct species they must be prevented from interbreeding for a period of time

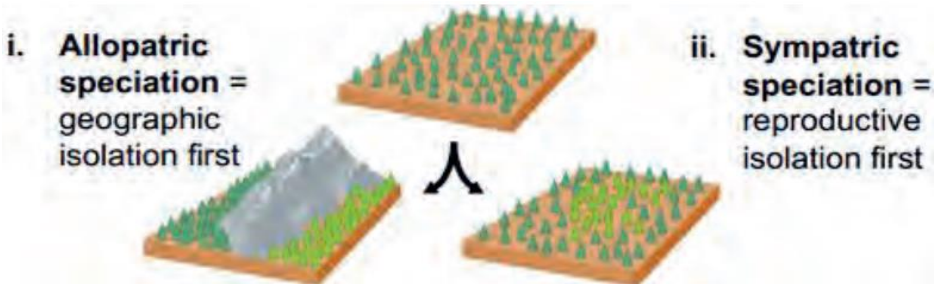
There are two main ways

1) **allopatric speciation**, and
2) **Sympatric speciation**.

- ✓ During this period, mutations that arise in one population cannot be passed to the other. Genetic differences between the two populations increase.
- ✓ Eventually, the two populations will become so different that they will be unable to interbreed i.e. 'reproductively isolated' and become distinct species

QUESTION NO 31. Among the following which one of the best criterion to show that two populations belong to same species?

A. Morphological similarity C. Inhabiting the same geographic area
B. Physiologically similarity **D. Production of fertile offspring**



- ✓ This is a type of **geographical isolation** ;the species become isolated by some physical feature and *develop into a new species*

Examples

- a river changing course
- a mountain range being created
- a land mass separating two bodies of water

❑ **<u>sympatric speciation</u>**

The two diverging populations may inhabit the same area, but be prevented from breeding in many ways, including:

- **seasonal isolation** – members of the two populations reproduce at different times of the year
- **temporal isolation** – members of the two populations reproduce at different times of the day
- **behavioural isolation** – members of the two populations have different courtship patterns

QUESTION NO 32. Which of the following species isolating processes could lead to the evolution of a new species by the mechanism known as sympatric speciation?

A. A river that change its course for many years
B. A new mountain range that was created many years ago
C. Population of a species having different breeding seasons
D. A land mass that separated two water bodies for many years

Polyploidy

Poly=many

- ✓ Polyploidy cells have many sets of chromosomes per cell – 4 sets ,8 sets or more

<u>Example</u>. Some liver cells have 92 chromosomes =they are **tetraploid** ,have four sets of chromosome(23 each)

- ✓ Normal body cells have 46 chromosomes =they are diploid
- ✓ Polyploidy is important in plant evolution because it has allowed infertile hybrid to become fertile
- ✓ Very often a hybrid produced from two species is infertile due to failure of bivalent(homologous pair) formation in meiosis, which leads to absence of sex chromosome and infertility
- ✓ If chromosome number is doubled then all chromosomes would be able to form homologous pair. Sex cell formation can take place and the hybrid becomes fertile

Reproductive isolation mechanism

- ✓ Any interruption in courtship, fertilization ,embryo formation ,or offspring development
- ✓ Can fall into two categories

1) ***Pre zygotic*** reproductive barriers-acts before fertilization and prevent mating
2) ***Post zygotic*** reproductive barriers-act after fertilization and prevent evelopment of viable offspring or reduce offspring fertility

❑ **<u>Pre zygotic reproductive barriers</u>**

- ✓ Affect the ability of two species to combine gamete and form zygote

This includes :

- ➢ **Ecological(habitat)isolation-** a difference in habitat preference can separate two populations in the same geographic area
- ➢ **Temporal isolation** –species that become active at different time of the day or reach reproductive maturity at different times of the year **Behavioral isolation** – behavioral difference may prevent two closely related species from mating. ex- frog calls
- ➢ **Mechanical isolation** –any change in shape of gamete delivering or receiving structure
- ➢ **Gametic isolation** –if a sperm cannot fertilize an egg cells
- ➢ ex. Many marine organisms release egg and sperm cells into water, gametes of different species cant form a zygote
- ➢ **<u>Post zygotic reproductive barriers</u>**
- ➢ Prevent viable or fertile offspring
- ➢ **This includes:**
- ➢ **Hybrid in viability -**Interspecific hybrid dies at early stage of embryonic development because genes of its parent is incompatible
- ➢ **Hybrid infertility (sterility)-**hybrid survives until adulthood but unable to reproduce successfully. Ex .mule is infertile ,meiosis can't occur because the chromosomes are not homologous
- ➢ **Hybrid breakdown** –the interspecific hybrid are fertile ,But offspring of the interspecific hybrid are unable to reproduce successfully .

Question no 33. Male moths recognize females of their species by sensing chemical signals called pheromones. This is an example of:

A. Behavioral isolation C. Gamete isolation
B. Habitat isolation D. Mechanical isolation

Question no 34. Which one of the following is most important for speciation to occur?

A. Hybridization among populations C. Migration between populations
B. **Isolation of the gene pool** D. Free flow of genes between populations

- ➢ **Hybrid breakdown** –the interspecific hybrid are fertile, But offspring of the interspecific hybrid are unable to reproduce successfully.

QUESTION NO 35. Male moths recognize females of their species by sensing chemical signals called pheromones. This is an example of:

A. Behavioral isolation B. Habitat isolation C. Gamete isolation D. Mechanical isolation

QUESTION NO 36. Which one of the following is most important for speciation to occur?

A. Hybridization among populations C. Migration between populations
B. Isolation of the gene pool D. Free flow of genes between populations

QUESTION NO 37. What is the reproductive isolating mechanism called if two species of frogs do not interbreed because they cannot understand the mating calls of one another?

A. Seasonal isolation C. Temporal isolation
B. Behavioral isolation D. Isolation by distance

QUESTION NO 38. Which of the following reproductive isolating mechanisms keeps the horse and donkey as the two independent species?

A. Hybrid in viability **B. hybrid infertility** C. Ecological isolation D. habitat isolation

HUMAN EVOLUTION

- ❑ Wrong statements about human evolution
- ✓ 'we evolved from monkeys'
- ✓ 'we evolved from apes'

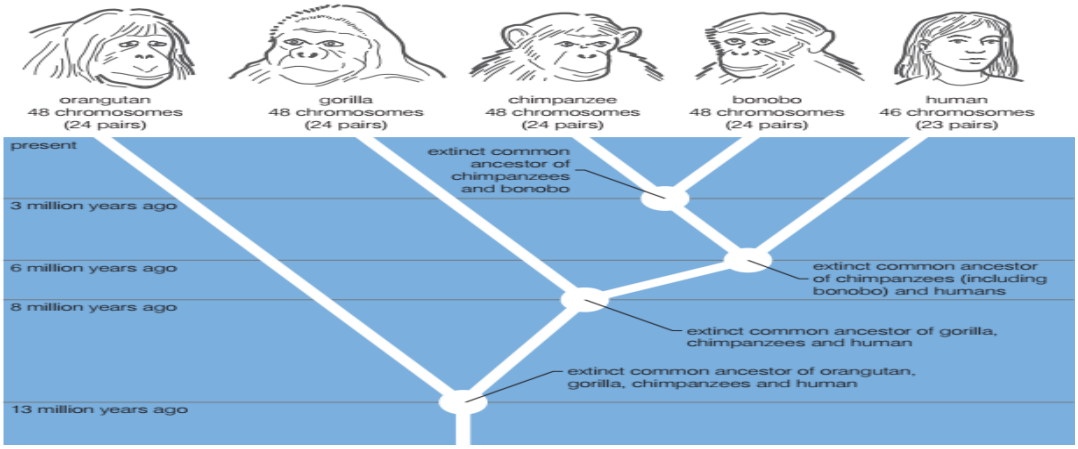
✓ 'we evolved from chimpanzees'

❑ There has been a 'line of evolution' for millions of years

❑ This line gave rise to old world monkeys, new world monkeys, the great apes and the different species of humans that have lived.

❑ But, we are Homo sapiens,the latest of several humans to live on the planet.

❑ There were other humans before us and, before them, what we might call 'pre-humans'. All humans belong to the **genus** *Homo*.



The evolutionary tree of humans and the great apes

❑ at several points in the evolutionary tree

❑ Chimpanzees and bonobo diverged 6 million years ago from evolutionary line that gave rise to humans

❑ Gorilla about 8 million years ago

❑ Orangutan about 13 million years ago

❑ So chimpanzees and bonobo are more related to humans than gorilla

❑ Homo sapiens have two features in particular that distinguish them from other primates

1. a very large brain, and
2. Bipedalism – the ability to truly walk on just two legs.

▪ There was a lot of debate amongst biologists as to which of these came first until Lucy discovered

species a group of related organisms that can reproduce with each other so that they produce fertile offspring

genus a group of closely related species

hominin any member of the genus Homo. This includes H.sapiens, Neanderthals, H. habilis and H.erectus

hominid a group of species that includes all the species belonging to the genus Homo along with other species such as ***Ardipethecus ramidus*** and ***Australopithecus afarensis*** (Lucy)

Ardi

✓ Belonged to the species ***Ardipithecus ramidus*.**

✓ was a female fossil 4.4 million years old(1.2 million years older than Lucy)

✓ is the nearest fossil to the 'common ancestor' of humans and chimpanzees

✓ Was also bipedal , This proves that the common ancestor of humans and chimpanzees could not have resembled a chimpanzee because chimpanzees are not bipedal

QUESTION NO 39. During the evolution of the hominids, which of the following features developed before all the rest as evidenced from fossil records?

A. Bipedalism B. Larger brain C. Ability to make tools D. Shorter arms relative to legs

QUESTION NO 40. Among the following fossil hominid species, which one is the oldest of all?

A. Homo erectus B. Australopithecus afarensis **C. Ardipithecusramidus** D. Australopithecus africanus

QUESTION NO 41. In which hominid species did scientists find the smallest brain size (cranial capacity)?

A. Homo sapiens B. Homo erectus **C. Homo habilis** D. Homo neanderthalensis

How has brain size changed during human evolution?

- ❑ During the course of human evolution the brain has got bigger generally and as compared to their body size
- ✓ species of *Australopithecus* have a brain that is between 0.7% and 1.0% of their body mass
- ✓ modern humans have a brain that is between 1.8% and 2.3% of their body mass
- ✓ brain of *Homo sapiens* uses 25% of the resting energy requirement
- ✓ Brain of great apes uses 8% of the resting energy requirement
- ❑ A larger brain allows humans to:
- ✓ run faster and in a more upright posture
- ✓ plan in advance to avoid attack
- ✓ develop and use tools and weapons
- ❑ Other physical adaptations which allow the above activities but would not confer the same advantage , without the larger brain
- ✓ longer legs
- ✓ more nimble fingers
- ✓ straighter spine

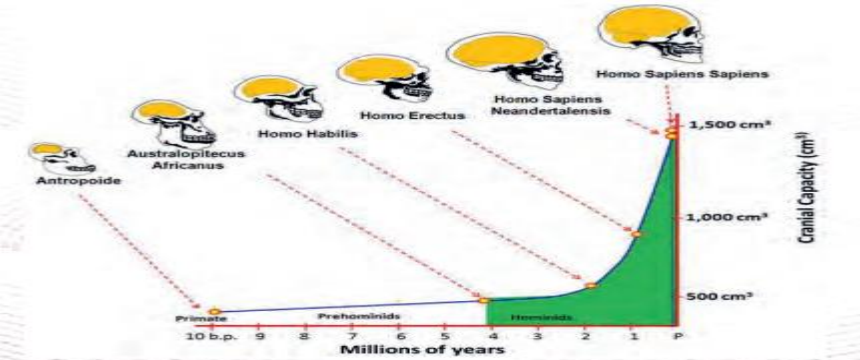


Figure 4.33 Brain size in different hominids

QUESTION NO 42. Which of the following hominids had brain size comparable to that *Homo sapiens*? A. Lucy B. Ardi **C. Neanderthalman** D. Homo habilis

QUESTION NO 43. Which of the following changes that happened during human evolution had the most contribution to the evolutionary success of *Homo sapiens?*

A. Proportionately big brain size to the body size
B. Big body parts big overall body mass
C. Long legs, arms and more upright body posture
D. Fast running ability and overall physical strength

QUESTION NO 44. Which of the following is consistent with the understanding of human evolution

A. Bipedalism was never important in human evolution.
B. Larger brain size had no contribution to the evolution of the human species
C. Human ancestry had no relation whatsoever with that of the chimpanzees
D. Fossils of Lucy and Ardi provided evidence for human origin.

QUESTION NO 45. Which group of hominids is called the handy human?

A. Homo sapiens B. Homo erectus **C. Homo habilis** D. Australopithecus

Are we still evolving?

- ❑ *Homo sapiens* (modern humans) first appeared in Africa and moved into different areas of the world, they encountered different environments
- ❑ For example, as humans encountered colder climates, developed body features that help them to conserve heat. These included:

- ✓ a shorter, squatter body shape; this reduces the surface-area-to volume ratio and so reduces the rate of heat loss by radiation
- ✓ an increased layer of adipose tissue under the skin to act as insulation
- ✓ increased hairiness; this reduces heat loss by convection

❑ Humans have been evolving into different 'races' for thousands of years. The classification of these races is difficult and there is some disagreement about their exact nature

QUESTION NO 46. Which of the following criteria strongly supports that all human races belong to a single, *Homo sapiens* ?

A. Larger brain size B. Bipedal gait C. Pent dactyl limbs **D. Inter -fertility between races**

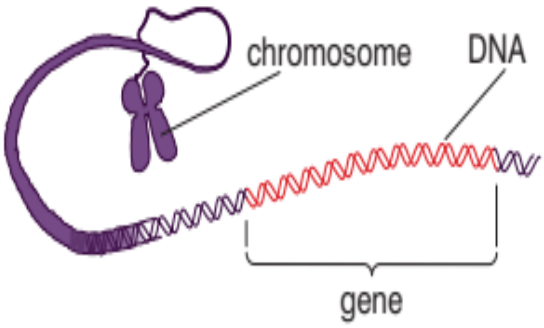
Mutation

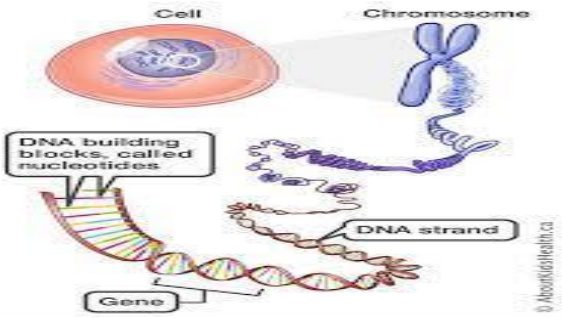
Nucleus: - is the membrane-enclosed organelle within a cell that contains the chromosomes.

Chromosome: - is a thread-like structure composed of DNA and proteins

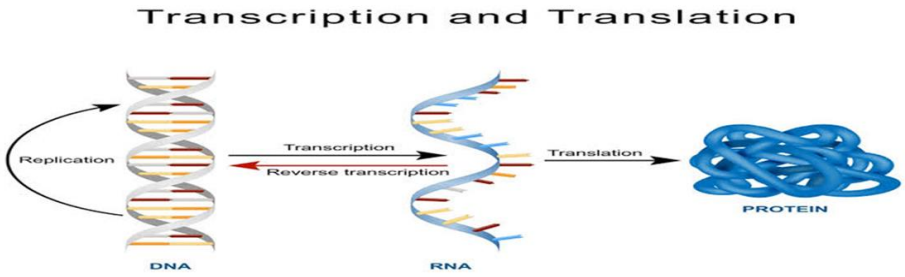
Gene: - *a section of DNA that determines a specific feature*

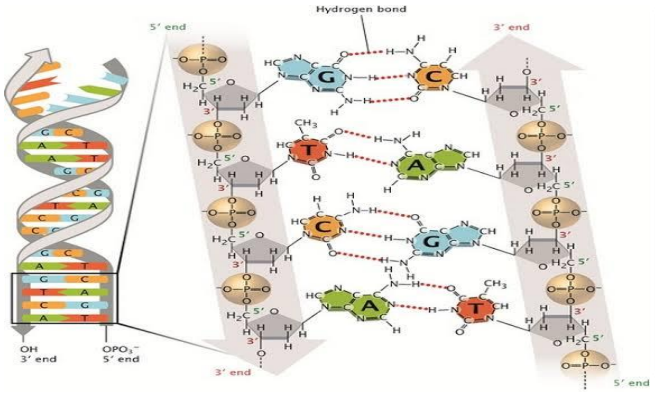
allele: - *a version of a gene that determines a particular trait*

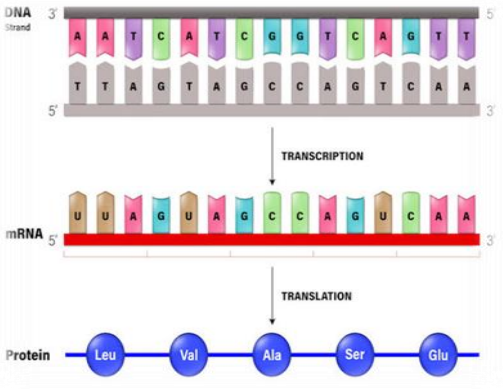


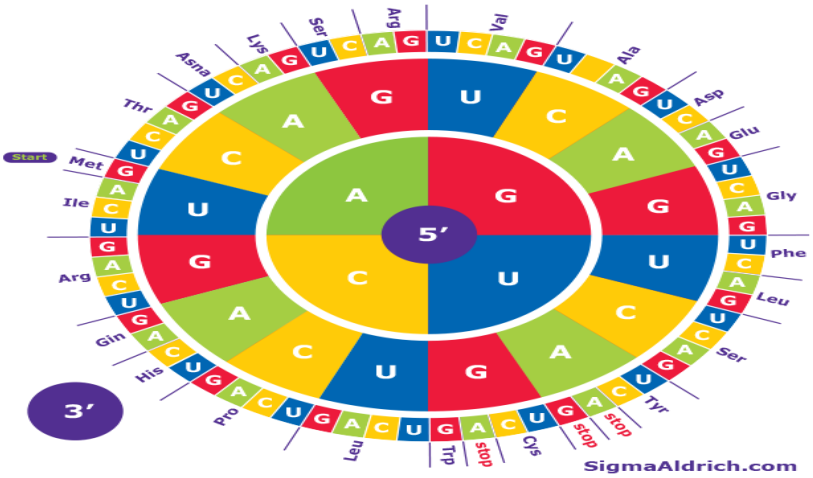


Protein synthesis









- ❑ **mutation** is *a random change in genetic information*
- ✓ can be structural changes involving whole chromosomes or parts of chromosomes, or only a single base
- ✓ The changes involving only a single base are called **point mutations**

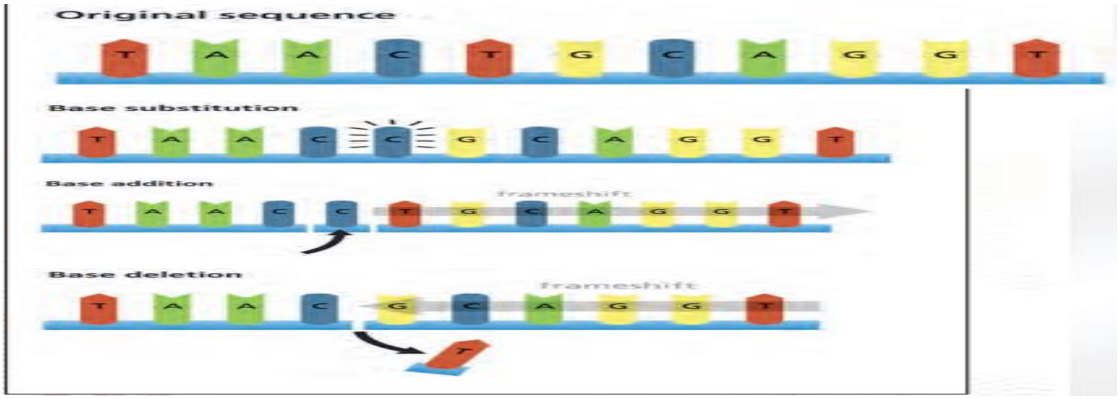
This includes:-

- substitution
- addition
- deletions

- These mutations occur quite randomly when DNA is replicating
- each involves a change to just one base, but 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

Question no 47. Mutation may be described as:

A. phenotypic change B .continuous variation **C. change in genetic structure** D. change due to hybridization



Substitution

- ❑ In substitution mutations, one base is replaced by a different base

GAC	GGG	ATT	GAG	GAG
aspartic acid	glycine	isoleucine	glutamic acid	glutamic acid

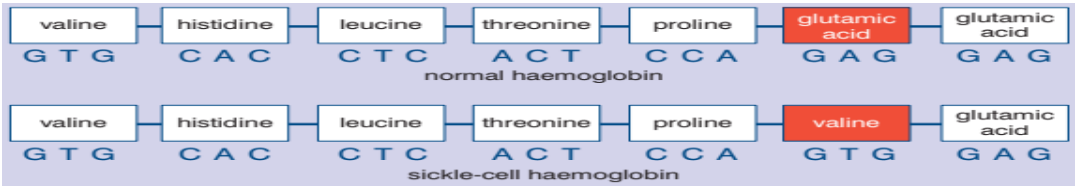
Original sequence

GAC	GGG	ATG	GAG	GAG
aspartic acid	glycine	methionine	glutamic acid	glutamic acid

Mutated sequence

- ❑ Guanine replaces thymine in the above substitution and The triplet ATT(isoleucine) has been changed to ATG(methionine) - no other triplet is affected

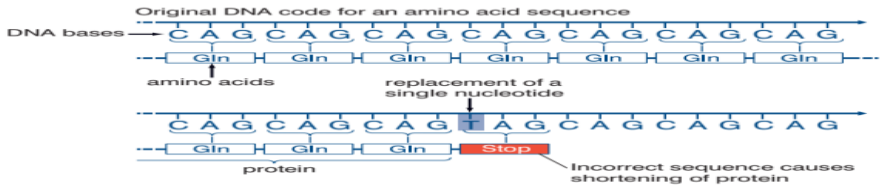
- ❑ As a result a different protein will be synthesized, which may or may not be significantly different from the original
- ❑ One different amino acid in a protein does not always make a functional change.
  - ✓ If the substitution had been by any base other than guanine the triplet would still have coded for isoleucine and the same protein would have been synthesized, because the DNA code is degenerate
  - ✓ **sickle-cell anaemia** is caused by substitution mutation
  - *It affects the structure of the haemoglobin molecules in red blood cells causing the red blood cells to sickle under low oxygen tension*
  - A substitution of one base in one polypeptide of *haemoglobin changes the triplet from GAG(glutamate)to GTG(valine)*
  - The different haemoglobin molecule formed results in the condition known as **sickle-cell anaemia**







- ❑ 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



A nonsense substitution.

Question no 48. Which one of the following types of mutations is responsible for sickle cell anemia?

A. Addition of a base pair **C. Substitution of a base pair**

B. Deletion of a base pair D. A shift in the reading frame of the genetic code

Question no 49. What is the circumstance that causes the health condition known as sickle-cell anemia?

A. DNA denaturation **B. Haemoglobin mutation** C. RNA mutation D. Phosphate mutagenesis

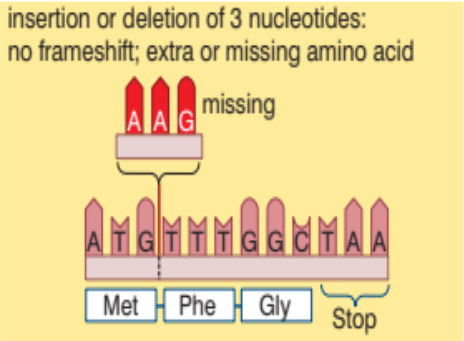
Question no 50. What exactly happens during a substitution mutation?

A. One base is replaced by a different base.

B. An extra base is added during DNA replication.

C. A base is missed out during DNA replication.

D. Changes occur in the arrangement or structure of a chromosome.



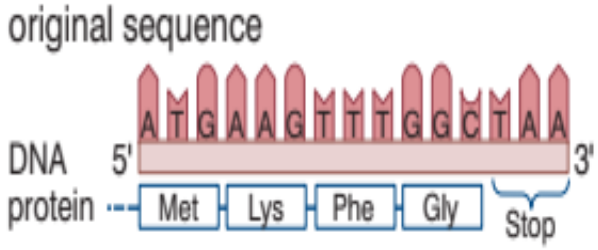
Addition and deletion

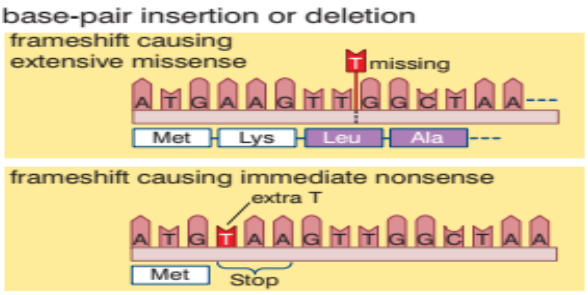
- ❑ In a **deletion mutation** a base is 'missed out' during replication
- ❑ whilst in additions mutation , an extra base is added
- ❑ both these are more significant mutations than substitutions because they do not just alter the triplet in which the mutation occurs.
- ❑ The whole sequence after the point of the mutation is altered
- ❑ This leads to a frame shift – totally different mRNA\no mRNA & non-functional or no protein is produced

Example

- Look of this sequence of letters: with a 'reading frame' of three letters
  THE MAN WAS HOT AND RAN FOR HIS HAT- it makes sense
- if we take out the **S** at the end of **WAS** (a deletion mutation), it becomes:
  THE MAN WAH OTA NDR ANF ORH ISH AT - it makes no sense**(mis-sense** coding**)**

- ❑ Sometimes, a whole triplet is missed out or inserted resulting in either one extra or one fewer codon in the mRNA. In turn, this will lead to one extra or one fewer amino acid in the polypeptide chain





Frameshift mutations

Table 4.2 Description of point mutation

Type	Description	Example	Effect
Silent	mutated codon codes for the same amino acid	CAA (glutamine) → CAG (glutamine)	none
Missense	mutated codon codes for a different amino acid	CAA (glutamine) → CCA (proline)	variable
Nonsense	mutated codon is a premature stop codon	CAA (glutamine) → UAA (stop) usually	serious

Chromosome mutations

- ❑ a mutation involving a long segment of DNA
- ❑ Refer to any change in the **number** ,**arrangement** or **structure of the chromosomes**
- ❑ They occur most often during meiosis at crossing over in prophase 1
- ❑ are much bigger events than point mutations and usually result in the death of a cell.
- ❑ They may also affect the whole organism.
- ❑ For example, if essential parts of the DNA are affected by chromosomal mutations, a fetus may be aborted.

There are several different mutation types:-

- ✓ Inversion
- ✓ Deletion
- ✓ Duplication

✓ Translocation

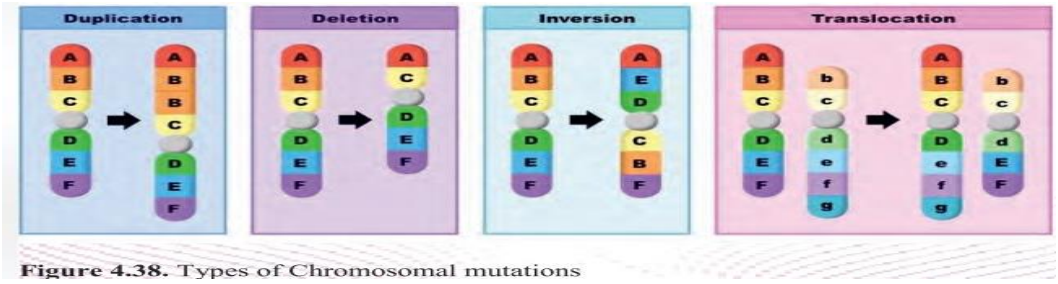
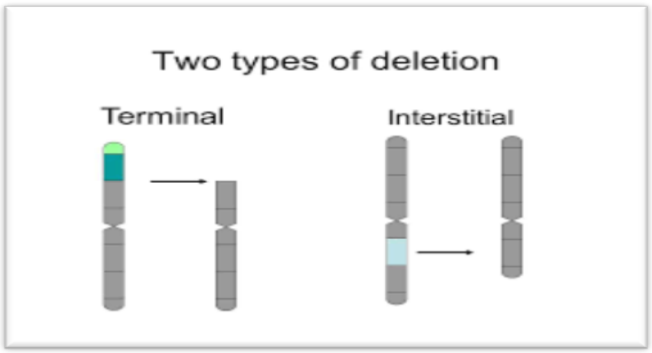
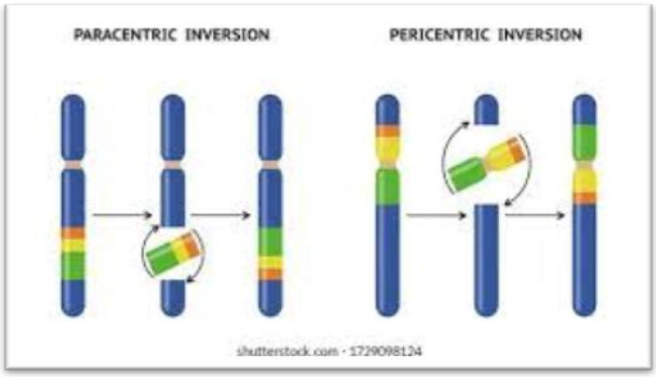


Figure 4.38. Types of Chromosomal mutations

Chromosomal mutation type I – alter the structure of chromosome

✓ involves Inversion ,Deletion ,Duplication ,Translocation
✓ **Chromosomal mutation type II**- change the number of chromosomes(heteroploidy)
✓ involves polyploidy and aneuploidy
✓ **Inversion**
✓ Segment of a chromosome is reversed from end to end
✓ A piece of chromosome is removed an reattached in the opposite direction
✓ **Paracentric inversion:-**doesn't involve centromere
✓ **Pericentric inversion:-**involves centromere(center) of chromosome
✓ **Deletion**
✓ Loss of large portion of chromosome
✓ Also known as **partial monosomies**
✓ **Terminal deletion:-** one piece is deleted on the end
✓ **Interstitial deletion:-** one piece deleted within chromosome and one on the end
✓ **Micro deletion:-** when deletion is to small to be detected





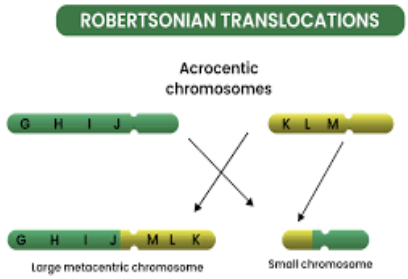
Duplication/amplifications

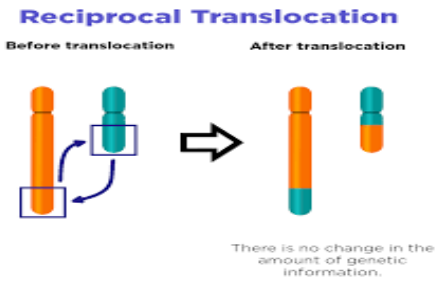
✓ An extra copy of a segment or whole chromosome is present in the nucleus
✓ Also known as partial trisomy
✓ Can occur anywhere in the chromosome whether in the middle or on the end

Translocation

✓ a segment of chromosome breaks off and then relocated to a completely different chromosome
✓ Non homologous chromosomes exchange a piece of chromosome among themselves
✓ This creates fusion chromosome as one type of chromosome fuses with another
✓ **Reciprocal translocation:-**two different chromosomes have exchange segments with each other. Pieces of chromosome "swap" places

- ✓ **Robertsonian translocation:-** a segment of chromosome attached to another chromosome ,causing an elongation of it
- ✓ Balanced –if chromosome is functional with no missing genetic information
- ✓ Unbalanced –if chromosome in not functional with important piece missing
- ✓ Example - **down syndrome**(translocation of chr21 to chr14)





Aneuploidy

- ✓ Causes addition or loss of chromosome
- ✓ Caused usually by **non-disjunction** during meiosis or mitosis

Polyploidy (euploidy)

- ✓ Creates many sets of chromosome in a cell(tri, tetra,penta …)
- ✓ Usually not common ,but can be observed in some plants

Advantage of chromosomal mutations

- ✓ Sometimes chromosomal mutation can benefit an organism

Example - lactose intolerance became an advantage to have over others when numerous populations depended on cows and goats as source of food

Genetic disorders: - disorder caused by mutation within organism's DNA

- Trisomy 21: Down Syndrome
- Trisomy 18
- Trisomy 13
- Klinefelter Syndrome
- XYY Syndrome
- Turner Syndrome
- Triple X Syndrome

Question no 51. Which one of the following is **NOT** a mutation?

A. DNA replication to form two daughter DNAs.

B. Deletion of a base pair from DNA.

C. Gain of an extra chromosome by a cell

D. Loss of a chromosome by a cell.

Question no 52. In some human liver cells there are 92 chromosomes per cell. What is the ploidy level of such cells?

A. Haploid B. Diploid **C. Tetraploid** D. Hexaploid

QUESTION NO 53. Which of the following types of chromosome mutations gives rise to an extra chromosome?

A.Inversion B. Translocation C. Deletion **D. Non-disjunction**

QUESTION NO 54. Which form of mutation is responsible for the disease known as leukemia?

A. Duplication **B. insertion** C. inversion D. deletion

PRACTICAL EUEE QUESTIONS WITH ANSWERS

EUEE Questions on Evolution

I: THE ORIGIN OF LIFE

1. Which group of organisms is found at a lower level of evolution according to the modern principles of biology?
   A. Protists
   B. Fungi
   C. Animals
   D. Plants
2. In the process of the evolution of life on earth, which of the following four processes evolved last?
   A. Photosynthesis
   B. Aerobic respiration
   C. Chemosynthesis
   D. Photo-autotrophism
3. During the course of evolution, which of the following events came before all the others?
   A. Origin of dinosaurs and other reptiles
   B. Availability of free oxygen in the atmosphere
   C. Origin of the oldest eukaryotic organisms
   D. Origin of the first multicellular animals and plants
4. What is the branch of biology that studies about the origin and gradual changes of living things?
   A. Microbiology
   B. Evolution
   C. Mutation
   D. Reproduction
5. Which one of the following eukaryotic cell organelles was a free living cell before eukaryotic cells evolved?
   A. Nucleus
   B. Ribosomes
   C. Chloroplast
   D. Nucleolus
6. Which of the following did the early heterotrophs do that probably assisted the origin of autotrophs?
   A. They added oxygen and chlorophyll to the environment
   B. They added carbon dioxide to the environment
   C. They stored energy in the bonds of inorganic compounds.
   D. They manufacture food from carbon dioxide and oxygen
7. Which of the following groups are believed to be the first photosynthetic organisms to evolve on Earth?
   A. Green plants
   B. Green algae
   C. Blue green algae
   D. Lichens
8. Among the following four processes, identify the one that probably evolved before all other three?
   A. Aerobic respiration
   B. Anaerobic respiration
   C. Oxidizing atmosphere
   D. Photosynthesis
9. Among the theories about the origin of life, which one better agrees with the concept of change in organisms and their genetic composition over generations being caused by meiosis, hybridization, natural selection or mutation?
   A. Biochemical origin theory
   B. Cosmozoan theory
   C. Special creationism theory
   D. Spontaneous generation theory
10. Which of the following is the most accepted theory about the origin of life on earth?
    A. Theory of spontaneous evolution
    B. Theory of chemical evolution
    C. The cosmic theory

D. Theory of special creation

11. What is the reason that Stanley Miller excluded free oxygen from the mixture of the gases that used for his simulation experiment?
    A. Primitive atmosphere was reducing.
    B. Early organic molecules did not contain oxygen.
    C. Oxygen cannot react with the rest of the gases.
    D. The primitive atmosphere was full of oxygen.
12. Which of the following is the common idea held by all the creationists?
    A. Life is eternal.
    B. All life was created in six days.
    C. Life was created by a supernatural being.
    D. Life came to earth from elsewhere in the universe.

II: THEORIES OF EVOLUTION

13. According to the theory of evolution as proposed by Charles Darwin, which one of the following is the most important driving force of evolution?
    A. Mutation
    B. Over – reproduction
    C. Genetic recombination
    D. Natural selection
14. Which one of the following modes of natural selection was responsible for the fast increase in the number of the black form of moths in Europe during Industrial Revolution?
    A. Stabilizing selection
    B. Disruptive selection
    C. Normalizing selection
    D. Directional selection
15. From which of the following sources did Charles Darwin get the idea that selection can change living organisms? From:
    A. the work of plant and animal breeders.
    B. his observation of the Galapagos birds.
    C. the evolution theory of Lamarck.
    D. the book by Malthus.
16. Which of the following statements is consistent with the concept of the gene pool?
    A. Species with large gene pool have low potential of adaptation.
    B. Endangered species usually have small gene pool.
    C. Large gene pool is a hindrance for livestock improvement.
    D. Species with large gene pool are prone to disease.
17. Which of the following ideas is **NOT** a part of Darwin's Theory of Evolution? (2004)
    A. Over reproduction
    B. Use and disuse of body parts
    C. Existence of heritable variation
    D. Competition for scarce resources
18. What are the most likely causes of variations within species? (2005)
    A. Mitosis and asexual reproduction
    B. Overpopulation and overproduction
    C. Vegetative propagation and cloning
19. Which of the following theories explains evolutionary changes of living things in terms of changes in their allele frequencies?
    A. Darwin's natural selection
    B. Spontaneous generation
    C. Inheritance of acquired characteristics
    D. Neo-Darwinism
20. Which one of the following factors is **NOT** important for evolutionary change of a population?
    A. Over reproduction
    B. Insufficiency of natural resources
    C. Existence of heritable variation
    D. Survival of all that are born
21. According to Lamarck's theory of evolution, what is the mechanism by which evolving organisms acquire new

structures?

A. Mutation
C. Use and disuse of parts of the body
B. Hereditary variation
D. Recombination of ancestral genes

22. Why is it that mutations are considered as one of the raw materials of evolution?
    A. They contribute to new variations in organisms.
    B. They are usually related to the environment in which they appear.
    C. They are mostly beneficial to the organisms in which they appear.
    D. They usually become the causes for species extinction.
23. Which of the following expression is more related to the phrase ‚survival of the fittest'?
    A. Natural selection
    C. Gene mutation
    B. Mendelian inheritance
    D. Inheritance of acquired characteristics
24. Why mutations are considered important in evolution?
    A. They are usually related to the environment.
    B. They contribute to new variations in organisms.
    C. They are always beneficial to the organism.
    D. They become causes for species migrations.
25. How many years have passed since Darwin's book on the theory of evolution was published?
    A. About 50 years
    C. About 120 years
    B. About 160 years
    D. About 100 years
26. In his theory of evolution, the cause of which of the following concepts was **MISSING** in Darwin's explanation?
    A. Over-reproduction
    C. Hereditary variation
    B. Struggle for survival
    D. Survival of the fittest
27. Which of the following factors brings about changes both during evolution and breeding of plants and animals?
    A. Limited resources
    C. Selection
    B. Production of excess progeny
    D. Competition
28. Lamarck's theory of evolution is known as:
    A. inheritance of acquired characters
    C. natural selection
    B. survival of the fittest
    D. mutation theory
29. Which one of the following is the primary contribution of Darwin to biological theory?
    A. New alleles arise through mutation.
    B. An important mechanism of biological evolution is natural selection.
    C. Evolution is the change in gene frequencies over time.
    D. Genes are the units of inheritance.
30. In which of the following ways does mutation contribute most to evolution?
    A. It preserves adaptive genes.
    B. It forms a new gene pool.
    C. It helps genes to recombine.
    D. It creates new alleles.
31. Which of the following combinations is known as Neo-Darwinism?
    A. Natural selection and Mendelian law of inheritance
    B. Natural selection and acquired inheritance
    C. Acquired inheritance and Mendelian law of inheritance

D. Natural selection and Lamarck's theory of evolution

32. On which of the following points do Lamarck's and Darwin's theories of evolution agree?
    A. Evolution occurs by natural selection
    B. Evolution produces new species
    C. All living things tend to over reproduce
    D. New structures arise by use-and-disuse

33. Which of the following concept is attributed to Charles Darwin?
    A. In the struggle for existence, the fittest would survive.
    B. Every cell must come from a pre-existing cell.
    C. Use and disuse of organs is of great importance in evolution.
    D. The gametes will carry only one of a pair of contrasting characters.

34. Which one of the following phenomena supports Darwin's concept of natural selection in organic evolution?
    A. Development of transgenic animals
    B. Prevalence of pesticide resistant insects
    C. Production of 'Dolly', the sheep by cloning
    D. Development of organs from 'stem cells' for organ transplantation

III: THE EVIDENCE FOR EVOLUTION

35. Carbon 14 has a half-life of about 5730 years. Suppose a fossil contains only 12% of the amount of carbon 14 normally present in living organisms, how old is the fossil?
    A. 5730
    B. 11460
    C. 17190
    D. 22920

36. Which of the following is true about the evolutionary origin of groups of organisms?
    A. The dinosaurs appeared before the origin of the land plants.
    B. The earliest *Homo sapiens* appeared before the flowering plants.
    C. The first photosynthetic organisms appeared before the oldest eukaryotes.
    D. The first animals appeared before the formation of free O_2 in the atmosphere.

37. Why are fossils of soft-bodied organisms usually relatively rare in the environment?
    A. They are generally small in size.
    B. Their bodies decompose readily.
    C. They all lived in environments where sedimentation did not occur.
    D. They were never common in environments in which they lived.

38. What does the structural similarity between the flippers of whales and arms of humans show?
    A. Whales evolved from the human species.
    B. Whales are older than the human species.
    C. The human species began life in the oceans.
    D. Whales and humans had a common ancestry.

39. Which of the following pairs of molecules can give information about how much two species are evolutionary related to one another?
    A. DNA and proteins
    B. Starch and cellulose
    C. Lipids and carbohydrates
    D. Carbohydrates and proteins

40. What is the specialist in biology called if he/she studies fossils to generate new knowledge on the origin and

evolution of living things of past geologic periods?

A. Geneticist
C. Paleontologist
B. Ecologist
D. Comparative Biochemist

41. When two species are compared, which of the following sources of evidence is least informative about the degree of relationships between the species?

A. Nucleotide sequence of DNAs
C. Glucose sequence of polysaccharides
B. Amino acid sequences of proteins
D. DNA – DNA hybridization

42. Which of the following characteristics can show the evolutionary relationships among organisms?

A. Structures having similar functions
C. Structures having common origin
B. Structures having same size
D. Structures having different origins

43. In which geologic period does the fossil record show more diverse and relatively higher forms of organisms? (2005)

A. Devonian
C. Jurassic
B. Cretaceous
D. Permian

44. Which of the following can be taken as case for evidence of evolution from the field of plant & animal breeding? (2006)

A. Artificial breeding always creates new species.
B. Artificial breeding only produces new organisms with higher yield
C. Artificial breeding shows that natural selection can produce variations
D. Artificial breeding can produce new variations in organisms

45. If a radioactive substance that weighs one kilogram has a half-life of 100 years, what would be the percentage of the substance left after 300 years? (2006)

A. 50
C. 25
B. 30
D. 12.5

46. What do you call structures that have the same evolutionary origin but are different in structure or have different functions?

A. Endemic
C. Homologous
B. Analogous
D. Indigenous

47. The half-life of carbon-14 is about 5730 years. If a fossil is 17200 years old, about what percent of its original carbon-14 is still present in the fossil?

A. 75%
C. 25%
B. 50%
D. 12%

48. Which of the following pairs are analogous structures?

A. Wing of a bird & wing of a butterfly
B. Front leg of a horse & a human arm
C. Wing of a bird & wing of a bat
D. Front leg of a frog & wing of a bat

49. Which of the following conclusions can be drawn from the structural similarities observed between the flippers of whales and the arms of humans?

A. The human species began life in the ocean
B. The human species and whales share a common ancestry
C. Whales are older than the human species
D. Whales have evolved from early humans that went back to the ocean

50. From evolutionary point of view, which of the following animals is expected to have haemoglobin proteins that are least similar to that of human?
A. Ape
B. Cow
C. Chicken
D. Frog

51. If a substance that weighs 2,000 grams and has a half-life of 100 years is left with only 250 grams, for how long has the radioactive decaying activity been undergoing?
A. 200 years
B. 250 years
C. 300 years
D. 500 years

52. Suppose a fossil initially contains 100,000 atoms of a certain radioactive element whose half-life is 10,000 years, after how many years would the number of the atoms be 12500?
A. Ten thousand years
B. Twenty thousand years
C. Thirty thousand years
D. Forty thousand years

53. Based on similarity in number of amino acids found in haemoglobin, which one of the following animals has closer phylogenetic relations to human beings?
A. Chicken
B. Protozoa
C. Bacteria
D. Algae

54. What do you call structures that have the same evolutionary origin even though they may now have different structural make ups or functions?
A. Endemic
B. Analogous
C. Homologous
D. Indigenous

55. Which of the following pairs are **ANALOGOUS** structures?
A. The human arm and the front leg of a mule
B. The front leg of a frog and the wing of a bat
C. The wing of a bird and the wing of a butterfly
D. The wing of a bat and the wing of a bird

56. Which of the following can be understood about living things from the study of how breeders improve domesticated plants and animals?
A. Living things tend to over-reproduce
B. Natural resources are of limited supply
C. Living things can be improved through selection
D. Individuals compete for resources

57. Which of the following do biologists consider ancestral to the higher organisms of today?
A. Plantae B. Animalia C. Fung D. Protista

58. Which of the following characteristics can show the evolutionary relationships among organisms?
A. Structures having similar functions
B. Presence of analogous structures
C. Presence of homologous structures
D. Structures having different origins

59. Which of the following features do analogous structures mostly share?
A. Phylogenetic similarity
C. Ancestral similarity

B. Functional similarity
D. Developmental similarity

60. Based on differences in DNA, which of the following animals is closer to human beings?
A. Frog
C. Zebra fish
B. Domestic pig
D. Domestic chicken

61. Which of the following organic molecules is least informative about the evolutionary relationship between species?
A. RNA
C. Carbohydrates
B. Proteins
D. DNA

62. One of the following sources of evidence provides a more direct support to the process of Charles Darwin's theory of evolution.
A. Genetics
C. Physiology
B. Anatomy
D. Geographical distribution

63. If a radioactive substance that weighs 5,600 grams and has a half-life of 100 years is left with 700 grams, for how long has the decaying activity been undergoing?
A. 100 years
C. 200 years
B. 300 years
D. 500 years

PART VI: THE PROCESSES OF EVOLUTION

64. In spite of their ability to form hybrids when mated, which one of the following factors is more important to keep the horse and the donkey as separate species?
A. Their hybrid is not viable.
C. They cannot form hybrid zygotes.
B. Their hybrid is sterile.
D. They are ecologically isolated.

65. Which one of the following is most important for speciation to occur?
A. Hybridization among populations.
B. Isolation of the gene pool.
C. Migration between populations.
D. Free flow of genes between populations.

66. Animals without close evolutionary relations are sometimes seen to have similar structures adapted for the same function. Which evolutionary principle is illustrated by this observation? (2003)
A. Convergent evolution
C. Sympatric evolution
B. Divergent evolution
D. Allopatric evolution

67. Which of the following descriptions is true about the action of selective pressure in populations? Selective pressure that acts:
A. around the mean value is stabilizing
B. around the mean value is disruptive
C. at both ends of the distribution is directional
D. at one ends of the distribution is stabilizing.

68. What is the most probable selection pressure responsible for the evolution of green skin colour in frogs inhabiting tropical rainforests?
A. Climate
C. Infection by pathogens
B. Reproduction
D. Predation

69. What is the reproductive isolating mechanism called if two species of frogs do not interbreed because they cannot understand the mating calls of one another?
A. Seasonal isolation
C. Temporal isolation
B. Behavioral isolation
D. Isolation by distance

70. Among the following, which one is the best criterion to show that two populations belong to same species?

A. Morphological similarity
B. Physiological similarity
C. Inhabiting the same geographic area
D. Production of fertile offspring

71. If a new mutant allele arises in a certain population, which of the following factors determines if the allele is going to be adaptive or non–adaptive?
A. The environment in which the population lives
B. The rate at which the gene mutates
C. The population in which the gene is found
D. The use and disuse of the gene by the population

72. What kind of natural selection is at work in a situation where individuals at both extreme ends of the range get better survival advantages than those around the middle?
A. Stabilizing selection
B. Directional selection
C. Disruptive selection
D. Selection that removes the extremes

73. Which of the following is prevented from taking place if populations are separated by a geographic barrier?
A. Mutation
B. Evolution
C. Gene flow
D. Natural selection

74. Which of the following is an evolutionary requirement for two sub-populations of a species to evolve into independent species?
A. Free exchange of genes
B. Geographic isolation
C. Free migration between populations
D. Absence of natural selection

75. What does an evolutionary selective pressure that acts around the mean do?
A. It stabilizes.
B. It terminates.
C. It converges.
D. It disrupts.

76. Which of the following reproductive isolating mechanisms keeps the horse and donkey as two independent species?
A. Hybrid in viability
B. Hybrid infertility
C. Ecological isolation
D. Habitat isolation

77. Which of the following was the most possible mode of evolution by which the many species of Darwin's finches evolved on the Galapagos islands?
A. Phyletic evolution
B. Divergent evolution
C. Convergent evolution
D. Sympatric evolution

78. Which of the following species isolating processes could lead to the evolution of a new species by the mechanism known as sympatric speciation?
A. A river that changed its course for many years
B. A new mountain range that was created many years ago
C. Populations of a species having different breeding seasons
D. A land mass that separated two water bodies for many years.

79. For which of the following can divergent evolution be taken as an alternative name?
A. Allopatric speciation
B. Adaptive radiation
C. Sympatric speciation
D. Disruptive selection

80. Which of the following is the result of the similarity observed between the wings of a bird and a pterodactyl?
A. Convergent evolution
B. Directional selection
C. Stabilizing selection
D. Divergent evolution

81. In the process of allopatric speciation, which of the following is the mechanism that prevents populations from

exchanging genes?

A. Polyploidy
C. Geographic barrier
B. Seasonal isolation
D. Temporal isolation

82. The evolution of a species which is based upon the sum total adaptation changes could be preserved by:
A. isolation
C. natural selection
B. speciation
D. human conservation

83. What is the possible cause or isolating mechanism for the formation of allopatric species?
A. Seasonal isolation
C. Geographical isolation
B. Temporal isolation
D. Behavioral isolation

V: THE EVOLUTION OF HUMANS

84. To which genus of human-like organisms does Lucy belong?
A. The genus Homo
C. The genus Sahelanthropus
B. The genus Ardipithecus
D. The genus Australopithecus

85. Which of the following fossils is the nearest to the common ancestor of the hominids and the apes?
A. *Homo habilis*
C. *Ardipithecus ramidus*
B. *Homo erectus*
D. *Australopithecus afarensis*

86. In which hominid species did scientists find the smallest brain size (cranial capacity)?
A. *Homo sapiens*
C. *Homo erectus*
B. *Homo habilis*
D. *Homo neanderthalensis*

87. Among the following fossil hominid species, which one is the oldest of all?
A. *Homo erectus*
C. *Australopithecus afarensis*
B. *Ardipithecus ramidus*
D. *Australopithecus africanus*

88. Which of the following is consistent with the understanding of human evolution?
A. Bipedalism was never important in human evolution.
B. Larger brain size had no contribution to the evolution of the human species.
C. Human ancestry had no relation whatsoever with that of the chimpanzees.
D. Fossils of Lucy and Ardi provided evidence for human origin.

89. Which of the following changes that happened during human evolution had the most contribution to the evolutionary success of *Homo sapiens*?
A. Proportionately big brain size to body mass
B. Big body parts and big overall body mass
C. Long legs, arms and more upright body posture
D. Fast running ability and overall physical strength

90. Choose the one that had LEAST contribution to human evolution?
A. Development of bipedalism
C. Attaining opposable thumb
B. Adaptation to flight
D. Increasing brain size

91. Which of the following played an important role in the evolution of human being?
A. Emergence of wings in addition to limbs
B. Development of even toes in the forearms
C. Development of feathers and hollow bones
D. Development of opposable thumb to grasp

92. To which genus of primates are the Neanderthal humans classified?
A. The genus *Homo*

B. The genus *Ardipithecus*
C. The genus *Australopithecus*
D. The genus *Zinjanthropus*

93. In which geologic period is the evolution of humans most probably believed to have happened?
A. Tertiary period
B. Jurassic period
C. Cretaceous period
D. Quaternary period

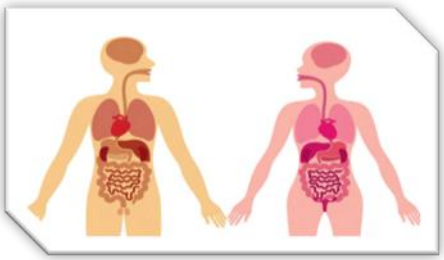
94. Among the following, which one had the cranial capacity of about the same size as that of *Homo sapiens*?
A. The Neanderthal man
B. *Homo habilis*
C. Lucy
D. *Homo erectus*

Answers Key for Evolution UEE Questions

1. A
2. B
3. B
4. B
5. C
6. B
7. C
8. B
9. A
10. B
11. A
12. C
13. D
14. D
15. B
16. B
17. B
18. D
19. D
20. D
21. C
22. A
23. A
24. B
25. B
26. C
27. C
28. A
29. B
30. D
31. A
32. B
33. A
34. B
35. C
36. C
37. B
38. D
39. A
40. C
41. C
42. C
43. B
44. C
45. D
46. C
47. D
48. A
49. B
50. D
51. C
52. C
53. A
54. C
55. C
56. C
57. D
58. C
59. B
60. B
61. C
62. D
63. B
64. B
65. B
66. A
67. A
68. D
69. B
70. D
71. A
72. C
73. C
74. B
75. D
76. B
77. B
78. C
79. B
80. A
81. C
82. C
83. C
84. D
85. C
86. B
87. B
88. D
89. A
90. B
91. D
92. A
93. D
94. A

Unit 5

Human Body System



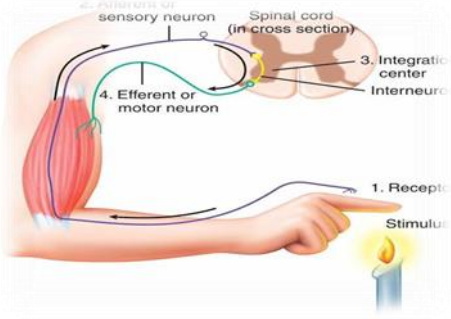
After successful completion of this unit, the learner will be able to:

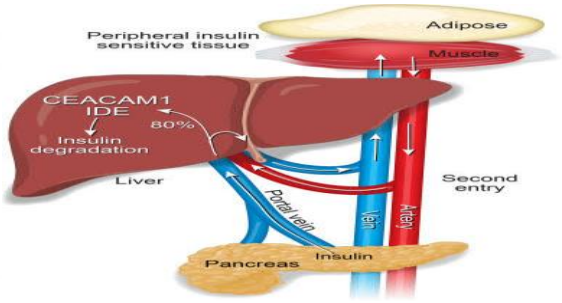
- **Explain the structure and function of the nervous system**
- **Explain how the organs of each organ system work together**
- **Explain what homeostasis is and how the human nervous and endocrine system helps maintain homeostasis**
- **Discuss how the nervous and endocrine system works**
- **Describe the effects of drug abuse on the normal functioning of the nervous and endocrine system**

<u>Body coordination</u>

- **The nervous system** and **the endocrine system** are the two important system responsible for body coordination
- The nervous system uses nerve cells to pass electrical impulses
- ✓ nerve cells act on their target cells by releasing **neurotransmitters**(chemicals)
- The endocrine system releases hormones(chemicals) that is transported in the blood to their target cells
- Target cells have specific cell surface receptors and changes in concentration of hormone stimulates them

	Nervous system	Endocrine system
Speed of action	Seconds	Minutes to hours (even days)
Duration of action	Seconds to minutes	Minutes to days
Method of transmitting messages	Electrical	Chemical
Transport method	Neurones	Hormones

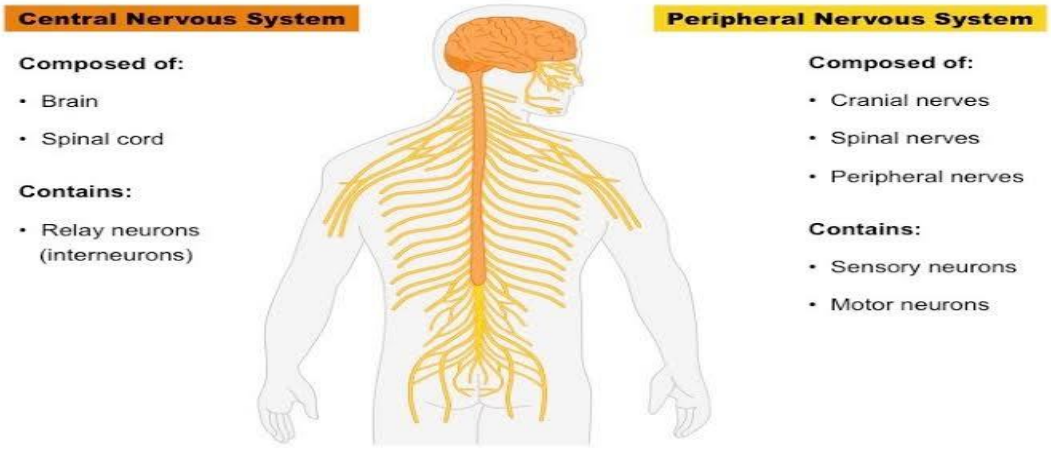




5.1. The Nervous System

- The nervous system has two major division(anatomical)

1) <u>The central nervous system(CNS)</u> -consists of **brain** and **spinal cord**
2) <u>The peripheral nervous system(PNS)</u> - consists of nerves outside CNS
   - these are ***cranial*** and ***spinal nerves***



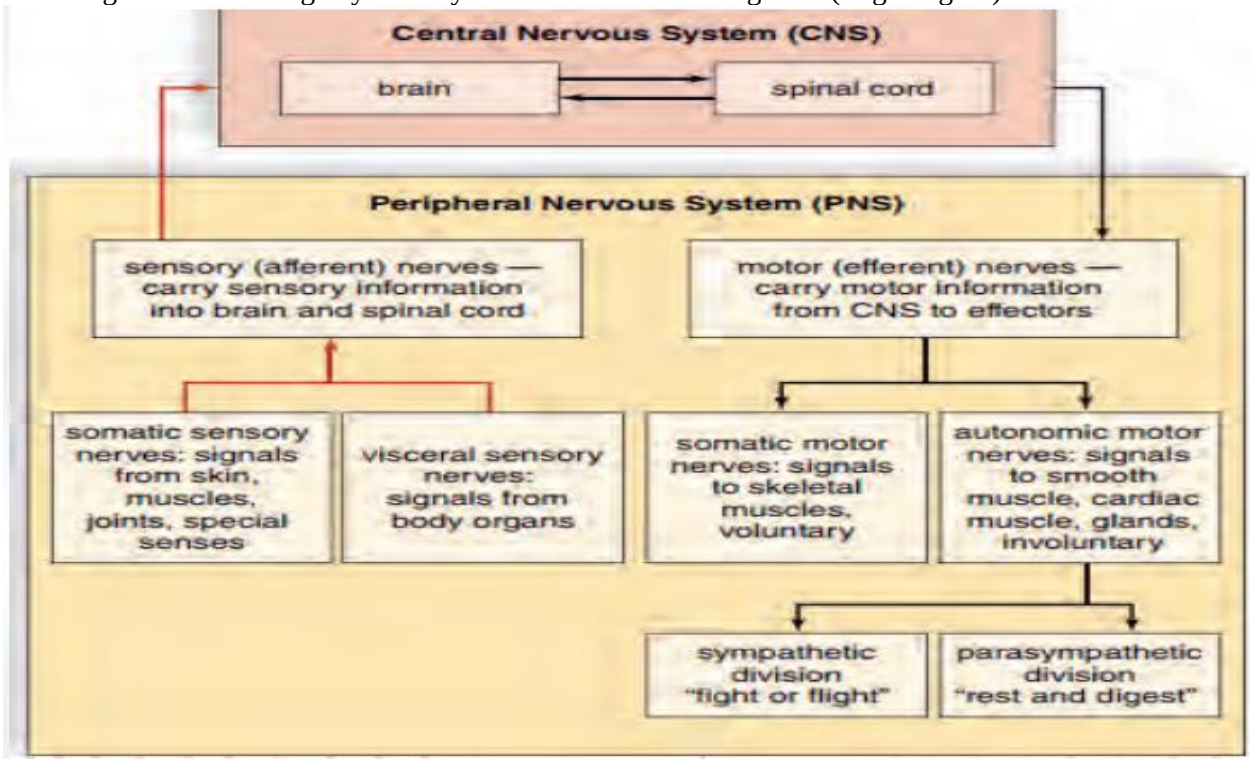
❑ Nervous system has three specific functions :-

1) Receives sensory input from sensory receptors in the skin and other organs ,in response to external and internal stimuli

• Sensory receptor generate nerve signal that travel by way of PNS to CNS

2) CNS processes and integrates the input it receives from all over the body
3) The CNS generates motor output

• Nerve signals from CNS go by the way of PNS to muscles and glands (target organs)



Neurons and their function

❑ The nervous system is composed of only two principal types of cells

1) <u>Neurons</u>:- structural and functional units of the nervous system

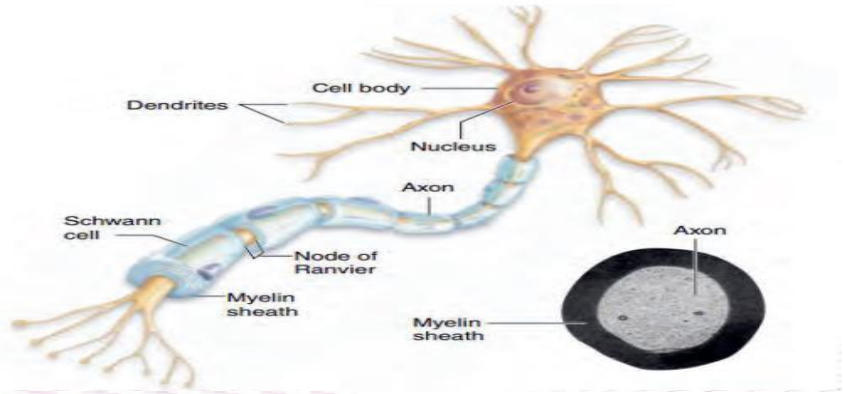
✓ basic unit of communication in the nervous system
✓ Specialized to :
• respond to chemical and physical stimuli
• Conduct electrochemical impulses and release chemical regulators
✓ Through these activities Enable :
• perception of sensory stimuli, learning, memory & control of muscle and glands
✓ A neuron consists of **cell body** ,**dendrites** and **axon**

- Dendrites and axon are referred to as **extension** or **process** from cell body

2) **Supporting cells(glial cells):-** aid the function of neurons

✓ About five times more abundant than neurons

✓ Provide support and nourishment to the neurons



Parts of a neuron

❑ **Cell body(soma) :-** core of the neuron

✓ Contains the nucleus, as well as other organelles

✓ Maintains the neuron's structure and provides energy to drive activities

✓ Most neuron cell bodies are located inside CNS and form **grey matter**

✓ Cell bodies located in the PNS are called **ganglia**

❑ **Axon :-** long process from cell body that carries nerve impulse away

✓ Each neuron has only one axon

✓ The axon branches into many **axon terminals**

✓ Axon terminals deliver the impulses to another neuron or a muscle or a gland

✓ Individual axons are termed **nerve fibers** and collectively form a **nerve**

✓ Many axons are insulated by a fatty substance called **myelin sheath**

❑ **Dendrites :-** short extensions from cell body that receive signals from other nerve at synapse

✓ Signal from dendrites result in nerve signal that is conducted by an axon

✓ Neurons have more than one dendrites , called **dendritic tree**

✓ Number of dendritic tree a neuron have depends on its role

❑ **Myelin sheath** :- fatty insulating sheath that covers axons

✓ In the PNS **Schwan cells** are wrapped in layer around the axon to form myelin sheath

✓ In the CNS **oligo dendrites** are wrapped in layer around the axon to form myelin sheath

✓ Protects and electrically insulates the neuron, speeding up impulse transmission

✓ Some nerve fibers are unmyelinated ,and This makes nerve impulse transmission slower

✓ **Nodes of Ranvier:-** periodic gap in the axon where there is no myelin sheath

- Serves to facilitate the rapid conduction of nerve impulses

Question no 1. Which of these statements correctly explains the relationship between neurons and nerves?

A. A neuron is a bundle of nerves. B . They are the same thing.

C .Neurons carry messages to the brain and nerves carry messages away from the brain.

D. A nerve is a bundle of neurons

Question no 2. Which of the following is NOT part of a nerve cell?

A. cilia B .dendrites C .cell body D .axon

Types of neuron

❑ **Functionally neurons are classified in to three:- sensory ,motor and interneuron**

1) Sensory(affecter /afferent) neurons

✓ Carry message from receptors to the CNS

✓ Typically have long dendrite and short axon

✓ Triggered by physical and chemical stimuli such as sound ,touch ,heat and light

2) Motor(effector /efferent) neurons

- ✓ Transmit message from the CNS to effectors(muscles and glands)
- ✓ Have long axon and short dendrite
- ✓ Play role in voluntary and involuntary movements
- ✓ Allow CNS to communicate with muscles, organs and glands all over the body

3)**Interneurons(association neurons)**

- ✓ Found entirely within CNS
- ✓ They pass signal from sensory to motor neuron and integrate these functions

Sequence of information flow in the nervous system

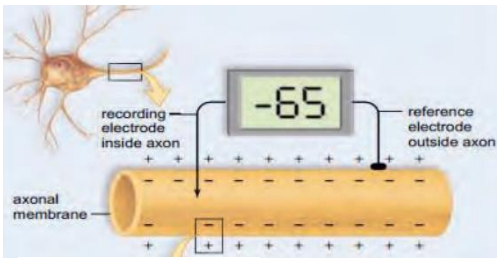
- ✓ **Nerve:-** a group of neurons(bundle of neuron) with blood vessel and connective tissue in PNS
- ✓ **Sensory(afferent) nerves:-** made up of only sensory neurons

Example -optic nerves(for vision)
-olfactory nerves(for smell)

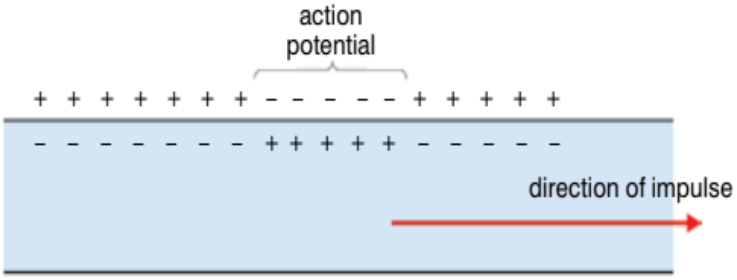
- ✓ **Motor(efferent) nerves:-** made up of only motor neurons
- autonomic nerves are motor nerves
- ✓ **Mixed nerves:-** contain both sensory and motor neurons
- Most of our peripheral nerves are mixed nerves. ex .sciatic nerve in the leg
- ✓ **Nerve tract:-** group of neuron in CNS
- Often referred to as ***white matter***. Myelin sheath gives them white color

The nerve impulse and transmission

- ✓ **Nerve impulse:-** minute electrical event that works as a result of energy differences across the membrane of the axon
- ✓ **Resting potential:-** membrane potential of the axon when not conducting an impulse(at rest)
- The voltmeter records -65mV ,indicating that the inside of the neuron is more negative than the outside
- ✓ **Action potential:-** wave of positive charge inside the axon when the neuron is stimulated



Resting potential

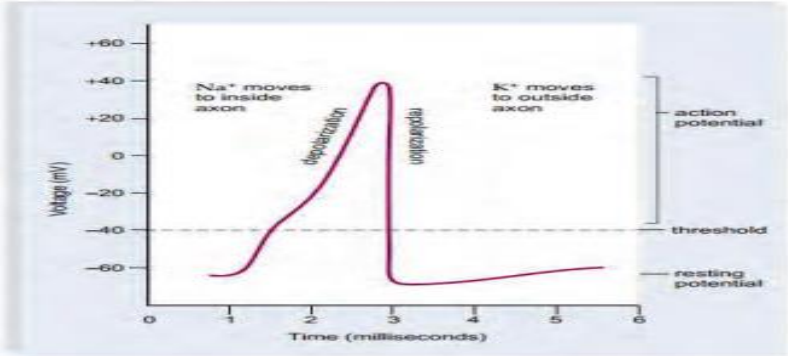


Polarization

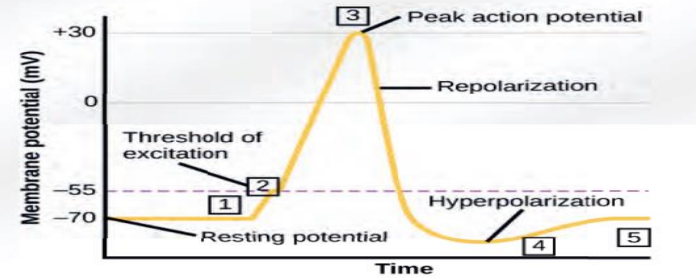
- ✓ At the resting state the inside of axon membrane is negatively charged and the outside is positively charged
- ✓ **Interstitial (outside)fluid** have high Na concentration,16 times higher than the inside
- ✓ **The axoplasm(inside)** have high K concentration ,25 times higher than the out side
- ✓ Due to difference in concentration:
- Na ions tend to diffuse into the exoplasm
- K ions tend to diffuse out of the axon
- ✓ At rest neuron membrane is more permeable to K ion than Na ion. So K leaves the neuron faster than Na enters
- ✓ Na-K pump transports 3 Na ions outside & 2 K ion inside against concentration gradient
- ❖ The difference in permeability results in accumulation of positive ion outside of neuron than inside
- ✓ **Threshold potential(-40mV)** a membrane potential created by the influx of Na ions into axon
- Influx of Na ion through Na channel changes membrane potential from -65mV(resting) to -40mV(threshold). #note this channel is not a voltage gated channel
- ✓ Threshold potential triggers the opening of voltage gated Na channel which causes the influx of Na changing membrane potential from -40mV to +40mV(peak)
- This is **depolarization** & it makes inside of the axon electropositive
- ✓ At peak potential(+40mV) Na channels close & voltage gated K channels open

- K ions diffuse out through these channels and return membrane potential back to -65mV(resting)- this is called **repolarization**

  Hyperpolarization:- increasing neuronal membrane potential to more than it resting potential
- ➢ During depolarization Na ion move to the inside of the axon
- ➢ During repolarization K ions move to the outside of the axon



B) Action potential graph



What ion enters a neuron causing depolarization of the cell membrane?

a. Sodium

b. Chloride

c. Potassium

d. phosphate

Synapses

- ✓ Whenever one neuron ends and another begins there is a gap known as a **synapse**
- ✓ Neuron-neuron synapse involves connection b/n the axon of one neuron and dendrites ,cell body or axon of the second neuron
- ✓ The axon of presynaptic neuron branches into many axon terminals which ends into slight swellings called **synaptic knob**
- ✓ **The synaptic knob** contains **synaptic vesicles** which stores **neurotransmitter** (a chemical messenger)
- The Synaptic knob comes close to ,but doesn't touch the postsynaptic neuron
- ✓ **Synaptic cleft** is the space between the presynaptic and postsynaptic neuron
- ✓ **Synaptic transmission** is a process by which the impulse in the presynaptic neuron signals the postsynaptic neurons
- Is a one way process carried out by neurotransmitters
- When an impulse reaches a synaptic knob, voltage-gated calcium channels open and calcium diffuses inward from extracellular fluid

Increased calcium concentration inside the cell causes the synaptic vesicles to fuse with cell membrane and release neurotransmitter by exocytosis

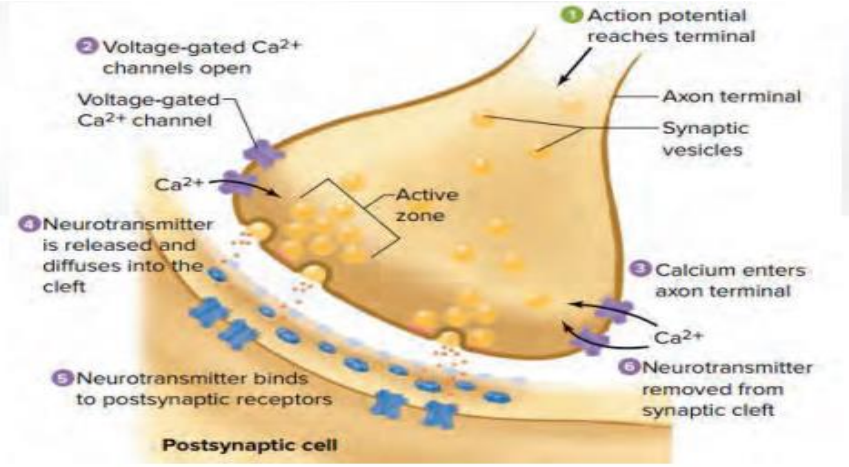


Figure 5.8 Signal transmission through a synapse.

- ❑ **Neurotransmitters** are referred to as body's chemical messenger
- ✓ Used by nervous system to transmit message between neurons or from neurons to muscle
- ▪ Acetylcholine(Ach) is an abundant neurotransmitter in the human body which is found in both CNS and PNS
- ✓ **Excitatory transmitter** –promotes the generation of action potential in the receiving neuron
- ✓ **Inhibitory transmitter** –prevents the generation of action potential in the receiving neuron

Question no 3. A nerve impulse crosses a synapse by means of (G-10 STB OLD)

A. electricity
B. vibration
C. chemical transmitters
D. light ray

Question no 4. A nerve impulse is transmitted from one neuron to another by neurotransmitter at the____

A .axon B .cell body **C .synapse** D. Myelin sheath

Question no 5. In the nervous co-ordination system, which of the following statement explains the synapse? It is a (EUEE 2015)

A .chemical that transmits nerve impulses across the nervous system
B .part of the skull that encloses brain for the purpose of protection
C .junction between two neurons or a neuron and a muscle
D .short term change in the electrical potential on the surface of cells

Types of nervous system

- ✓ Human nervous system has two main parts

1) **Central nervous system(CNS):-**made up of brain and spinal chord
2) **Peripheral nervous system(PNS):-**consists of the nerves that branch out from the brain and spinal cord –spinal & cranial nerves

A.<u>The Central Nervous System</u>

- ✓ Central nervous tissue is delicate, fragile and irreplaceable. Because of this it must be well protected
- ✓ Four major features help protect the CNS from injury:

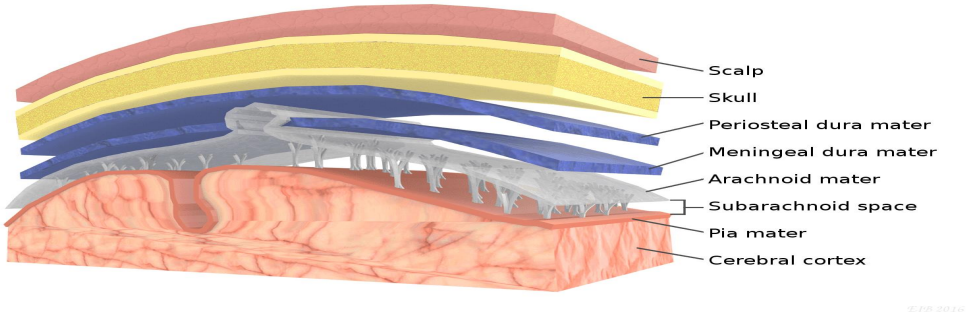
1) It is enclosed by hard, bony structures

- ▪ **Cranium(skull)** encases the brain
- ▪ **Vertebral column** surrounds the spinal cord

2) The meninges:- three protecting and nourishing membranes

- ▪ Lie between bony covering and the nervous tissue
- ▪ Meninges consists of three layer : Dura matter, Arachnoid matter and Pia matter
- ❑ **Dura matter**
- ✓ is the thickest outer most covering
- ✓ It is a <u>double layer</u> of tough ,fibrous , connective tissue
- ▪ **Periosteal layer-** the outer layer(absent in spinal cord). Is Closer to skull bone
- ▪ **Meningeal layer-** the inner layer. Is closer to brain and spinal cord
- ❑ **Arachnoid mater**

- ✓ Is delicate serous membrane
- ✓ **Subdural space-** a space between the dura matter and the arachnoid matter
- ✓ **Subarachnoid space-** a space between the arachnoid mater and the pia mater
- ▪ Contains CSF and is home for some larger blood vessels serving the brain & spinal cord
- ❑ **Pia mater**
- ✓ Is the inner most covering
- ✓ Is delicate connective tissue that adheres tightly to brain and spinal cord
- ✓ It stabilizes the spinal cord through lateral extension called denticulate ligament



The meninges

Cerebrospinal fluid(CSF)

- ✓ Brain and spinal cord floats in CSF
- ✓ It is a thin fluid similar to plasma and have several important functions:
- ▪ Acts as a cushion, supporting the weight of brain & spinal cord and protecting them from injury
- ▪ Helps to maintain a constant pressure around the brain and spinal cord

There is a limited exchange of nutrients and waste product between neurons and CSF

The brain

The brain is composed **cerebrum**, **cerebellum** and **brainstem**(medulla)

- ❑ **Cerebrum:-** also called the telencephalon
- ✓ Is the largest part of the brain and is composed of Right and Left hemispheres
- ✓ Performs higher functions like**:**
- ▪ Speech, Learning ,Reasoning & Emotions
- ▪ Fine control of movement
- ▪ Interpreting touch , vision and hearing
- ❑ **Hypothalamus**("under thalamus")
- ✓ Is the center for homeostatic control of the internal environment
- ✓ Regulates thirst ,appetite , and body temperature
- ✓ It also control sex drive
- ✓ Is an **endocrine gland** that interacts with the adjacent **pituitary gland**
- ❑ **Thalamus**
- ✓ Is superior to hypothalamus and inferior to cerebrum
- ✓ Many of its functions are concerned with **sensation**
- ✓ Third ventricle is a narrow cavity which passes through both hypothalamus and thalamus
- ❑ **Midbrain**
- ✓ Acts as a relay station for tracts passing between cerebrum and spinal cord or cerebellum
- ✓ The right side of the body is controlled by the left portion of the brain & the left side of the body is controlled by the right portion of the brain ,because the tracts cross in the midbrain
- ❑ **Cerebellum**
- ✓ Lies under the occipital lope of the cerebrum
- ✓ Separated from the brain stem by the fourth ventricle

- ✓ Is the largest part of the hind brain
- ✓ The cerebellum maintains body posture and balance
- ▪ Receive sensory input from the eyes ,ears, joints & muscles about present position of body parts
- ▪ Receive motor output from cerebral cortex about where this bodies should be located
- ▪ After integrating this information the cerebellum sends motor impulse through brain stem to skeletal muscle
- ✓ Assists the learning of new motor skills such as playing piano or hitting baseball
- ✓ New evidence suggests that the cerebellum is important in judging the passage of time

❑ **Brain stem**

- ✓ Brain stem is consists of medulla oblongata ,pons and midbrain & connects the spinal cord to the remainder of the brain
- ✓ **pons("bridge")** –contains bundles of axons travelling between cerebellum & rest of CNS
- ▪ Pons contain reflex centers for breathing and reflex centers for head movement in response to visual and auditory stimuli
- ✓ **Medulla oblongata**-lies just superior to spinal cord
- ▪ Contains reflex centers for regulating heartbeat, breathing rate and blood pressure
- ▪ Also contains reflex centers for: Vomiting , Coughing , Sneezing , Hiccupping, Swallowing

White and gray matter

- ❑ The brain and spinal cord contain gray matter and white matter
- ✓ **Gray matter :-** area that consists of unmyelinated nerve cells
- ▪ Primarily made up of cell bodies
- ✓ **White matter :-** area that consists of myelinated nerve cells
- ▪ Consists of bundled axons
- ✓ In the brain white matter forms the inner layer & grey matter forms the outer layer
- ✓ In the spinal cord white matter forms the outer layer & grey matter forms the inner layer

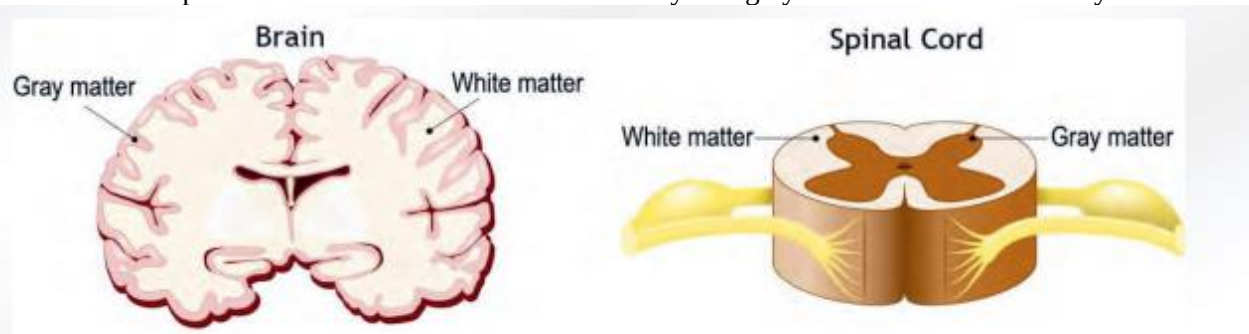


Figure 5.12 The cross-section of the CNS showing the position of grey and white matters.

The spinal cord

- ✓ Spinal cord is tubular structure composed of nervous tissue that extends from brain stem to lower thoracic/upper lumbar region

Conus medullaris:- is tampered terminal(distal) end of the spinal cord

- ✓ The spinal cord is encased and protected by the vertebrae making up the spine
- ✓ Nerves that come out of the spinal cord are known as **spinal nerves**
- ▪ They stretch to arms ,legs, trunk and to rest of the body
- ✓ In the spinal cord the gray matter is located in the middle whereas the white matter is found on the outside
- ✓ At regular interval along the spinal cord there**:**
- ▪ are entrance points for afferent nerves that bring information into CNS &
- ▪ exit points for efferent nerves carrying instructions from CNS

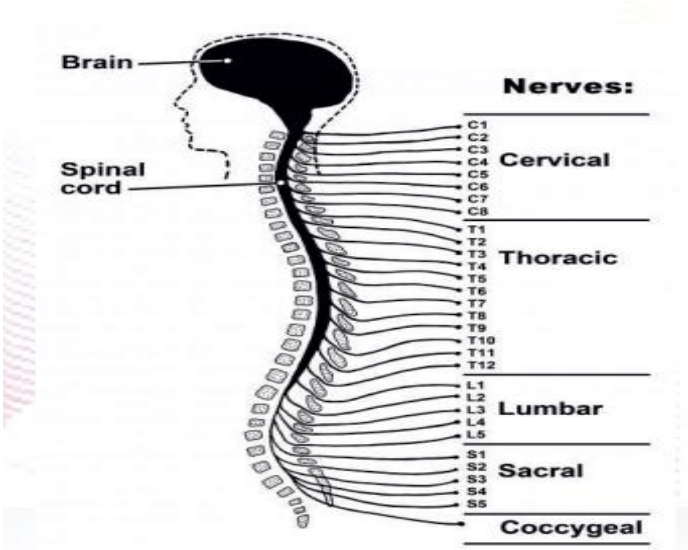


Figure 5.11 The spinal cord and spinal nerves

The peripheral nervous system

- ✓ PNS is a division of nervous system that contain all nerves that lie outside CNS
- ✓ In mammals there 31 pairs of spinal nerves and 12 pairs of cranial nerves
- ✓ The PNS is subdivided into the afferent division & the efferent division

The afferent division

- ✓ carry signals to the CNS
- ✓ Includes all neurons that transmit sensory information from their receptors

The efferent division

- ✓ carry signals from the CNS to effectors(muscles & glands)
- ✓ The efferent division is further subdivided into the somatic nervous system and the autonomic nervous system

The somatic nervous system

- ✓ is part of PNS responsible for carrying out sensory & motor information to & from the CNS
- ✓ Is responsible for transmitting sensory information as well as for voluntary movement

The autonomic nervous system(ANS)

- ✓ is part of PNS that is responsible for regulating involuntary body functions such as blood flow ,heartbeat, digestion and breathing.
- ✓ Involuntary body functions = body functions that are not under voluntary control
- ✓ This system allows these functions to take place without consciously thinking about what is happening
- ✓ The ANS is further subdivided in to sympathetic nervous system(SNS) & parasympathetic nervous system(PSNS)

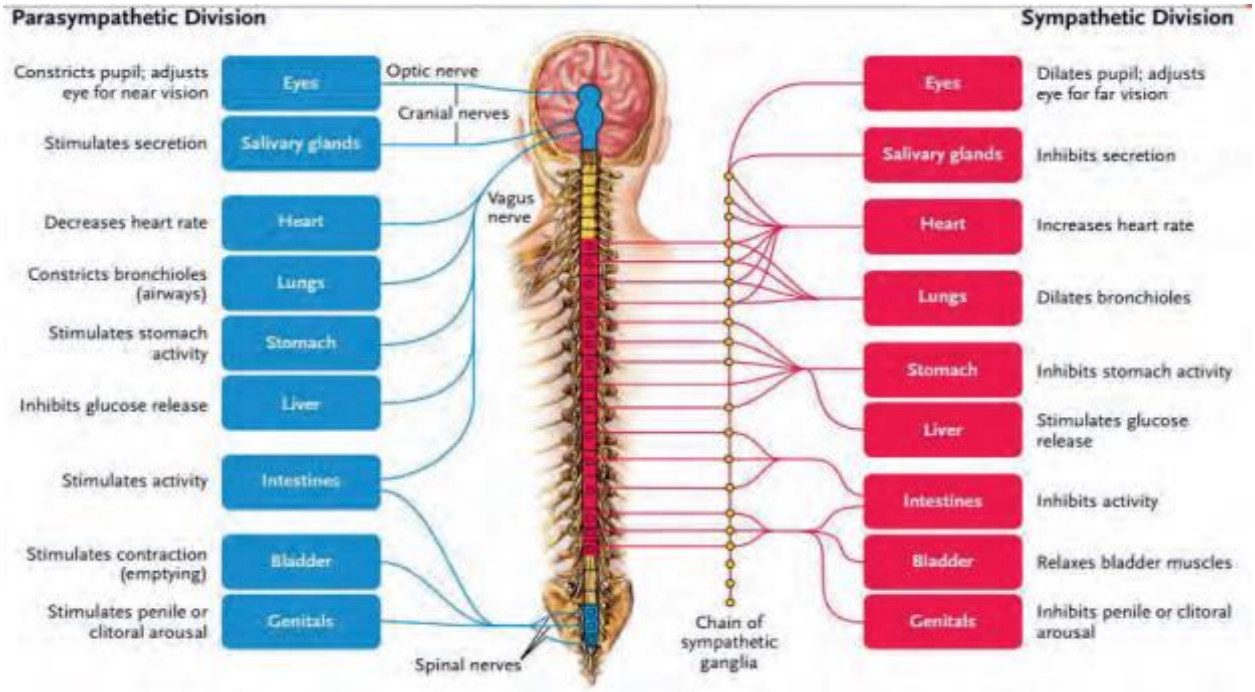
The sympathetic nervous system

- ✓ prepares the body to expend energy to respond to environmental threats by regulating "fight or flight actions" such as

- Accelerating heart rate
- Increasing breathing rate
- Boosting blood flow to muscles
- Activating sweat secretion
- Dilating the pupil

Parasympathetic nervous system

- Helps maintain the normal body function and conserves energy
- After the threat is recognized this system slows heart rate , slows breathing rate ,reduce blood flow to muscle and constricts the pupils



Reflex actions

- ✓ Reflex actions are sudden, automatic & uncontrolled response of body part or the whole body to the external stimuli
- ✓ Usually help us to avoid danger or damage
- ✓ When body is in danger it can respond to the situation without conscious thought
- ✓ This causes faster response preventing or minimizing damage to the body
- ✓ **Reflex arc** is the path that nerve impulses travel when a reflex is elicited

  There are five essential parts

  1.Receptors :- detect a change(stimuli) and generate impulses
  2.Sensosory neurons:- transmit impulses from receptors to the CNS
  3.CNS :-contains relay neurons that connect efferent& afferent neuron
  4.Motor neurons:-transmit motor output from CNS to the effectors
  5.Effector:- performs its characteristics action

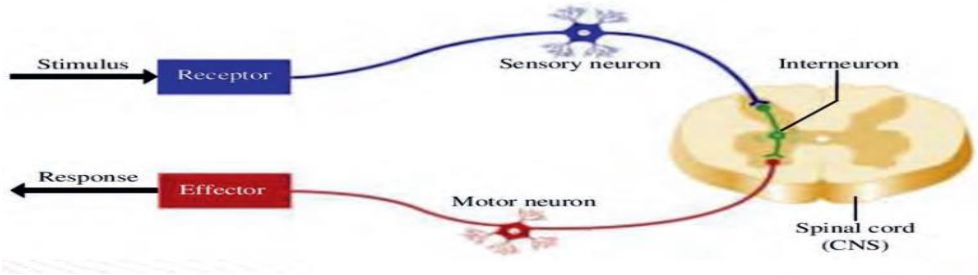
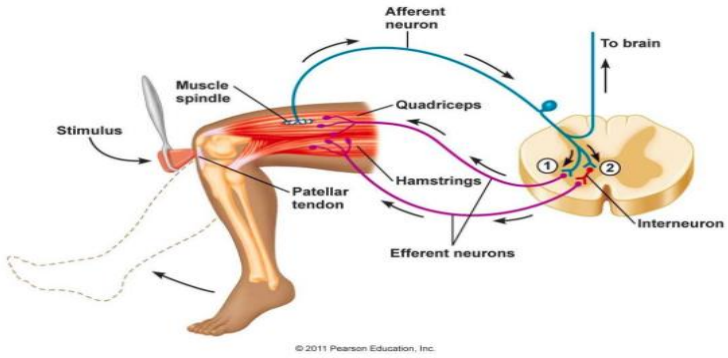


Figure 5.15 Path way for a nerve impulse in reflex action

Examples of reflex actions

Patellar(knee jerk) reflex

- ✓ In this reflex ,a tap on the patellar tendon just below the knee causes the extension of the lower leg
- ✓ This is a stretch reflex ,which means a muscle that is stretched will automatically contract
  - Knee jerk reflex helps a person stand erect



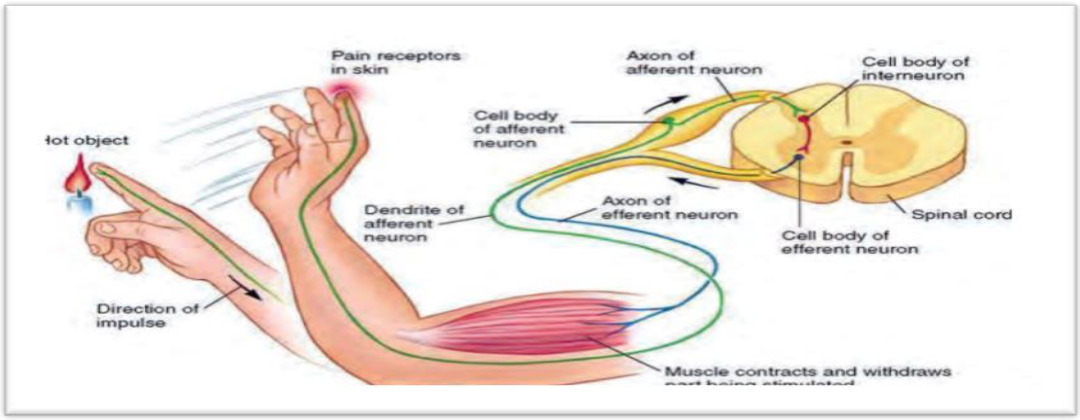


Figure 5.16 The reflex action

As shown in the above figure

- ✓ Impulses from sensory receptors in the skin pass through afferent neuron to CNS
- ▪ The efferent neuron enters the spinal cord through dorsal root
- ✓ The impulse arrives at the synapse between afferent and relay neuron & a neurotransmitter is released which causes impulse to be sent along the relay neuron
- ✓ Impulse reaches at synapse between relay and effector neuron .again another neurotransmitter is released
- ✓ This starts impulse travelling along effector neuron to the organ(effector)
- ▪ The effector neuron leaves the spinal cord though ventral root
- ✓ In this example arrive in the muscles of the upper arm causing them to contract and move the hand upward sharply
- ✓ The key point about reflex action is that the message doesn't reach the conscious area of the brain before instructions are sent out to take action
- ✓ Many reflex involve the spinal cord ,whereas others involve the brain
- ✓ They involve three types of neurons ; afferent ,efferent & relay neuron

Relay neuron (interneurons with short axon):- connect afferent & efferent neuron

Question no 6. Assume you wanted to demonstrate a simple reflex action using the knee jerk reflex. You asked a friend to sit with one leg crossed over the other. Which one of the following indicates the correct demonstration? EUEE 2014 E.C

A. Pulling down your friend's leg that is followed by downward movement
B. Hitting your friend on the toes followed by sudden upward movement of the leg
C. Bending up your friends leg followed by sudden upward movement of the leg
D.Hitting your friend below the knee cap followed by a sudden upward movement

5.2. SENSE ORGANS

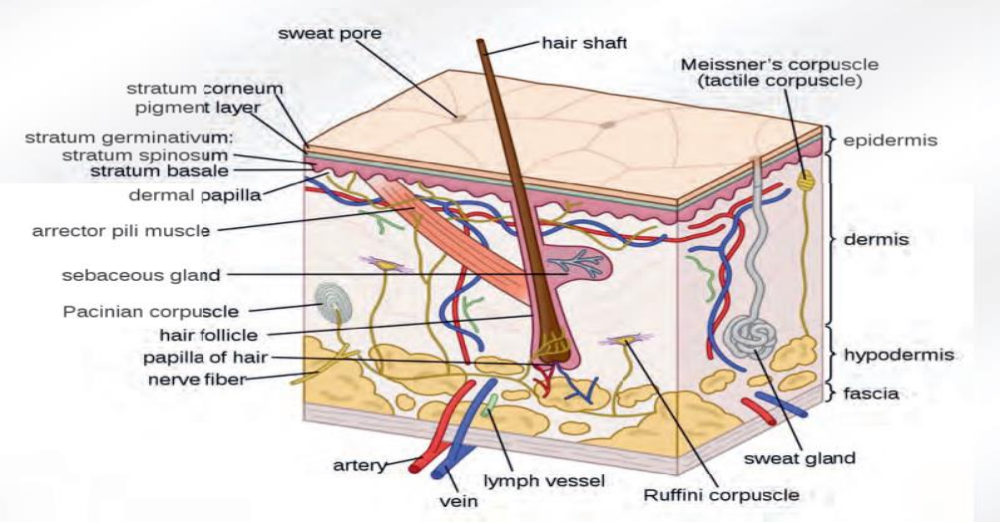
SKIN

- ❑ The human skin is the largest organ of the body in surface area and weight

The skin:

- ✓ Contains huge variety of sense receptors(touch, temperature ,pressure &pain receptors)

- It permits the sensation of touch ,heat and cold
- ✓ Forms a water proof layer around the body
- ✓ Protects against water loss by evaporation and water gain by osmosis
- ✓ protects the body from the entry of bacteria and other pathogens
- ✓ protects the body from damage by UV light
- ✓ is an excretory organ(nitrogenous wastes are lost with the sweat)
- ✓ Is vital in controlling the body temperature



- ❑ Skin has three main layers: **epidermis** ,**dermis** and **hypodermis**

1) **Epidermis**

- ✓ It is the upper layer of the skin made up dead cells
- ✓ Some important cells found in the epidermis:-
- Keratinocytes –produce keratin(a protein) which is the main component of the skin
- Melanocytes –produce a pigment called melanin
- Langerhans cells-prevent pathogens from getting into the skin

2) Dermis

- ✓ Contains connective tissue ,blood vessels ,hair follicles , sensory receptors , sweat glands and sebaceous(oil) glands
- ✓ Closely involved in temperature control in homeostasis and in sense of touch

Contains proteins (keratin & elastin) which are necessary for skin health

Collagen and elastin

- ✓ Offer support and elasticity
- ✓ Responsible for awarding of wrinkles and fine lines on the skin
- ✓ Collagen is the most plentiful protein in the skin ,making 75-80% of the skin
- ✓ Overtime environment and aging reduces the body's ability to produce collagen

3) Hypodermis **-** beneath the dermis

- ✓ Is deeper(or lower) layer made up of fat and connective tissue

Acts as :-

- ✓ Energy store and Insulator protecting against heat loss

The tongue

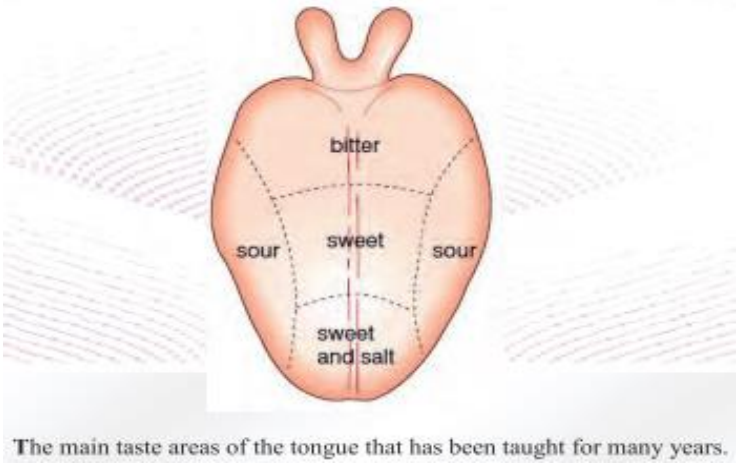
- ✓ Is muscular organ in the mouth which is covered by **mucosa**(moist pink tissue)
- ✓ Is vital organ for chewing and swallowing food , as well as for speech
- ✓ **Papillae**- tiny bumps that gives tongue its rough texture
- ✓ **Taste buds** – collection of nerve like cells that connects to nerves running into the brain
- They cover the surfaces of papillae
- ✓ Tongue is anchored in the mouth by webs of though tissue and mucosa
- Frenum:- tether holding down the front of the tongue
- On back of mouth it is anchored to hyoid bone
- ✓ Sensory receptors of taste(taste buds) are sensitive to certain chemical substances and

are located:

- On the upper surface of the tongue &
- To lesser extent on the surface of the throat

✓ There are five taste sensations **sweat** , **sour** , **bitter** , **salt** and **umami**
Umami-is a flovour in foods such as meat , cheese, broth and mushroom and is discovered recently
Distribution of taste receptors on the surface of the tongue

✓ It was thought that receptors for known five senses had their areas of greatest concentration on different parts of the tongue
✓ Currently it is known all of the five taste receptors are spread out all over the tongue



The main taste areas of the tongue that has been taught for many years.

❖ When a person speaks of taste sensation they are referring to a compound sensation produced by stimulation of both taste and smell receptors.
❖ One reason why hot foods often have more 'taste' than cold foods is because they vaporise more.
❖ The reason why you cannot 'taste' foods well when suffering from a cold is that, with your nasal passages inflamed and coated with mucus, your smell receptors cannot work

Question no 7. Which is the most recently discovered sense of taste?

A. Sweat B. Bitter C. Sour **D. Umami**

The nose

✓ The human nose is a sense organ of smell
- Smell = olfaction , sensory receptor of smell = olfactory receptor

✓ Olfactory receptors are located on the upper surface of the nasal cavity
- They are sensitive to solutions of certain chemical substances

Functions of the nose

✓ One of the important means by which the environment communicates with us through olfaction
✓ Allow the passage of air for respiration
✓ Conditions the inhaled air by making it humid and warm
✓ Filters the inhaled air . Hairs inside the nose prevent large particles from entering the lung

How do you smell ?

✓ In order to be detected by smell or taste receptors chemicals must go into solutions in the form of liquid which coats the receptors

The main difference between smell and taste receptors

✓ Smell receptors are specialized for detecting vapors coming to organism from distant source
✓ Taste receptors are specialized for detection of chemicals present in the mouth
✓ Smell receptors are much more sensitive than taste receptors

The eye

✓ Eye functions as a sensory organ of vision
✓ It transmits visual stimuli to the brain for interpretation

External structures of the eye

✓ **Eye brows** – protect the eye by preventing perspiration from running down the forehead ,causing irritation
- Helps shade the eyes from direct sunlight

- ✓ **Eye lids** (upper & lower) – are two movable structures composed of skin and two types of muscle(striated & smooth)

  Functions of eyelid
- Protect the eye from foreign bodies
- Limit the amount of light entering the eye
- Serve to distribute tears that lubricate the surface of the eye
- The eyelid join at two points

1. The lateral(outer) canthus
2. The medial(inner) canthus

   The medial canthus contains

   Puncta-a small opening that allow the drainage of tear

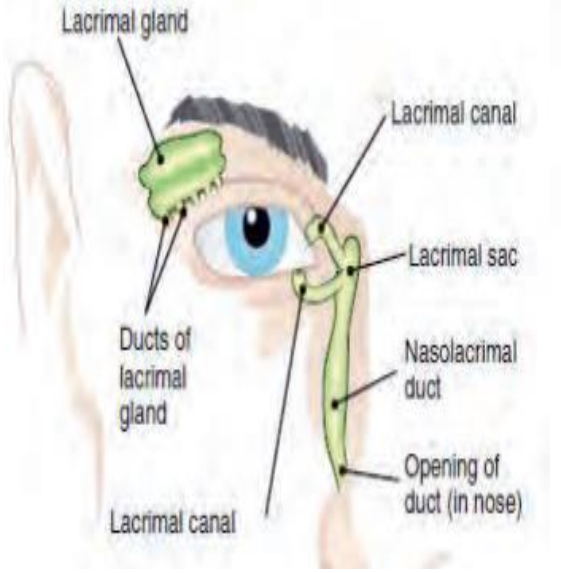
   Caruncle – small fleshy mass that contain sebaceous glands
- When closed the eyelids should touch
- When open the upper lid position should be between the upper margin of iris and the upper margin of pupil

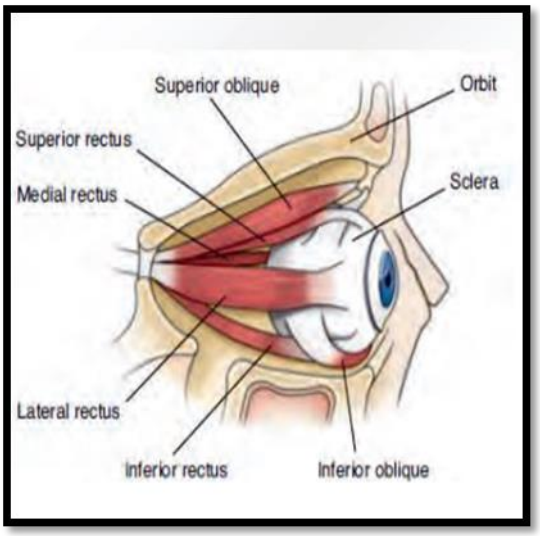
- ✓ **Eyelash** – projection of stiff hair curving outward along the margin of the eyelids
- It filters dust and dirt from air entering the eye
- ✓ **Conjunctiva** – thin transparent continuous membrane

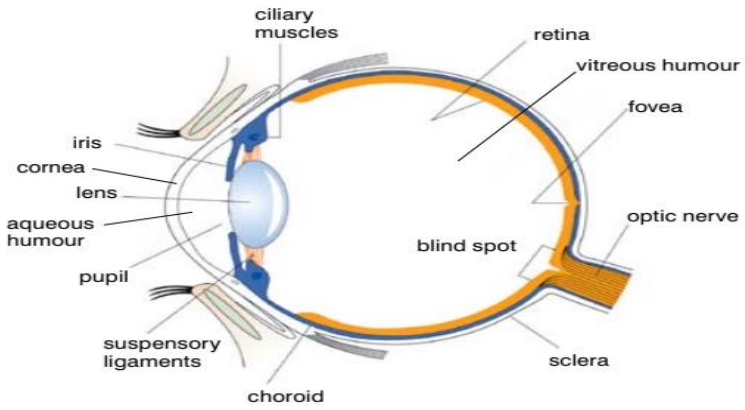
  Divided into two portions

  1.Palpebral portion – lines inside of the eyelids

  2.Bulbar portion – covers most of the anterior of the eye







Internal structures of the eye

- ✓ Eyeball is composed of three separate coats or layers

1) The external(protective) layer
2) The middle(nourishment) layer

3) The inner most (photosensitive) layer

1. **The external layer** consists of sclera and cornea

Sclera – though opaque tissue that serves as eye's outer protective layer

- It is continuous anteriorly with cornea

Cornea("window of the eye")

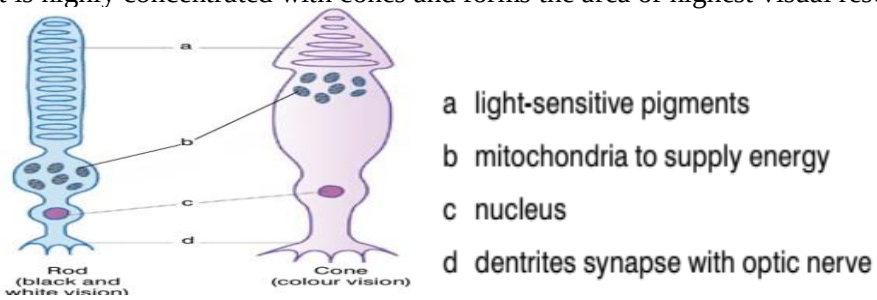
- Transparent structure over front of the eye that allow the light to enter

2. **The middle layer** – choroid

- Contain the vascularity(blood vessels) necessary to provide nourishment to the inner part of the eye
- It also prevents light from reflecting internally
- Is continuous anteriorly with ciliary body and iris

3. The innermost layer – retina

- ✓ A light sensitive tissue lining the inner surface of the eye
- ✓ It receives visual stimuli and sends it to the brain
- ✓ The retina consists of numerous layer of nerve cells including **rods** and **cons**(specialized nerve cells)
- ✓ Rods and cons are also referred to as **photoreceptors** because they are responsive to light
- ✓ **Rods**- perceive light and movement and work well in **dim light**
- They regulate black and white vision
- ✓ **Cones**- perceive light and movement and only work in **bright light**
- Are sensitive to color
- ✓ **Optic disc(blind spot)-**circular area on the retina where the optic nerve enters the eyeball
- At the point when optic nerve leaves the eye there is no retina , but a blind spot
- ✓ **Fovea centralis** –is retinal depression located adjacent to blind spot
- It is highly concentrated with cones and forms the area of highest visual resolution and color vision



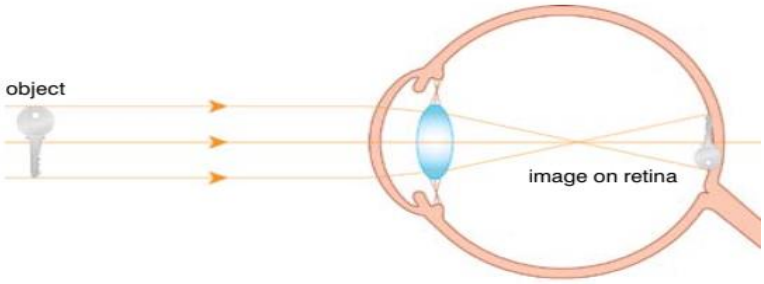
- ✓ **Iris**-is the colored part of the eye
- Is made up muscles that contract and relax to control the size of pupil which controls the amount light reaching the retina
- Circular muscles run around the iris whereas the radial muscles run across the iris like the spokes of bicycle wheal

<u>In dim light</u>

- ✓ Radial muscles contract and circular muscles relax
- ✓ The pupil dilates (becomes wider) and a lot f light gets into the eye. This enables as to see in low light conditions

<u>In bright light</u>

- ✓ radial muscles relax and Circular muscles contact
- ✓ The pupil constricts (becomes narrower). This reduce the amount light that goes into the eye, so that the delicate light sensitive cells are not damaged
- ✓ **Lens** –is biconvex , transparent ,avascular , encapsulated structure located immediately posterior to the iris
- Suspensory ligament attached to ciliary muscle supports position of the lens
- Lens functions to refract(bend) light rays on to the retina
- ✓ Adjustment is made on refraction depending on the of the object being viewed
- The lens bulges(become more convex) to focus on close objects and
- Flattens(elongates) to focus on far objects



- ✓ The eye ball contains several champers that maintain structure , protect against injury and transmit light rays
- ▪ **Anterior chamber-** located between cornea and iris
- ▪ **Posterior chamber-** located between iris and lens
- ▪ These two chambers are filled with **aqueous humor**
- ✓ **Aqueous humor** – is a clear liquid produced by ciliary body
  It helps
- ▪ cleanse and nourish cornea and lens
- ▪ Maintain intraocular pressure
- ✓ **Vitreous chamber** –area between lens and retina
- ▪ It is the largest chamber and is filled with clear and gelatinous **vitreous humor**

Question no 7. Which one of the following eye structure is correctly matched with its function? 2015 EUEE

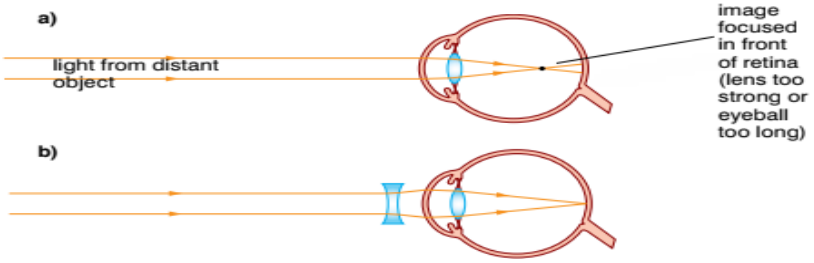
A. Pupil- serves as eye's protective outer layer
B. Iris – controls the amount light entering the eye
C. Cornea – provide nutrition for the retina
D. Choroid – bends the light in to the eyes

Question no 8. During image formation, light is refracted twice before it is focused on the retina
This phenomenon happens at the: 2014 EUEE

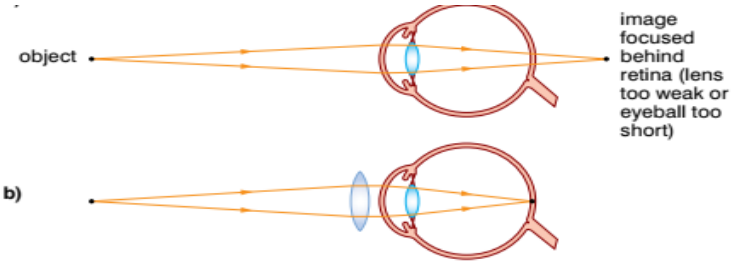
A. Aqueous humour and lens
B. Lens and vitreous humour
C. Iris and lens
D. Cornea and lens

<u>Common eye defects</u>

- ✓ A lens is a piece of transparent material (usually glass or plastic) that has one or more curved surfaces.
- ✓ an outward curve makes a **convex** lens and this will bend the light rays towards each other (a **converging** lens).
- ✓ An inward curve makes a **concave** lens and this will spread the light rays out (a diverging lens)
- ✓ **Short sight** : a short-sighted person can focus clearly on things that are close to them but has much more difficulty with objects in the distance, which appear blurred.
- ▪ **Cause** : too strong(too curved) lens or long eye ball
- ▪ The image is focused in front of the retina
  This problem can be corrected using concave (diverging) lenses that spread the light out more before it gets into your eye



- ✓ **Long sight** : a long-sighted person can focus clearly on things that are at a distance but has much more difficulty with objects close to them, which appear blurred
- ▪ **Cause**: too weak(too flat) lens or short eye ball
- ▪ The image is focused behind the retina
- ▪ This problem can be corrected using **convex (converging) lenses** that bring the light rays together more before they reach your eye



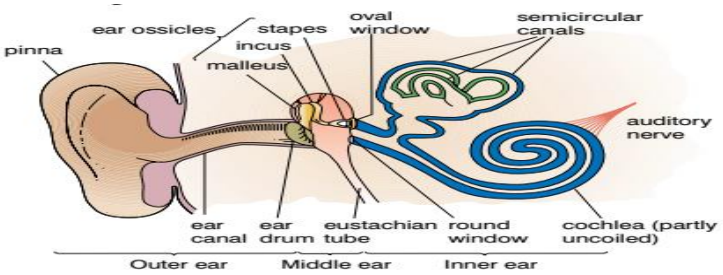
Question no 9. Short sightedness is corrected by a concave lens because the problem arises from
2014 EUEE

A. Weak eye lens that converges light slightly
B. Powerful eye lens that diverges light
C. Weak eye lens that diverges light
D. Strong eye lens that converges light too soon

Question no 10. Imagine you have been out on the beach looking at some friends at the sea .you walk into the shade of palm tree and begin to read a book. What changes would take place in your eyes ?

A. Your pupil would constrict ,your lens becomes flatter & less convex
B. Your pupil would constrict , your lenses would become rounder and more convex
C. Your pupil would dilate , your lens would become flatter and less convex
D. Your pupil would dilate , your lens would become rounder and more convex

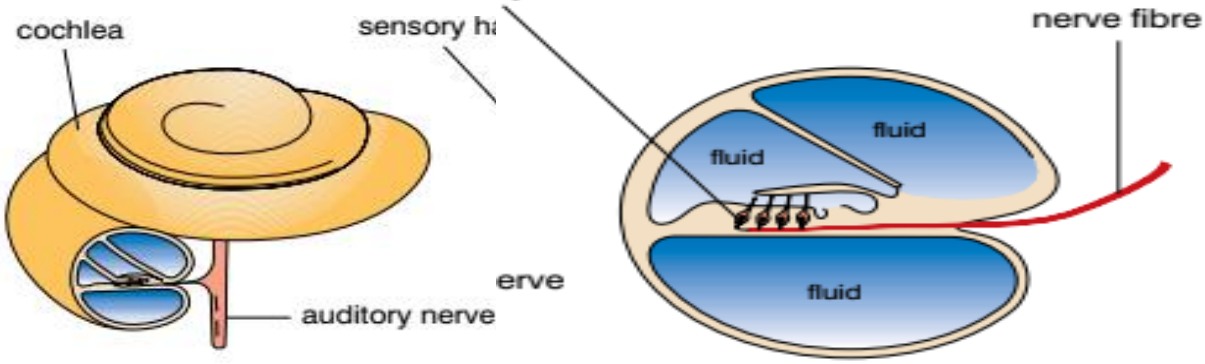
The ear



- ✓ a specialised organs which enable you to hear sound.
- ✓ also concerned with the balance and position of the body
- ✓ The ear is divided into three regions: the **outer ear**, **middle ear** and **inner ear**.
- ➢ **The outer ear** consists of **pinna, ear canal** and **the eardrum**
  - **pinna** helps to trap and funnel sound into the ear.
  - **ear canal** is a tube Leading from the pinna to the eardrum
  - **Eardrum(**tympanum) a sheet of very thin membrane at the end of the ear canal that closes the tube.
  - At the entrance of the ear canal are a number of small hairs. These filter out dust particles from the air entering the ear canal
  - The cells lining the ear canal produce waxy material which traps dust and germs, and lubricates the eardrum.
- ➢ **The middle ear** is an air filled cavity behind the eardrum
  - It contains three tiny bones – called the **malleus** (**hammer**), the **incus** (**anvil**) and the **stapes** (**stirrup**) because of their shape – are the smallest bones in your body
  - They form joints with one another, with the malleus attached to the eardrum and the stapes to the oval window
  - Eustachian tube connects the middle ear with the throat
  - This is usually closed but when the pressure in the middle ear increases – when you are flying, the tube opens until the air pressure in the middle ear is equal to that in the throat and therefore to the atmosphere.
  - At one end of the middle ear, opposite to the eardrum, there are two openings: the oval window and the round window which are covered by a membrane
- ➢ **The inner ear** consists of a cavity filled with a fluid
  - two sac-like structures called the **sacculus** and **utriculus**
  - three **semicircular canals** and
  - a coiled tube called the **cochlea**
    - A cross section of the cochlea reveals that it is made up of three tubes in one

- The floor of the middle tube is lined with sensory cells linked to affector neurons.

These nerve fibers join to form the auditory nerve which leads to the brain.



Mechanism of hearing

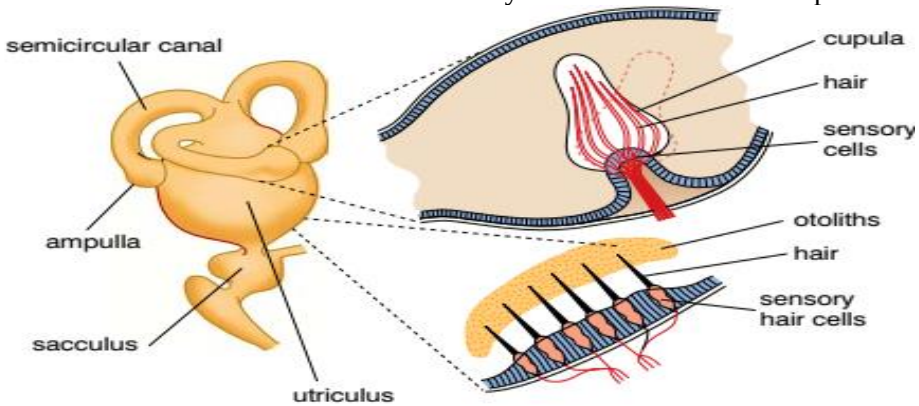
- ✓ The pinna collects sound waves and directs them to the eardrum through the ear canal
- ✓ sound waves hit the eardrum and causes it to vibrate
- ✓ The vibration then transmitted through the ear ossicles to the oval window
- ▪ both eardrum and ossicles amplify the vibrations(make them bigger)
- ✓ The vibrations of the stapes make the membrane at the oval window vibrate
- ✓ The vibrations of the oval window are transmitted to the fluid and then spread to the cochlea
- ✓ Vibrations of the fluid cause the hair-like sensory cells to move.
- ✓ These movements in turn cause production of nerve impulses in the affector nerve fibers.(auditory nerve)
- ✓ These impulses are transmitted to the brain for interpretation
- ❖ The human ear is sensitive to vibrations ranging from those of a very low note of about 20 vibrations per second, to a very high note of about 30 000 vibrations per second.

High notes are detected in the first part of the cochlea and low notes are recorded in the last part of the cochlea.

The senses of balance and movement

- ✓ The semicircular canals in your inner ear are concerned with the detection of motion
- ✓ **Ampullae** is a swellings on the semicircular canals that contains sensory cells attached to sensory nerve endings.
- ✓ The sensory cells have hairs which are enclosed in a core of **cupula** (a jelly substance)
- ✓ Whenever the body or the head moves, the semicircular canals move with the head. The fluid in the semicircular canals also starts to move but it lags behind in its motion and so it apparently moves in the opposite direction.
- ✓ The moving fluid causes the cupula to tilt, thus pressing the hairs of the sensory cells.
- ✓ The pressing of the sensory hairs creates nerve impulses in the sensory nerve endings and the nerve impulses are transmitted to the brain.
- ✓ The brain then interprets the direction and speed of motion of the body or head.
- If you spin round and round fast and then stop, you will feel dizzy. This is because the fluid in your semicircular canals keeps on moving after you have stopped. Your ears are telling your brain that you are moving round, but your eyes and other senses are saying you are standing still – and these mixed messages result in <u>the dizzy sensation</u>

The utriculus and sacculus are concerned with your sense of balance and posture.



Question no 11. Which is the correct order of the bones in the middle ear, from eardrum inwards ?

A. Hammer ,anvil, stirrup
B. Anvil , hammer , stirrup
C. Stirrup , hammer , anvil
D. None of these

Question no 12. Which one of the following correctly traces the transmission of sound from the external environment to the nerves that carry the signal to the brain to be interpreted ?

A. Cochlea , tympanic membrane , ossicles , pinna , external auditory meatus
B. pinna , external auditory meatus , tympanic membrane , ossicles, Cochlea
C. tympanic membrane , Cochlea, ossicles , pinna , external auditory meatus
D. external auditory meatus, pinna , tympanic membrane , ossicles , Cochlea

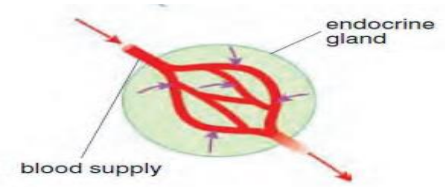
5.3. The endocrine system

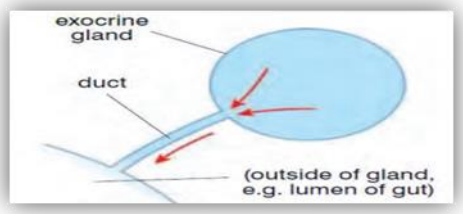
- A gland is an organ in the body that secretes substances such as hormones and other useful substances. Ex. enzymes
- There are two types of glands : **endocrine glands** and **exocrine glands**
- ✓ **Exocrine glands:-** release their secretion through a duct or a tube
  - Example sweat glands ,salivary glands , pancreas , sebaceous and mammary glands
- ✓ **Endocrine glands:-** are also known as ductless glands
  - They secrete hormone directly in to blood stream and the blood carries the hormone to all cells of the body
  - Hormones act as chemical messenger that are produced in one part of the body , but have an effect somewhere different
  - Most hormones affect only certain tissues or organs(their target organ)
  - The hormone is picked up from blood by receptors on cell membranes of target organ cells

Examples of endocrine glands

Hypothalamus, pituitary ,thyroid , adrenal glands , gonads , pancreas

- ❖ **Note :** pancreas is both an endocrine and exocrine gland
- ✓ Endocrine because it releases hormones(insulin and glucagon) directly to blood which act on target organs such as liver , adipose tissue and muscles
- ✓ Exocrine because it releases digestive enzymes(pancreatic lipase ,amylase ..) into small intestine through pancreatic duct
  - **Islets of Langerhans** produce insulin and glucagon
  - **Acinar** cells produce digestive enzymes





The major endocrine glands

Hypothalamus

- It connects the nervous system to endocrine system
- It receives and process signals form other brain regions and translates them into hormones
- These hormones flow to the **pituitary gland** by the infundibulum
- ✓ Some hormones are stored in the **posterior pituitary** for later use
  - These are **oxytocin** and **ADH**(antidiuretic hormone)
- ✓ Some hormones activate **the anterior pituitary** to release its own hormones
  - These are called releasing hormones
- ✓ Some hormones inhibit the **anterior pituitary** and prevent the release of anterior pituitary hormones
  - These are called inhibiting hormones

Pituitary gland

- ❑ Pituitary is about the size of a pea and found in the brain
- ❑ Because of its location in the brain it is involved in the coordination between the nervous and hormonal system
- ❑ Is sometimes described as the **'master gland** ' ,because hormones released from pituitary controls the secretion of hormones from other glands
- ❑ Pituitary is divided in to two lobes: **Anterior lobe** and **Posterior lobe**
- ✓ Anterior lobe is 3 times larger than the posterior lobe

Anterior lobe

- ❑ Also known as adenohypophysis
- ❑ Anterior lobe makes 6 peptide hormones whose secretion is regulated by hypothalamus
- ❑ Hypothalamus makes releasing hormones which encourage secretion of anterior pituitary hormones
- ❑ Hypothalamus also makes inhibiting hormones that slows secretion of anterior pituitary hormones
- ❑ The hormones of anterior pituitary play major role in the control of metabolic function through out the body
- ❑ Anterior pituitary hormones include **GH**, **ACTH**, **TSH**, **Prolactine** and **gonadotropins**(**FSH** & **LH**)

Growth hormone(GH)

- ❑ Promotes the growth of the entire body by affecting:
- ✓ Protein formation
- ✓ Cell multiplication
- ✓ Cell differentiation
- ❑ Its quantity is greatest during childhood and adolescence when most body growth occurs
- ❑ **Pituitary dwarfism** – small stature
- ✓ Occurs if little GH is produced during childhood
- ❑ **Gigantism** – excessive growth and height
- ✓ Occurs if too much GH is produced during childhood
- ✓ Individuals with gigantism often have diabetic mellitus ,because GH has secondary effect on blood glucose level
- ❑ **Acromegaly**
- ✓ Occurs if GH is overproduced in adult
- ✓ Only face , feel and face becomes large because these portions of the body can respond to GH , but large bones are not responsive to GH in adults

Adrenocorticotropic hormone (ACTH) – Corticotropin

- ❑ Control the secretion of some of the adrenocortical hormones which affect metabolism of glucose , protein and fat
- ❑ So ACTH acts on adrenal glands

Thyroid stimulating hormone(TSH) – thyrotropin

- ❑ Control the secretion rate of thyroxine and triiodothyronine from thyroid glands
- ❑ Thyroid hormones control the rate of most intracellular chemical reactions in the body
- ❑ So TSH acts on the thyroid glands

Prolactin

- ❑ Stimulates milk production in women's breast after she gives birth
- ❑ So prolactin acts on mammary glands of breast

Gonadotropins- FSH & LH – follicle stimulating hormone and luteinizing hormone

- ❑ Control growth of ovaries and testes as well as reproductive activities

Question no. 13. Which of the following endocrine gland secretes a hormone that directly affects the metabolic rate of the body? Text new

A. Pituitary gland
B. Ovary
C. Thyroid
D. Pancreas

Question no 14. Which of the following reproductive hormone is produced by the pituitary gland ?

A. Estrogen
B. Testosterone
C. Follicle stimulating hormone
D. Progesterone

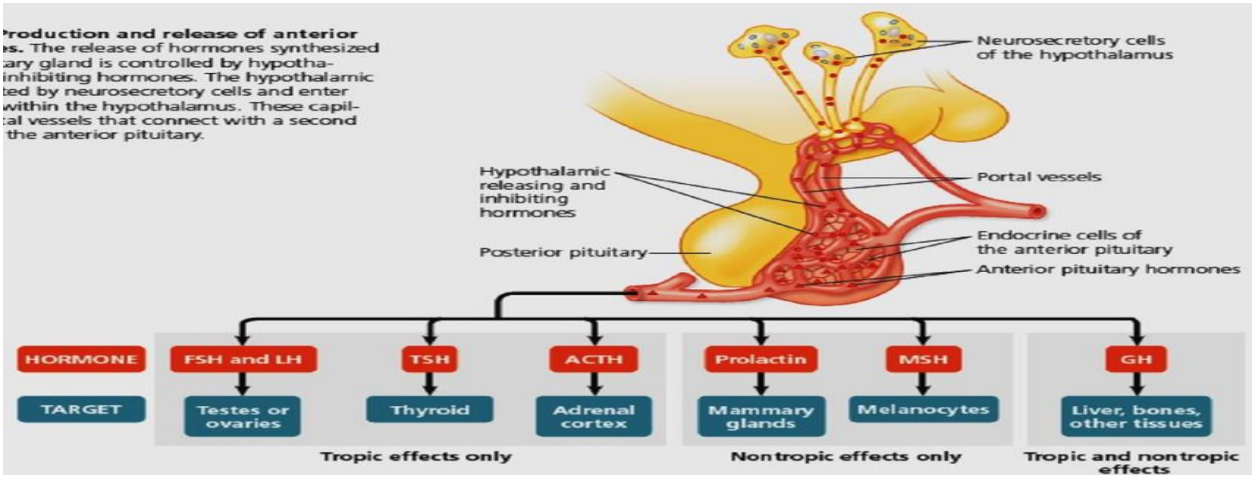


Figure 5.37 hormones secreted by anterior pituitary gland

Posterior pituitary

- ❑ Stores hormones which are produced by hypothalamus & releases when needed
- ✓ These hormones are **Antidiuretic hormone(ADH)** and **oxytocin**

ADH – also called vasopressin

- ❑ Controls the rate of water excretion in the urine
- ❑ It helps the control of water concentration in the body fluid
- ❑ When the amount of water in the body decreases ADH causes the water to be reabsorbed back from kidney tubules to blood

Oxytocin

- ❑ Helps express(eject) milk from glands of breast to nipples

Also helps the delivery of baby by the end of gestation

Thyroid gland – thyros =‘butterfly ‘

- ❑ Is a small butterfly shaped gland located inferior to larynx(voice box) attached to trachea
- ❑ It is subdivided into two lateral lobes
- ❑ It produces **thyroid hormones**(**T3**, **T4**) and **calcitonin**

Calcitonin

- ❑ lowers blood calcium and phosphate
- ❑ Both hypo and hypersecretion of calcitonin affects normal balance of calcium and phosphate

thyroid hormones*(T3, T4)*

- ❑ Thyroid follicles produce thyroglobulin(TGB) by utilizing iodine
- ❑ TBG is then stored in the colloid
- ❑ When stimulated by TSH, thyroid follicles convert TGB into thyroid hormones
- ❑ Thyroid hormones are thyroxine(T3) & triiodothyronine(T4)
- ❑ This hormones promote normal metabolism and control the rate of most intracellular chemical reactions

Malfunctions of thyroid gland

- ❑ Hypo secretion of thyroid hormone causes hypothyroidism which results in goiter, cretinism and myxedema
- ❑ Hypothyroidism in childhood and infancy can cause cretinism

Cretinism

- ❑ condition characterized by retarded mental & physical development
- ✓ When diagnosed early it can be treated with thyroid hormone & prevented
- ✓ Adults suffering from hypothyroidism shows the following signs
- ▪ Feels like sleeping all the time
- ▪ Has little energy
- ▪ Is mentally slow and confused

Goiter – is an enlargement of thyroid gland

- ✓ It can be caused by hypothyroidism
- ✓ Decreased level of iodine in the body caused hypothyroidism ,because thyroid hormones are made from iodine

- ✓ Decreased T3 & T4 causes the pituitary to release high amount of TSH
- ✓ High level TSH stimulates thyroid gland whose cells enlarge to produce more thyroid hormone. Without iodine the gland keeps getting bigger and bigger
- ✓ Hyper secretion of thyroid hormone causes hyperthyroidism which results in **graves' disease**

Parathyroid glands

- ❑ Are four oval shaped glands at the back of thyroid gland
- ❑ They secrete PTH which controls the calcium level in the blood stream
- ❑ PTH acts on the kidney , intestine and bones to increase calcium level in the blood

How ?

- ✓ In kidney –PTH stimulates calcium reabsorption from filtrate into blood and causes vit –D activation which promotes calcium absorption from intestines
- ✓ In bone – PTH causes calcium release into blood
- ✓ In intestines – active vit-D increase calcium absorption from food into bloodstream
- ▪ All the above activities causes calcium level in the blood to increase
- ▪ Calcium is important the body especially for muscle and nerve
- ❑ Hypo secretion of PTH causes **tetany** –involuntary muscle contraction
- ❑ Hypersecretion of PTH causes **osteitis fibrosa cystica**

Adrenal glands

- ❑ Also called suprarenal glands
- ❑ Are triangular shapes glands located on top o each kidney
- ❑ Are composed of two parts : cortex and medulla

Adrenal cortex

- ❑ is the outer portion of the adrenal gland
- ❑ Is divided in two three regions from outside to inside zona glomerulosa , zona fasciculate and zona reticularis
- ❑ Adrenal cortex produces steroid hormones crucial for normal homeostasis

Adrenal medulla

- ❑ Is the outer portion of the adrenal gland
- ❑ Is made up of modified nerve cells(Chromaffin cells) which produce epinephrine(adrenalin) and norepinephrine(noradrenalin)
- ❑ Adrenalin is fight or flight hormone
- ❑ If you are stressed , angry ,exited or frightened adrenal glands release adrenalin which causes pupil dilation ,increased heart beat(fight or flight action)

Pancreas

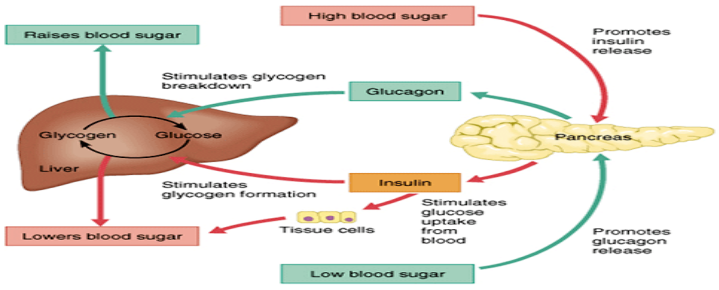
- ❑ Is a small pink organ found bellow the stomach
- ❑ It is both exocrine and endocrine organ

Acini(exocrine aspect)

- ❑ Makes 99% of mass of the gland
- ❑ Release digestive enzymes and fluid in to small intestine through pancreatic duct

Islets of Langerhans (endocrine aspect)

- ❑ makes 1% of mass of the gland
- ❑ Secrete hormones to regulate blood glucose level
- ❑ **Alpha cells** secrete **glucagon** which increases blood glucose level
- ❑ **Beta cells** secrete **insulin** which decreases blood glucose level
- ❑ **Delta cells** release **GHIH(growth hormone inhibiting hormone)(somatostation)** which inhibits glucagon release



- ❑ Insulin decrease blood glucose level when its concentration increases above normal

It does this by:

- ✓ Increasing the conversion of glucose in to glycogen & deposition in liver and muscle
- ✓ Increasing rate of conversion of glucose into fat and its deposition in adipose tissue
- ✓ Also regulate the rate at which amino acids are catabolized into H2O and C2O

Diabetes mellitus

- ❑ a condition characterized by blood sugar level
- ❑ **Type 1 Diabetes -** pancreas can no longer produce insulin
- ✓ Can be caused by autoimmune which targets beta cells of the pancreas
- ❑ **Type 2 Diabetes -** is due to insulin resistance
- ✓ That means the pancreas can synthesize insulin but the target cells do not respond to insulin

Can be caused by obesity, overeating and lack of exercise

Insulin resistance can be corrected by:

- ✓ Decreasing caloric intake(dietary control)
- ✓ Regular exercise

Glucagon

- ❑ Has opposite effect to insulin. It increase blood glucose level
- ❑ Production and secretion of glucagon are stimulated by:
- ✓ decreased blood glucose concentration
- ✓ Elevated blood level of amino acid
- ✓ Exercise

Glucagon is important to maintain normal blood glucose level, especially as the neurons(brain) can only use glucose for fuel

Glucagon increases blood glucose level by:

- ✓ stimulating breakdown of glycogen stored in the liver
- ✓ Stimulating gluconeogenesis(creating glucose from non-carbohydrate substance)
- ✓ Enhancing triglyceride breakdown , thus providing fatty acid as a fuel for most cells and sparing glucose for neurons(brain cells)

The Gonads: Ovaries and Testis

- ❑ The gonads are the endocrine glands which produces some of the sex hormones
- ❑ They become active at the time of puberty.
- ❑ During puberty big physical changes takes place, boys and girls look very different(their body takes its adult form)
- ❑ The changes come about in response to hormone released by the brain(FSH, LH) and by the gonads themselves(progesterone ,estrogen)

The role of the ovaries

- ❑ Ovaries are two walnut-sized organs found low I the abdomen in either side of the uterus
- ❑ Ovaries produce eggs and hormones.
- ❑ Girls often go into puberty slightly earlier than boys, between the age of **8-14**
- ❑ Puberty in girls controlled by hormones in the ***pituitary*** and from the ***ovaries***
- ❑ ***FSH*** from the brain stimulates the ovaries to become active and start producing hormones

Estrogen

- ❑ The hormones produced by ovaries are:- ***estrogen*** and ***progesterone***
- ❑ Secreted by the follicle cells of the ovary
- ❑ Its secretion is stimulated by FSH from anterior pituitary
- ❑ Promote the maturation of the ovum in the ovarian follicle
- ❑ Stimulates the growth of blood vessels in the ***endometrium*** (lining) of the uterus in preparation for a possible fertilized egg
- ❑ The 2dry sex chxcs in Women also develop in response to estrogen
- ❑ Female **secondary sexual characteristics** include:
- ❑ growth of the duct system of the mammary glands
- ❑ growth of the uterus
- ❑ the deposition of fat subcutaneously in the hips and thighs

- **Progesterone**
- Progesterone is secreted by **corpus luteum (**which also secretes estrogen**)**
- This is stimulated by **LH** from the anterior pituitary
- mature ovarian follicle becomes **corpus luteum** after it releases the ovum
- Progesterone promotes :-
- the storage of glycogen and the further growth of blood vessels in the endometrium, which thus becomes a potential placenta
- The development of **secretory cells** of the mammary glands

The role of the testes

- Testis is the male sex organ(produces sperm) that also serves as an endocrine gland
- Testes contains **interstitial** cells (or **leydig's cells**) that secrete testosterone which is responsible for development of male secondary sexual characteristics
- Puberty in boys usually begins somewhere between the ages of 9 and 15 years old
- **pituitary gland** produces increasing amounts of **FSH** which stimulates the testes to begin developing and producing the male sex hormone **testosterone**
- The rising levels of testosterone trigger the many changes which affect the body during puberty, causing the development of the secondary sexual characteristics

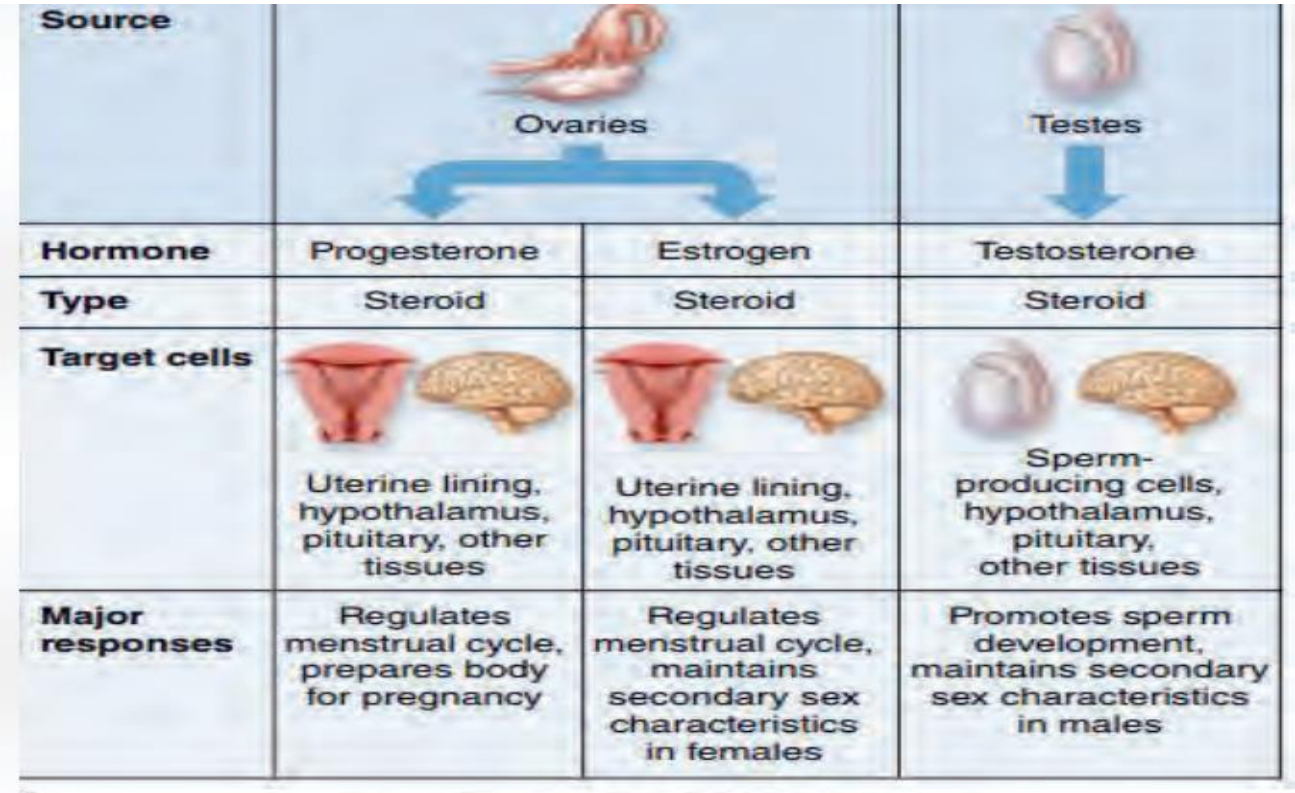


Figure 5.47 hormones secreted by ovaries and testes

Pineal gland

- pineal gland is pine cone shaped located deep in the cerebrum
- It secrets **melatonin** to regulate **circadian rhythms**
- Circadian rhythms are :-
- ✓ Body's physiological response to 24 hour day-night cycle
- ✓ necessary to keep track of day or night cycles, sleep/wake rhythm, menstrual and ovarian cycles
- ✓ driven by an internal (endogenous) circadian clock, although they can be modulated by external factors
- melatonin secretion is suppressed by bright light (principally blue wavelengths) and hence its level increase during night

- ❑ Melatonin promotes sleep in humans
- ❑ During sleep necessary physiological changes occur in body temperature, brain wave activity and hormonal production

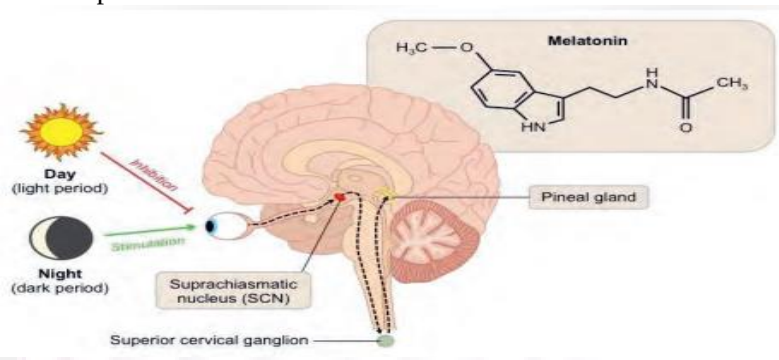


Figure 5.49 Pineal gland

Thymus gland

- ❑ thymus gland is a diminishing gland (over time) located between the lungs
- ❑ It secretes a group of hormones, such as **thymosin**, to affect the production and maturation of lymphocytes in body defenses

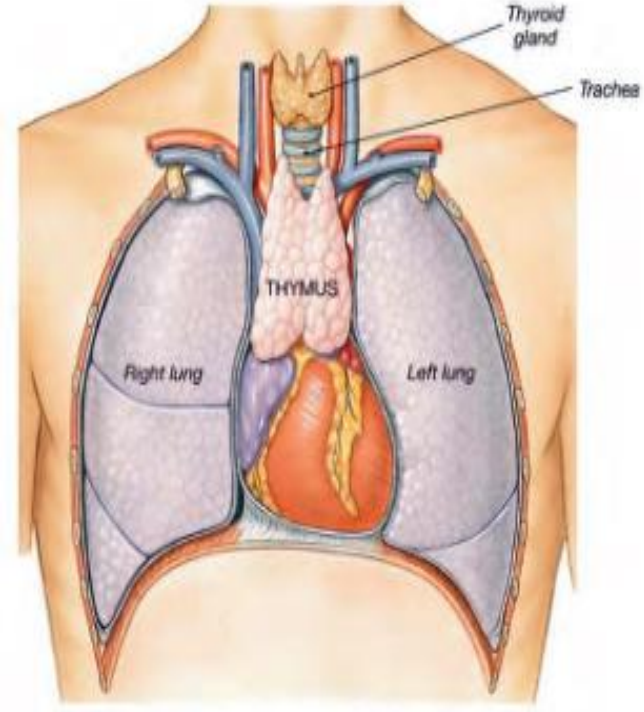


Figure 5.50 Thymus gland

Homeostasis in the human body

<u>The structure and function of the human kidney</u>

- ❑ **<u>Kidneys</u> :-** pair of bean-shaped organs just above the waist
- ❑ Are important organs in the body and have the following functions
- ✓ Filtering blood and producing urine
- ✓ Reabsorbing mineral ions
- ✓ Producing hormones – ex. erythropoietin
- ❑ The kidney has three regions

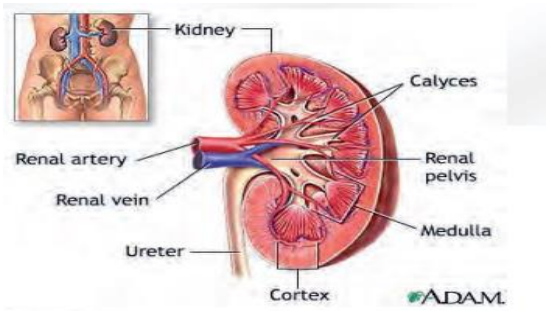
i. **Cortex** – outer part

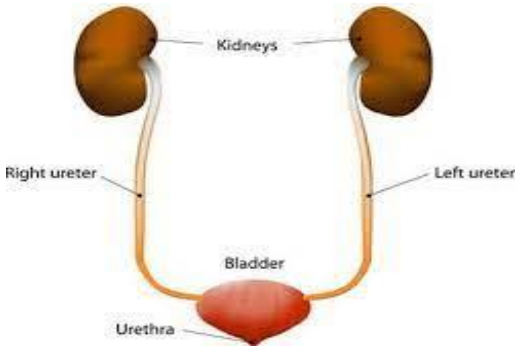
ii. **Medulla** – in the middle

iii. **Renal pelvis** – expanded end of the ureter

- Collects the urine and leads to the ureter on the outside of the kidney

❑ **Ureters** – are urine bearing tubes that exit the kidney and empty into the urinary bladder





❑ Blood flows into the kidney through **renal artery** and then get filtered

❑ So fluid containing water ,salt ,urea ,glucose and many other substances is forced out in to the nephron tubule

✓ Then evert thing the body needs is taken back ,including

- Water ,all sugar , all amino acids and mineral ions needed by the body

The amount of water reabsorbed depends on the need of the body

✓ The waste product(urea),excess ions and unwanted water of the body are lost as urine

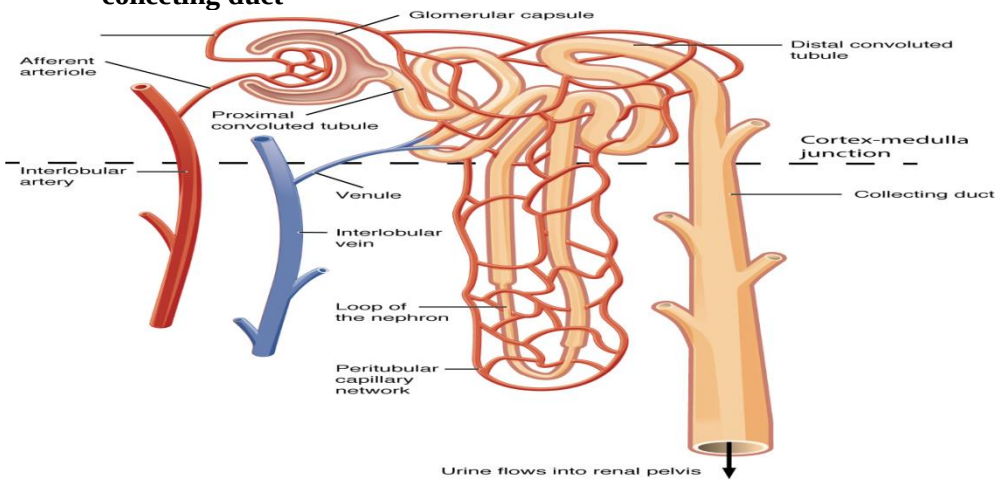
<u>Parts of a nephron and their functions</u>

❑ **Nephron**-the functional unit of the kidney

✓ Are tiny microscopic tubules where all filtration and reabsorption takes place

✓ Each kidney is made up of millions of nephrons

✓ A nephron has these structures :- **bowman's capsule** ,**1st coiled tubule** , **loop of Henle** , **2nd coiled tubule** and **collecting duct**



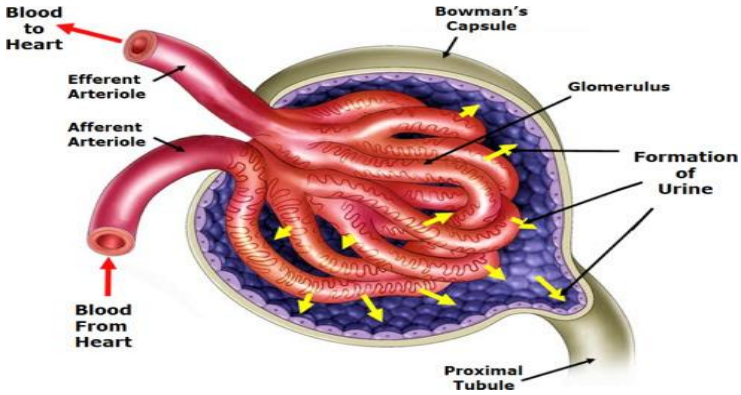
❑ **Bowman's capsule** - The site of ultrafiltration of the blood

❑ **Glomerulus** –is knot of blood vessels(capillaries) in the bowman's capsule

✓ Blood in the capillaries is under high pressure ,because vessels feeding into capsule are wider than the vessels leaving the capsule

✓ Wall of the blood capillaries and wall of the capsule have small gaps which acts as filter

- Blood cells and large blood proteins can't leave the blood vessels , because they are to big to fit through the gaps
- Whereas Water, glucose , amino acid , urea , and many other substances are forced out into the 1st coiled tubule



First coiled (convoluted) tubule

Glomerular filtrate = a fluid which enters the first coiled tubule

- ❑ 1st tubule is where much of reabsorption takes place
- ✓ it has many microvilli to increase the surface area for reabsorption

Reabsorption= movement of substances from nephron tubules to the blood

- ❑ All glucose ,67% of sodium ion and 80% of water in the glomerular filtrate are taken back to the blood in 1st tubule

Loop of Henle

- ❑ Part of the nephron where urine is concentrated and more water is conserved

2nd coiled (convoluted)tubule

- ❑ Is a place where main water balancing is done
- ❑ If the body is short of water, more is reabsorbed into blood under the influence of ADH

ADH = antidiuretic hormone

- ✓ Diuresis means passing urine and antidiuretic means reducing urine flow
- ❑ Ammonium ions and some drugs are secreted into the 2nd tubules

Secretion = movement of substances from blood to nephron tubules

- ❑ By the end of 2nd coiled tubule all salt needed by the body has been reabsorbed and the excess is lost with most of the urea

Collecting duct

- ❑ Is part of nephron where urine is collected
- ❑ Contains 1% of the original water with no glucose at all
- ❑ If the body badly needs more water , it can be reabsorbed from collecting duct under the influence of ADH
- ❑ The amount of salt in the urine will depend on the amount of salt consumed .if you consume more you will lose more in the urine
- ❑ Urine is constantly formed in the kidney and drips down through ureters in to the bladder

  Bladder:- muscular sac which can hold between 600 – 800 ml. we usually empty it when it contains only 150-300ml
- ❑ The amount of water lost in the urine is controlled by negative feed back mechanism which involves the hormone ADH
- ✓ If water concentration of urine becomes too low (i.e. high blood salt concentration)
- ▪ Osmoreceptors in the brain detect this change and stimulate the pituitary to release ADH
- ▪ ADH makes 2nd coiled tube more permeable to water.as a result more water is reabsorbed back to the blood

  This means:-
- ✓ Less water is left in the kidney(tubules) and concentrated urine is formed
- ✓ Amount water in the blood increases and concentration of salt in the blood returns to normal (decreases)
- ✓ If water concentration of blood becomes too high (i.e. Decreased blood salt concentration)
- ▪ Pituitary releases less ADH and kidney reabsorbs less water back to the blood

This means:-

- ✓ More water is lost from the kidney and large volume f dilute urine is formed
- ✓ Amount of water in the decreases and concentration salt in the blood returns to normal (increases)

 # Note :- if water concentration of blood fall , high amount of ADH is released and if water concentration of blood rises , less ADH is released

- ❖ Kidney filters **180 L** of blood per day but only about **1.5 L** is lost as urine. So more than 99% of filtered liquid is returned to the blood

Question no 17. Which of the following areas is NOT part of the nephron (kidney tubule)?

a. Bowman's capsule

b. urinary bladder

c. loop of Henle

d. first coiled tubule

question no 18. What will happen if water content of the blood is too high ? EUEE 2014

A. The second tubule of the kidney becomes more permeable

B. Antidiuretic hormone secretion decreases

C. Osmoreceptors stimulate pituitary to release ADH

D. The kidney reabsorbs more water back into the blood

Question no 19 Which of the following sentence is correctly matched with the function kidney structures?2015 EUEE

A. Bowman's capsule – acts as filter to produce urine

B. Cortex – monitors the osmotic pressure of the blood

C. Glomerulus- concentrates urine and conserves water

D. Loop of Henle` – involved in ultrafiltration

Question no 20. which of the following statements is true about ADH?

A. ADH is a hormone produced in the brain which affects the second coiled tubules of the kidneys, making them more permeable so more water is reabsorbed back into the blood and little, concentrated urine is formed.

B. ADH is a hormone produced in the brain which affects the first coiled tubules of the kidneys, making them more permeable so more water is reabsorbed back into the blood.

C. ADH is a hormone produced in the kidney which affects the coiled tubules of the kidneys, making them more permeable so more water is reabsorbed back into the blood.

D. ADH is a hormone produced in the brain which affects the second coiled tubules of the kidneys, making them less permeable so less water is reabsorbed back

Thermoregulation

- ❑ **internal (core) body temperature**
- ✓ is the temperature deep inside the body
- ✓ Internal (core) body temperature must be kept stable
- ✓ wherever we go and whatever we do our core body temperature is maintained at the temperature (around 37 °C) at which our enzymes work best.
- ❑ It is not the temperature **at the surface** of an organism which matters as the skin temperature can vary enormously without causing harm
- ❑ **Homeotherms** –organisms with constant internal body temperature
- ❑ the body temperature is controlled by a number of physiological and behavioral mechanisms which work together to allow gain or lose of heat

Osmoregulation

- ❑ the balance of water and salts in the body is very important because the concentration of the body fluids changes, water will move into or out of the cells by osmosis and they could be damaged or destroyed
- ❑ **Osmoregulation:-** controlling water and salt balance of the body
- ❑ Water and ion(salt) balance is maintained by the **kidney**
- ❑ we gain water when we drink and eat
- ❑ We lose water when
- ✓ we breathe out (water evaporates into the air in the lungs and is breathed out)
- ✓ we exercise or get hot(we sweat and lose more water)
- ❑ if we are short of water we produce very little urine and most water is saved for use in the body
- ❑ if we have too much water then our kidneys produce lots of urine to get rid of the excess
- ❑ We take in mineral ions with our food. Some are lost via our skin when we sweat
- ✓ excess mineral ions are removed by the kidneys and lost in the urine.

chemical regulation

- ❑ **liver** is the largest individual organ in the body that makes up around 5% of the body mass
- ❑ The liver cells are very active in carrying out a wide range of functions, many of which help to maintain a constant internal environment.
- ❑ the liver has a very special blood supply in addition to the usual artery and vein (hepatic artery and vein)
- ❑ **hepatic portal vein:-** comes to the liver directly from the gut and brings the products of digestion to the liver to be dealt with
- ❑ ***Liver plays a part in all of the following functions:***
- ✓ It controls the sugar levels in the body (through stored glycogen in the liver itself)
- ✓ It controls and balances the fats that you eat and the cholesterol levels in the blood
- ✓ It carries out the breakdown of worn-out red blood cells - in particular the red pigment hemoglobin
- ✓ it is vital organ for the formation of **bile**
- ✓ It is used to control temperature.
- ✓ It controls toxins. The liver breaks down most of the poisons you take into the body, including alcohol. This is why the liver is so often damaged when people drink heavily.
- ✓ It is an important organ where protein metabolism takes place
- ▪ If you eat more carbohydrate or fat than you need in the diet the body simply stores the excess energy as fat
- ▪ If you eat too much protein the body cannot store the excess amino acids or simply convert protein to fat
- ▪ Instead the amino acids are broken down in the liver by deamination

Deamination:- the process of removing the amino group from amino acids

- ▪ The removed amino group is converted to ammonia and then urea
- ▪ The rest of the amino acid can be used in cellular respiration or converted to fat for storage
- ❑ the regulation of tissue oxygenation is another typical example for chemical regulation in the body
- ✓ The respiratory chemoreceptors work by sensing the pH levels of their environment through the concentration of hydrogen ions
- ✓ most carbon dioxide is converted to carbonic acid in the bloodstream and chemoreceptors are able to use blood pH as a way to measure the carbon dioxide levels of the bloodstream
- ✓ The main chemoreceptors involved in respiratory feedback are:

1. Central chemoreceptors: are located in the brain and detect changes in PH of spinal fluid
2. peripheral chemoreceptors: These include
    - ➢ <u>aortic body</u>-detects changes in blood oxygen and carbon dioxide, but not in the pH
    - ➢ <u>carotid body</u>-detects changes in blood oxygen, carbon dioxide and pH changes in the levels of O_2, CO_2 and H^+ in the blood cause compensatory changes in the level of ventilation.

QUESTION NO 21. Which of the following is not an example of homeostasis?

a. control of the blood sugar levels
b. control of the body temperature
c. control of the water content of the blood
d. control of the length of the limbs

UNIT 6

CLIMATE CHANGE

- **Definition of climate change**
- **Cause of climate change**
- **Effects of climate change**
  - ✓ Effect of climate change on agriculture
  - ✓ Effects of climate change on Biodiversity
  - ✓ >> >> >> forest productivity
  - ✓ >> >> >> and natural disaster
- **International conventions**
  - ✓The united nations (UN) frame work convention
  - ✓Kyoto protocol (KP) on climate change
  - ✓International or national practices of implementation of conventions

What is climate?

- Is a long term pattern **of temperature, precipitation, and weather** condition in a particular region, like the arid climate of deserts or climate of rain forests.

What is climate change?

- Climate change is long term alteration of the planet earth's climate system primarily driven by human activities (***anthropogenic)***, such as **burning fossil fuels, deforestation, and industrial processes**, leading rising temperatures and shifts in precipitation patterns.
- Resulting in Global warming and various environmental impacts like ***hurricanes, droughts, floods, melting polar ice caps, and rising sea levels***.
- It is caused by the earth`s energy balance(Sun- Earth → Space)

Examples of Human Activities That Contribute To Climate Change

1. **Burning fossil fuels:-**The combustion of coal, oil, and natural gas for energy production releases CO2 into the atmosphere.
2. **Deforestation:-** clearing forests reduces the number of trees that absorb CO2, contributing to higher atmospheric CO2 levels.
3. **Industrial processes:-** manufacturing and industrial activities release greenhouse gases such as CH4 &N2O into the atmosphere.
4. **Agricultural practices:-** Farming methods like rice cultivation and livestock farming release methane, while the use of fertilizer emits nitrous oxide.
5. **Land use change:-** Conversion of land for urbanization agricultural alters ecosystem, affecting the carbon cycle and contributing to climate change.

CO_2 Concentration

- CO_2 is one of the most important greenhouse gases.
- It absorbs and radiates heat wormed by sunlight and thermal infrared energy (heat).
- It absorbs less heat per molecule than methane and nitrous oxide but it is abundant stays in the atmosphere much longer.
- CO_2 contribute 2/3(67%) of the earth`s total energy imbalance.
- Concentration of atmospheric CO_2 increased by more than 40% with over half the increase occurring since 1970.
- Naturally, CO_2 is exchanged continually b/n the atmosphere, plants, and animals through photosynthesis, respiration, gas exchange and decomposition.

- Without human activity a very small (1%) of CO_2 emitted from fossil fuels, and volcanic eruption in balanced by equivalent volume from the chemical weathering of rocks.
- The natural process add CO_2 to the atmosphere slowly compared to the human activities

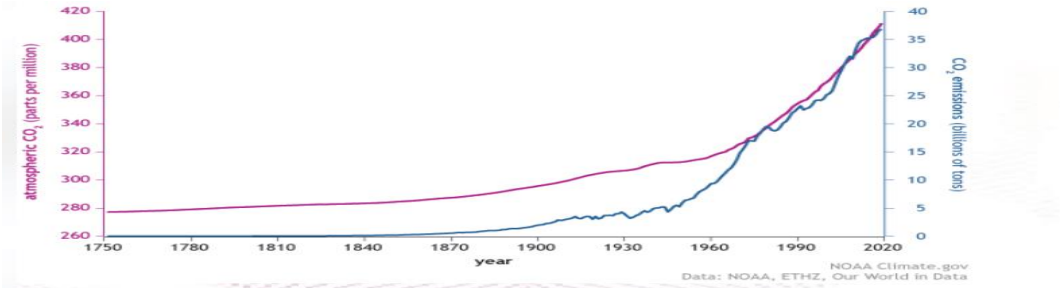


Figure 6.2. Progressive increase of of atmospheric Carbon dioxide concentrations since 1750 GC.

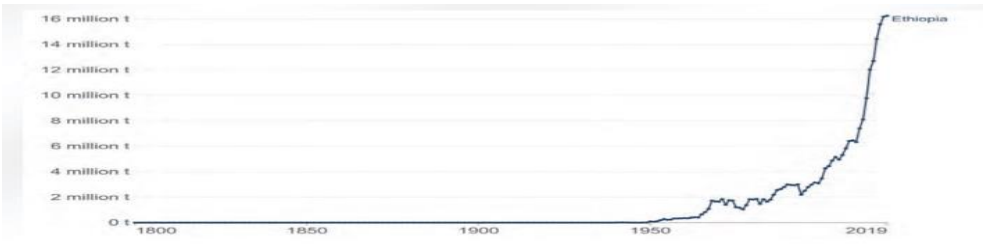


Figure 6.3. Ethiopia's annual CO_2 emission

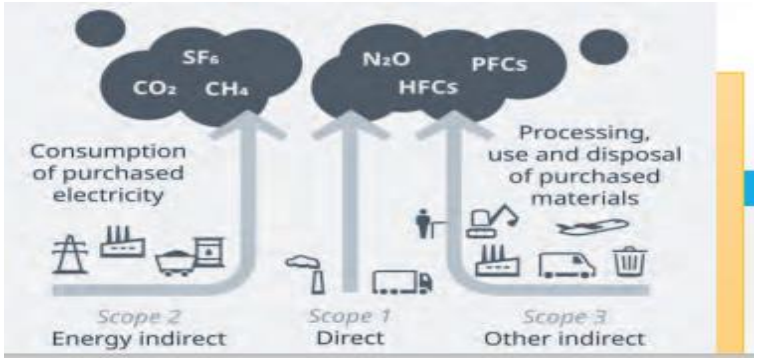
Causes of climate change

What is a greenhouse?

A greenhouse is a structure made of transparent material, such as glass or plastic, used to cultivate plants trapping by sunlight and heat, creating a warm environment conducive to plant growth.



What are greenhouse gasses? :-they are atmospheric gasses that trap heat from the sunlight contributing to the greenhouse effect.



The major greenhouse gases and sources

GHG Categories	Major Sources
Carbodioxide (CO_2)	Fossil Fuel Combustion, deforestation
Methane (CH_4)	Landfills, Rice paddies, Digestive tracts of cattle and sheep
Nitrous Oxide (N_2O)	Fertilizer, animal waste
Hydrofluorocarbons (HFCs)	Semiconductor manufacturing and other industrial processes
Perfluorocarbons (PFCs)	Same as HFCs, plus aluminum smelting
Sulfur hexafluoride (SF_6)	Electrical transmission systems, magnesium and aluminum production

What is the greenhouse effect?

- ❖ The greenhouse effect is the process by which certain gases in the Earth`s atmosphere trap heat from the sun, leading to an increase in temperature on the planet's surface.
- ❖ This natural phenomenon is essential for maintaining sustainable conditions for life on earth.
- ✓ With the greenhouse effect>> the earth`s average temperature ***14ºC*** (57^{O}F) suitable for life on earth.
- ✓ Without greenhouse effect>> the temperature would drop to ***-18^{O}C (-0.4ºF)*** too cold to sustain the life on earth.

♥ **However,** human activities have intensified the greenhouse effect by increasing the concentration of greenhouse gases, resulting in ***global warming and climate change***.

6.1. Effects of climate change

"You say you love your children above all else, and yet you are stealing their future in front of their very eyes." Greta Thunberg.



Figure 6.4 Greta Thunberg, Climate activist and Founder of Climate School Strike

Direct effects

- ❖ ***Extreme weather events***: for example Hurricanes, heat waves, droughts and flood
- ❖ **Rising temperature; global warming**
- ❖ **Water scarcity**
- ❖ **See level rising**
- ❖ **Impact on agriculture**
- ❖ **Ecosystem disruption**
- ❖ **Health impacts**

- **Social and economic disruption**

  Indirect effects
- **Increase pests and pathogens**
- **Ocean acidification due to increase of HCO3 as a result of CO2 increment.**
- **Increase hunger**
- **Shifts in ecosystem service**
- **Loss of biodiversity**
- **Migration and displacement**
- **Economic impacts**
- **Health risks**
- **Social vulnerability**
- **Security risks**
- **Psychological and mental impacts..**

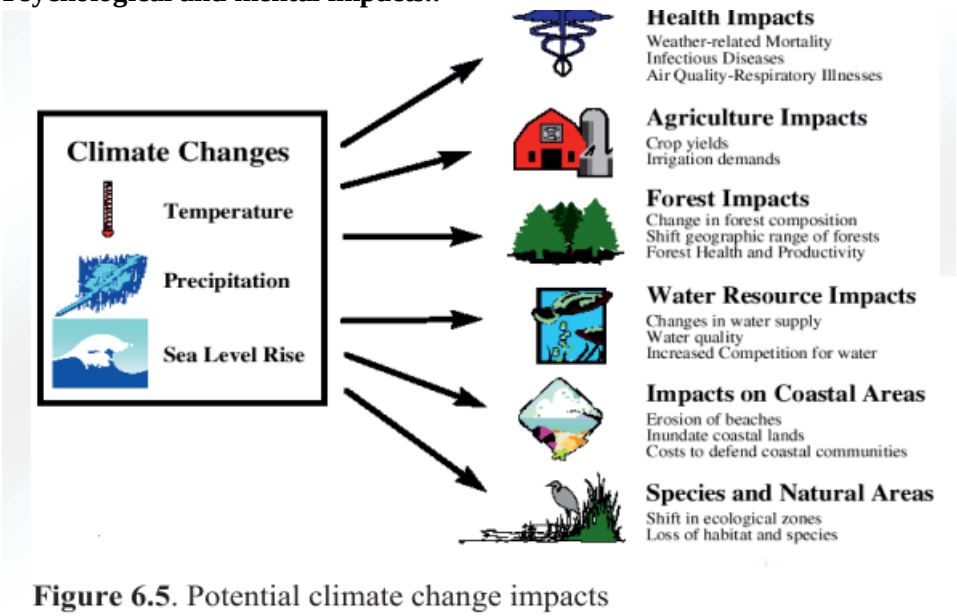


Figure 6.5. Potential climate change impacts

1. **Effects of climate change on biodiversity**

- Biodiversity provides immense direct benefits to humans
  - ✓ **Over 40%** of the world`s economy is derived from biological resources.
- **So,** maintaining biodiversity is used:
  - **To improve food security**
  - **For economic development**
  - **To develop new pharmaceuticals**
  - **To medical advances**
- **However,** climate change is affecting the biodiversity by
  - ✓ ***Altering habitats***
  - ✓ ***Disrupting ecosystem***
  - ✓ ***Affecting spp distributions and interactions***
  - ✓ ***Increasing migration***

2. **Effects of climate change on agriculture**

- **Climate change affects agriculture by altering**
  - ➢ Growing seasons
  - ➢ Precipitation patterns

- Pest and disease pressure

❖ Change in precipitation can lead to
- Floods
- Soil erosion
- Water logging
- Affecting crop productivity

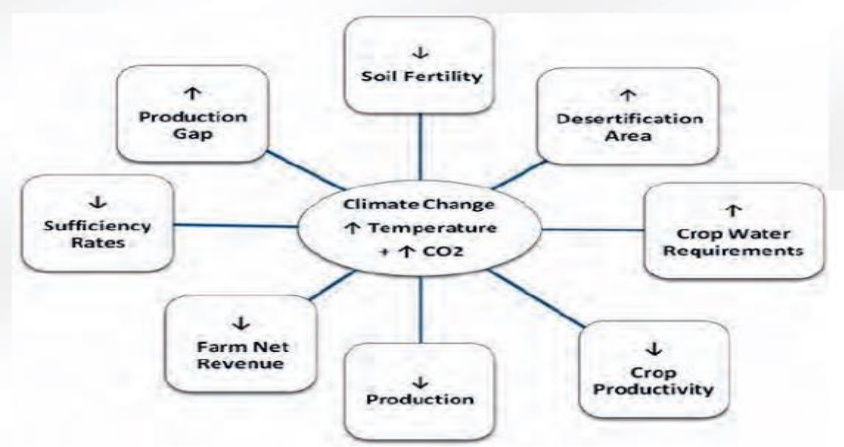


Figure 6.7 Climate change and its potential impacts on Agriculture.

3. Effects of climate change on forest productivity

❖ ***Climate change*** alter the frequency and intensity of forest

❖ This causes disturbances like:
- ✓ Pest out breaks
- ✓ Invasive species
- ✓ Wildfires
- ✓ Storms

❖ The disturbance also reduces
- ✓ Forest productivity
- ✓ Change the distribution of tree species

❖ In some cases, a forest can remove from a disturbance while in other cases- existing species may shift their range or die out replaced by new forests.

❖ Insect out breaks often defoliate, weaken, and kill trees.



Figure 6. 8 Galema forest on fire, Chilalo, Oromia state Ethiopia

4. Climate change and natural disaster

❖ Climate hazards are natural events in weather cycles
Examples: ***Hurricanes, storms, Droughts, Wild fires, High winds and Flooding***

❖ As more water vapor is evaporated into the atmosphere –storms develop.



Figure 6.9. Heavy rains and storms caused damage and flooding to the Lietchuor camp in Ethiopia, Gambella region.



Figure 6.10 Dust storms in Eastern Ethiopia

Melting of ice and rising seas

- When the water warms up it expands.
- Global warming causes polar ices sheets and glaciers to melt
- This causes sea level to rise resulting in flooding and erosion of coastal and low-lying areas.

Extreme weather, shifting rainfall

- Heavy rain and other extreme weather events are becoming more frequent
- This leads to flooding, decreased water quality, and water availability



Figure 6.11 Failed crops as a result of climate change, Ethiopia

RISKS OF CLIMATE CHANGE FOR HUMAN HEALTH

- Increase in heat-related deaths in some regions of the world
- Decrease cold related deaths in other regions
- Increase water borne illness and disease vectors

6.2. Safety rules /precaution during natural disasters

- Disaster risk management –is a comprehensive approach involving the identification of threats through the implementation of the proposed mitigation measures
- Natural disasters are catastrophic events that often occur without warning and disrupt the ecosystem by causing;
  - ✓ Damage to personal lives
  - ✓ Property
  - ✓ Transportation
  - ✓ Livelihood.
- While it is never possible to prevent a disaster, the damage can be minimized through timely preparation.



Figure 6.12. Elements of Comprehensive risk management

Precautions to be taken during natural disasters

1.**Earthquake**

- The shifting of tectonic plates under the earth`s crust causes earthquake
- It is responsible for mass destructions

Precaution during Earthquake

- **If you are indoors**
  - Take covers under a sturdy table or other pieces of furniture
  - Hold on until the shaking stops
  - Stay away from glass windows, outside walls and anything that could fall lighting mixture or furniture
  - Stay inside until the shake stops and safe to go outside
  - Do not use the elevetors
- **If you are outdoor**
  - Stay away from buildings, streetlights, and utility wires
  - Stand in open ground until the shaking stops
  - Do not stay around outside buildings ,at exits, and alongside exterior walls
  - Death or injury due to ground movement during an earth quake is seldom
  - Most earth quake –related casualties resulted from collapsing walls, flying glass, and falling objects

2.Tsunami

- Tsunamis are massive ocean waves typically caused by ***underwater earthquakes***, ***volcanic eruption, or landslides***.
- Its waves range from ***tens to hundreds*** of feet tall and can ***travel 20 to 30 miles*** per hour



Precaution

- Turn on your radio/TV to learn and fallow the precautionary instructions, and warnings, primarily when you reside near a coastal area.
- Move ***inland*** to higher ground immediately and stay there
- Check for a noticeable recession in water away from the shorelines as this is nature`s tsunami warning and should be heeded.
- It would help if you moved away immediately

3. Cyclones

- Cyclones are powerful rotating storms characterized by low pressure centers, such as ***hurricanes, typhoons, and tropical cyclones***.
- Cyclones are tropical storms caused by atmospheric disturbances around a low pressure area.
- Cyclones are accompanied by strong winds, moving at speed of 62 km per hour or more.

Precautions

- Be alert to the changing weather conditions
- Listen to radio /TV for the latest information.
- Look for approaching storms.
- Look for the following warning signs
  - ✓ Dark, often greenish sky
  - ✓ Large hailstones
  - ✓ A large, dark, low-lying cloud(particularly if rotating)
  - ✓ Roars, similar to freight train
    - Take shelter immediately
    - If no shelter take refuges there

4. Floods

- Flood is an over flow of water onto normally dry land, often caused by heavy rain fall, tsunami, melting snow, or storm surges from hurricanes.

Precautions

- Do not attempt to walk, swim, or drive through the floods
- Stay clear of bridges over fast-moving water
- Keep an eye out for evacuation alerts
- Move higher ground
- If your vehicle is trapped in a flood and water starts to fill inside the car, seek refuge on the roof.

6.3. International conventions

- Climate change is a long term, global problem. So it requires stable but flexible policy implementations over time.
- Various international conventions have continuously evolved to address the increasingly complex and changing environmental priorities of the world

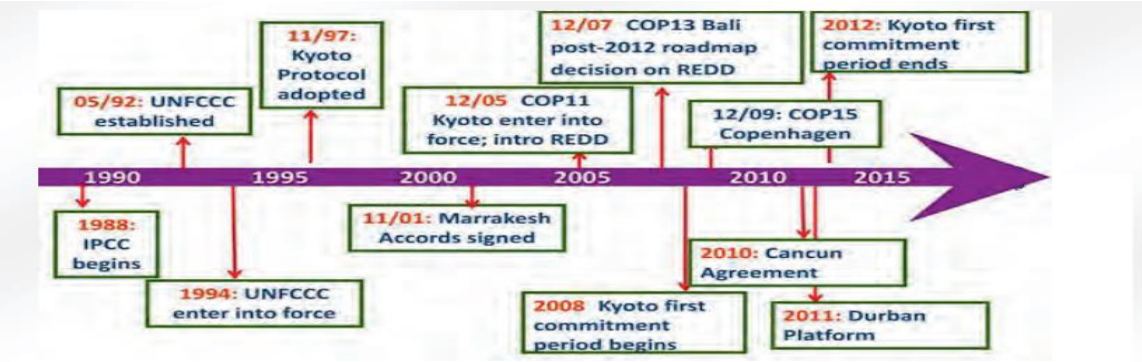


Figure 6.13. Climate Policy Timeline

Copenhagen (COP15) Policy, 2009

- The Copenhagen climate change conference, also known as COP15took place in December 2009 in Copenhagen, **Denmark**.
- The conference aimed ***to negotiate a global agreement on climate change to succeed the Kyoto protocol, which was set to expire in 2012***.
- For the first time it was decide that each country would propose a national contribution (INC, Intended Nationally Determine Contributions)
- All the 195UNFCCC countries pledge to reduce their greenhouse gas emission by **2025-2030**
- It aimed ``***to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty*** ``
- **The three key goals of COP15**

1. Holding the increase in the global average temperature to well below **2^{o}C** above pre-industrial levels and pursuing efforts to limit the temperature increase to **1.5 ^{o}C** above pre- industrial levels.
2. Increase the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development
3. Making finance flows consistent with a pathway towards low greenhouse gas emission and climate resilient development.

- However, the Copenhagen conference faced challenges and controversies.
- It lacked legally binding commitments and detailed plans for achieving its goals

The UNFCCC, 1992

- **United Nations Framework Convention on Climate Change (UNFCCC)** adapted in 1992.
- It Sets Out the Framework for global action to combat "***dangerous human interference with the climate system"*** to stabilize greenhouse gas concentrations in the atmosphere.
- Its main object is " ***to prevent dangerous man made interference with the global climate system***"
- The **UNFCCC** is an international environmental treaty
- Ethiopia and all its member countries are among the ***197*** parties of the convention.

Kyoto protocol (Japan 1997)

- **Kyoto protocol (Japan):** adopted in 1997.
- Is an international agreement.
- Operationalizes the UNFCCC
- It calls for industrialized/developed countries to reduce their greenhouse gas emission significantly

Doha Amendment and Paris Climate Agreement

- The Doha amendment is an amendment to the Kyoto protocol, adopted during the 2012 in ***Doha, Qatar***.
- It sets out new emission reduction targets for developed countries for the second commitment period of the Kyoto protocol, which runs from 2013 to 2020.

<u>Paris agreement</u>:- Adopted in 2015

- It aims "to limit global warming to well below ***2ºC*** above pre-industrial level and pursue efforts to limit it to ***1.5ºC***.
- It includes nationally determined contributions (NDCs) from each country, which outline their climate action plans
- It took 8 years for participant countries to ratify the Kyoto protocol
- Industrialized/ developed countries would be legally obliged to cut greenhouse gas emission by 5% on 1990 levels by 2008-2012.
- Developing countries like **china, India, Brazil, and South Africa** would face no restrictions on their emission but were encouraged to adopt policies to promote greener growth.
- Kyoto also offered mechanisms to offset emission by investing in ***low-carbon projects*** in poorer parts of the world.
- It was hailed as an***" environmentally strong and economically sound"*** **Bill Clinton US** president 1997 –***" it reflects a commitment from our generation to act in the interest of future generations"***, he said

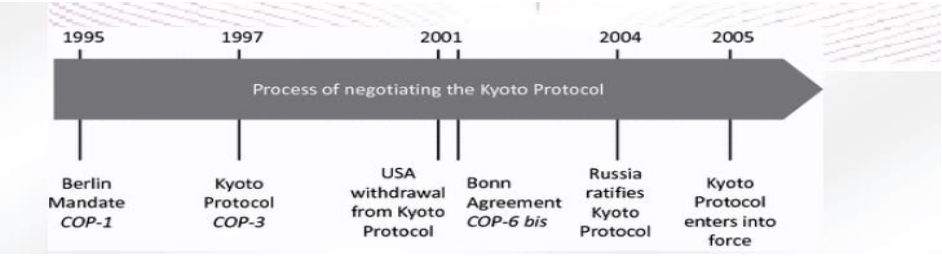


Figure 6.16. The Negotiation process leading to the Kyoto Protocol

6.4. The National Practice Of Implementation Conventions

6.4.1. Ethiopia Green Legacy Initiative

- Ethiopia is one of the world`s most drought-prone countries
- It has a high degree of vulnerability to hydro- meteorological hazard and natural disasters.
- Ethiopia`s policy response to climate change has progressively evolved since the ratification of the UNFCCC in 1994.
- It launched the national adaptation plan of action in 2007 and Ethiopian program of adaptation on climate change and nationally appropriate mitigation action in 2010.
- Moreover, Ethiopia endorsed climate resilient green economy (CRGE) strategy in 2011 to build a green and resilient economy.
- Over the years Ethiopia has implemented various programs with those policy frameworks.
- One among them and by far the most consequential has been **the green legacy initiative (GLI) launched in 2019.**
  - Vision to build a green and climate resilient Ethiopia and target to plant **20 billon** seedlings within **a period of 4 years**.
  - This aimed to combat the impacts of climate change by improving
    - ✓ Agroforestry
    - ✓ Forest sector development
    - ✓ Greening
    - ✓ Renewal of urban areas
    - ✓ Integrated water and soil resource management

6.4.2. Great Ethiopian Renaissance Dam (GERD)

- Hydroelectric dam on the Abay (Blue Nile) river
- Under construction since 2011 in Benishangul Gumuz region.

- ✓ The purpose is to generate electricity with a capacity of **5.15gigawatts** to relieve Ethiopia's acute energy shortage and for electricity export to neighboring countries.

- ❖ It is the largest hydroelectric power plant in Africa
- ❖ It is one of the best examples in Ethiopia to support the climate resilient green economy (CRGE) strategy.
- ❖ The lake being created on the GERD will be the biggest lake in Ethiopia with the potential for fishing and irrigation development.
- ❖ Ethiopia exports electricity to Djibouti, Sudan, Kenya and South Sudan