UNIT ONE

MICRO-ORGANISMS

Micro-organisms: are very small organisms usually having just one cell and can be seen only with a microscope.

There are 5 main groups of micro-organisms:

1. Protozoan 2. Some fungi 2. Some algae 3. Bacteria 2. Viruses

1. **Protozoan**: are unicellular organisms that lack a cell wall and most of them are motile (able to move).

They include organisms such as amoeba, plasmodium and paramecium.

Protozoans cause diseases in many ways. **E.g**. Malaria, sleeping sickness, etc.

2. Fungi

- lack chlorophyll and are non-photosynthetic
- are eukaryotic having cell wall made up of chitin
- are parasitic or saprophytic and some are mutualistic
- Store glycogen and oil like animals
- Higher fungi produce thread like structures called **hyphae** (interconnected mass of hyphae is called **mycelium**)
- The mycelium releases enzymes that digest whatever the fungus is growing on
- The products of the digestion are then absorbed into the fungus to help its growth and reproduction.
- Some fungi live in or other living organisms, as **parasites**.
- Others live on dead material as **saprobionts**.
- **Saprobionts** are organisms that digest their food externally and absorb the products.
- The only unicellular fungi are yeasts. Examples include **brewer's yeasts** and **baker's yeasts** (Saccharomyces as well as the yeast-like organism that causes **thrush** in humans (**candida**).

❖ When fungi grow in or on other organisms, their hyphae secrete enzymes.

❖ These enzymes digest substances in the tissue, and the substances produced are absorbed.

❖ Growth of hyphae also physically damages the tissue.

❖ Some fungi also secrete toxins.

❖ Others can cause an allergic reaction (e.g. farmer's lung).

❖ Very few fungi are parasites of humans

❖ One of the commonest fungal diseases is called **ringworm**, because it can produce a circular swelling on the skin.

❖ Ringworm fungi attack the **scalp**, and the **soft skin of the groins.**

❖ Another very similar fungus attacks the soft skin of the feet, especially between the toes, causing a disease called **athlete's foot.**

❖ Fungal diseases are spread by **airborne spores** by contact with infected people and, in the case of athlete's foot, by infected floors and mats on which people walk bare-foot.

❖ **Farmer's lung** is a fungal disease (allergy) caused by inhaling dust from moldy hay spores through nose or mouth.

3. Algae

1. are photosynthetic
2. are eukaryotic
3. many are large (the seaweeds are all algae).
4. Some are unicellular

- ❖ The unicellular algae in figure 1.4 page 4 are part of the **plankton**.
  Planktons--are collection of small microscopic plant-like (phytoplankton) and animal like (zooplankton) organisms that float or drift in large numbers in fresh or salt water, providing food for fish and other larger organisms.
- ❖ These unicellular algae in the oceans produce far more **oxygen** during photosynthesis than all the forests in the world together.
- ❖ Some unicellular algae are **motile** (they can move) using their flagella. Figure 1.5 shows an alga called
- ❖ Chlamydomonas, which has two flagella at one end to propel it through the water.

4. Bacteria

- are prokaryotic cells. The word prokaryotic is derived from Greek, pro (before) and karyos (nucleus).
- in prokaryotic cells **there is no true nucleus** separated from the rest of the cell by a membrane.
- instead, the DNA of the bacterium forms a **continuous loop** that is intermingled with the cytoplasm.
- they have cell wall made of **peptidoglycan**, which makes it rigid
- all bacteria do have:
  1. Cell wall made of peptidoglycan
  2. a cell membrane
  3. Cytoplasm
  4. Ribosomes
  5. DNA

Some other structures that are found in few bacteria only include:

1. Flagella 2. Capsule 3. Plasmids 4. Pilli (hair-like structures on the surface)

- ✓ The structure of a bacterium --see figure 1.9---page 6 (shows a generalized bacterial cell).
- ✓ Not all the bacteria have all the structures shown in the fig. 1.9.
  For example, not all bacteria have a capsule and many do **not** have a flagellum.
- ✓ **Peptidoglycan:**-is the complex molecule made from sugars and amino acids.
- ✓ Bacteria **do not** have membrane-bound organelles.
- ✓ Since bacteria do not have membrane-bound organelles, photosynthesis takes place in the **plasma membrane** and many of the reactions of the respiration take place in the **cytoplasm**, with some also occurring on the plasma membrane.

Bacterial cells come into 3 main shapes

1. Cocci (coccus)----------Spherical bacteria

2. Bacilli (Bacillus)----------rod-shaped bacteria

3. Spirochetes----------Spiral- shaped bacteria

Whatever their shape, bacterial cells:

1. Sometimes found singly
2. Sometimes two cells are stuck together and
3. Sometimes the cells exist in chain--see figure 1.10 page 7

- ✓ Although bacterial cells vary a great deal in size, they are usually much smaller than eukaryotic cells.
- ✓ Bacterial cells are usually between 1 and 10 micro meter long.
- ✓ **Streptococcus** and **Lactobacillus** are two well researched types of bacteria.

Other ways of classifying bacteria

Bacteria can be classified in other ways, besides their shape.

One of these ways is whether or not they are colored by Grams stain. This test gives two categories:

1. Gram positive----these can be stained **purple** by Gram's stain.
2. Gram negative---- are stained **pink** by Gram's stain.

- **Gram staining:** is a test for classifying bacteria (named after Hans Christian Gram who developed the technique in 1884).
- Because Grams stain produces different results with different types of bacteria, it is called a **differential stain.**

Steps of Gram's staining

1. Fixation
2. Crystal violet treatment
3. Iodine solution addition
4. Decolorization
5. Counter staining by safranin

Fixation: passing microscopic slide containing bacterial sample over the flame for few times

- Grams stain reacts with peptidoglycan cell wall of the bacteria.
- Because grams stain produces different results with different types of bacteria, it is called a **differential stain**
- The difference is due to the **structure of cell wall** of the different bacteria.
- **Gram-negative** bacteria have much **less peptidoglycan** in their cell walls.
- This is the part of the cell wall that absorbs the stain.
- **Gram-negative** bacteria also have a **membrane** outside the peptidoglycan cell wall which Gram-positive bacteria do **not** have.
- This outer membrane blocks the entry of the crystal violet and iodine solution, so their cell wall fails to interact with the stains.
- The stains are then washed away by ethanol.
- As a result, Gram negative bacteria **retain** the last stain (safranin) and stain **pink**.
- In Gram positive bacteria, nothing blocks the primary stain (crystal violet) from interacting with the cell wall.
- Consequently, they retain it and stain **purple**.
- In Gram negative bacteria, the outer membrane secretes **endotoxins** (a type of toxin that is the structural component of Gram-negative bacteria) and is quite resistant to many antibiotics.
- These make diseases caused by Gram-negative bacteria more difficult to treat.
- **Gram-negative bacteria**, as a whole cause serious disease, although there are exceptions--the bacterium that cause tuberculosis is Gram-positive.

Where are bacteria found?

- Bacteria are found in every ecosystem (everywhere)--around us, inside us, etc.
- There are **10** bacterial cells inside us for every **one** of our own cells.
- Most of these bacteria are found in the **large intestine**.
- Bacteria are important because they:
  1. Cause diseases
  2. Are used in many industrial process
  3. Recycle mineral elements such as --carbon, nitrogen and sulphur through ecosystems.

Role of bacteria and other micro-organisms in infectious diseases

- The theory that says some diseases are caused by the invasion of the body by micro-organisms was put forward by the French chemist and microbiologist called **Louis Pasteur.**

- The English **surgeon Joseph Lister** and the German physician **Robert Koch** were also involved in the development of this theory.
- In the mid-19th century **Pasteur** showed that micro-organisms in the air caused wine to go '**sour**'.
- In 1860s, **Liste**r showed that **carbolic acid (phenol)** acted as a disinfectant, and prevented disease in bones following surgery.
- In 1880, **Robert Koch** identified the micro-organisms that cause **tuberculosis and cholera.**
- The theory that says disease is caused by micro-organisms is called the **Germ theory.**
- Organisms that cause the disease are called **pathogens.**
- A disease that is caused by a micro-organism infecting the body is called an **infectious disease.**

Koch's Postulates (Ideas)

1, The micro-organism must always be present when the disease is present, and should not be present if the disease is not present.
2. The micro-organism can be isolated from an infected person and then grown in culture.
3. Introducing such cultured micro-organisms into a healthy host should result in the disease developing.
4. It should then be possible to isolate the micro-organism from this newly diseased hosts and grow it in culture.

- The **first** postulate establishes a **link** between the organism and the disease.
- The **other three** postulates prove that the metabolism of a specific living micro-organism, when transferred into a healthy host, causes the disease.

Different organisms cause diseases in different ways, as shown in the table 1.1 page 13.

- **Bacteria** release toxins as they multiply.
- **These toxins** affect cells in the region of the infection, and sometimes in other regions of the body as well.
- Bacterial diseases can be treated with **antibiotics**, as each bacterium is a true cell with its own metabolic systems, and is capable of cell division.
- Some bacteria invade and grow in the tissues or organs, causing physical damage.

  Examples of diseases caused by bacteria are:

  1. Cholera **2**. Pneumonia **3**. Pulmonary tuberculosis

Ways of transmission of Disease causing organisms

- The origin of microorganisms that infect other people is called **reservoir of infection.**
- **Reservoir of infection** is the principal habitat from which an infectious agent may spread to cause disease.
- **Reservoir of infection**: is any person, animal, plant, soil or substance in which an infectious agent lives and multiplies.
- The reservoir typically harbors the infectious agent without showing symptoms of the disease and serves as a source from which other individuals can be infected.
- People acting as the reservoir of infection are sometimes called **carriers of the disease.**

Reservoir of infection includes:

1. **Human beings**----the reservoir for many diseases, including the common cold, diphtheria, and others.
2. **Other animals**---for example chicken--the reservoir for salmonella, mosquito--the reservoir for malaria.
3. **Soil**----reservoir for tetanus and many other pathogens
4. **Water**--reservoir for Legionnaires disease, amebiasis, cholera, etc.

5. **Food**-----reservoir for many diseases including typhoid

6. **Air**-------reservoir for pneumonia, tuberculosis, etc.

7. **Contaminated objects**----contact infections such as HIV/AIDS and trachoma.

Because there are different reservoirs of disease causing organisms, there are different ways in which diseases can be transmitted. -----read page 15 table 1.2.

Different Methods of Transmission

1. Droplet infection------- common cold, flu, pneumonia, etc.
2. Drinking contaminated water-------cholera, typhoid fever
3. Eating contaminated food --- salmonellosis, typhoid fever, listeriosis, botulism, etc.
4. Direct contact ------athlete's foot, ring worm, etc.
5. Sexual intercourse ---candidiasis, syphilis, gonorrhea, AIDS,
6. Blood-to-blood contact-----AIDS, Hepatitis B
7. Animal vectors-----malaria, sleeping sickness, etc.

What other types of disease are there?

Eating too much food can result in **obesity**, which is regarded as a disease condition in itself, and can also lead to other diseases such as **coronary heart disease.**

According to **W**orld **H**ealth **O**rganization (WHO), **health** is a state of complete physical, mental and social **well-being.**

Disease: is a condition with a specific cause in which part or all of a body is made to function in a **non-normal** and **less efficient manner**.

Infectious disease is just one type of disease.

Disease can be caused by a number of other factors

1. **Human-induced diseases** --result due to a person's life style and working conditions.

Example, many cancers together with some forms of heart disease and fibrosis.

2. **Degenerative diseases**-----caused due to aging. Example, arthritis and arthrosclerosis.
3. **Genetic diseases** ---Our genes may lead to diseases. Example, hemophilia and sickle cell anemia, etc.
4. **Deficiency diseases** ------due to lack of balanced die. Example, kwashiorkor and scurvy, etc.
5. **Social diseases** ----alcoholism and drug addiction may result in dependency on the drug, isolation, clinical depression and various levels of anti-social behaviors.
6. **Multi factorial diseases** --describe a condition that is affected by the interaction of many factors (page 16).

   e.g. atherosclerosis (laying down of fatty substances in arteries) increases as we age, so it can be classified as a **degenerative** disease. But our diet influences this process.

   - If we eat more saturated fat, more fatty substances are laid down in our arteries----**Human-induced diseases.**
   - There is also a genetic component--some people are at increased risk of this disease because of the gene inherited from their parents.
   - Stress and high blood pressure increase the rate at which atherosclerosis develops and these can be the result of our **life style.**
   - Clearly, atherosclerosis does NOT fit neatly into any one category.
   - It is best to consider such condition as **multi factorial.**

7. **Functional diseases:** in some cases there is an obvious '**malfunction**' of an organ or system, **without** there being any obvious damage or physical sign of disease in the organ.

- Because of malfunction, these diseases are called **functional diseases**, for example, heart disease.
- Several **intestinal conditions** fall in this category.
- In many forms of **Irritable Bowel Syndrome (IBS**), there is **no sign of damage** or disease in the large intestine, yet the large intestine does not function normally.
- **Myalgic Encephalopathy** (ME or Chronic Fatigue Syndrome) is another functional disease.

In this condition, for no apparent reason, the sufferer is drained of all energy and the simplest task can be an extreme effort.

The Role of Bacteria in the Ecosystem

- Many bacteria are **decomposers**.
- When organisms die, bacteria break down the complex molecules that are found in the bodies of dead organisms into much simple molecules,
- These bacteria use some of these molecules for their own metabolism, but in the process they release some materials in various forms, into the environment.

Many elements are recycled in this way, including: 1. Carbon 2. Nitrogen 3. Sulfur 4. Phosphorus

Here we look at how Nitrogen and Sulfur are recycled.

The Nitrogen Cycle

The element nitrogen is found in many organic molecules in all living organisms.

These include: 1. Proteins, 3**. DNA**, 2. **RNA**, 4. **ATP** and many others.

It is important that once organisms die, the Nitrogen they contain is made available again to other organisms.

Several different types of bacteria are involved in this recycling of nitrogen.

The Role of Bacteria in the Nitrogen Cycle

Table:1.1 The role of bacteria in the ecosystem

Microorganism	Process
Nitrogen fixing bacteria e.g. Rhizobium, Azotobacter, Clostridium	Nitrogen gas in the air is added to the soil into forms other organisms can use. e.g. ammonium
Ammonifying bacteria (decomposers)	Decomposition of proteins in dead organisms and animal wastes releasing ammonium ions to nitrate
Nitrifying bacteria e.g. nitrosomonas, nitrobacter	Nitrification is a two-step process. Ammonia or ammonium ions oxidized first to nitrites (NO_2) by nitrosomonas and then nitrates (NO_3) by nitrobacter which is easily available to roots of plants
Denitrifying bacteria e.g. pseudomonas	Nitrates are reduced to nitrogen gas (N_2), thus replenishing the atmosphere and reducing the amount of nitrogen in the soil

1, Rhizobium---is nitrogen fixing bacteria which lives in the root nodules of leguminous plants.

It changes (fixes) the gas form of Nitrogen into ammonium (NH_4^+) or ammonia (NH_3) which can be used by other bacteria.

2. **Ammonifying bacteria (decomposers**)

- The decomposers break down proteins in dead organisms and animal wastes releasing ammonium ions, which can be converted to **nitrates**

3. **Nitrifying bacteria**→1. Nitrosomonas and 2. Nitrobacter

Nitrificaion is a two-step process----NH_3 or NH_4 ions are oxidized first.

NH_3 or $NH_4 + O_2 \xrightarrow{\text{Nitrosomonas}} NO_2 \xrightarrow{\text{Nitrobacter}} NO_3$

4. **Denitrifying bacteria** -----**NO_3** is reduced to nitrogen gas (N_2), returning N_2 to the air and reducing the amount of nitrogen in the soil. $NH_3 \longrightarrow NO_2 \longrightarrow NO_3 \longrightarrow N_2$

e. g. **Pseudomonads** do this. (Read page 18).

The Sulfur Cycle

Sulfur is found in fewer types of organic molecules than nitrogen, but it is found in many proteins.

The Role of Bacteria in the Sulfur Cycle

1, Decomposition----Sulfur is released from proteins of dead matter as

H_2S (giving the rotten egg's smell) by Desulphovibrio (anaerobic bacteria).

2, **Oxidation of H_2S**.

- **H_2S** is oxidized to release sulphur by **photosynthetic sulphur bacteria** (anaerobic bacteria).
- **Then sulfur is oxidized by non-photosynthetic sulfur bacteria** (aerobic bacteria) to sulphate ions (NO_3).

Table: 1.2 The role of bacteria in the sulphur cycle

Bacteria involved	Process
Desulphovibio (anaerobic)	Sulphur is released from proteins of dead matters as H_2S
Photosynthetic sulphur bacteria (anaerobic)	Hydrogen sulphide (H_2S) is oxidized to release sulphur (S)
Non-photosynthetic sulphur bacteria (Thiobacillus-aerobic)	Sulphur is oxidized to sulphate (SO_4)

Acid rain

- **Acid rain** has many serious effects on living organisms, and can also corrode stones and metals over a long period.
- Some initial causes for the formation of acid rain may include natural causes such as **volcanic eruption** and **lighting.**
- **Burning and fossil fuels** can also produce oxides of sulfur and nitrogen.
- **Water vapor** from clouds combines with these oxides of sulfur and nitrogen and forms **H_2SO_4** and **HNO_3** respectively.
- These acids (**H_2SO_4** and **HNO_3**) with rain form acid rain which causes:
  1. **Death of conifer**
  2. **Acidification of lakes** --leaching of some ions into lakes kills fish and root hairs of plants become less effective at absorbing minerals so the growth of trees slowed.

Death of bacteria and algae; death of amphibian and eggs; and change in ecosystem occurs.

- If the populations of bacteria that are involved in the nitrogen cycle and sulfur cycle were reduced, then the cycling of these elements could not occur, and all life would be impossible as a result.
- We are made from **atoms** and **molecules** that have been in many other bodies before they were in ours.
- The micro-organisms that recycle carbon, nitrogen, sulfur and all other minerals make them available again.....and…... again.....

How are Bacteria used in Industrial processes?

1. Food and beverage fermentation
2. Production of vinegar
3. Production of antibiotics
4. Sewage treatment

A. Food and beverage fermentation: Bread, alcohol, yoghurt, and vinegar as well as many other products are included here.

B. **Production of vinegar:** Vinegar is a dilute solution of Ethanoic acid in water. It also contains other substances that give the vinegar flavor.

Vinegar is used in two main ways: **1**. To flavor foods and **2.** To preserve foods

Vinegar ---is too acidic for most micro-organisms to grow and multiply, so keeping foods in vinegar is a good way of preserving them.

- This type of food preserving method is called **pickling.**

Vinegar is produced by fermenting beer, wine or cider for a second time using a culture of special bacterium called **acetobacter** in a special fermenter to oxidize **ethanol** into **ethanoic acid.**

- The alcohol in the beer, wine or cider is oxidized to **ethanoic acid.**
- This takes place in a special **fermenter**
- The fermenter is filled with **wood shavings** and the alcohol source is sprayed in from the **top**.
- It trickles down through the wood shavings which are covered with **acetobacter** bacteria.
- As liquid flows past them, the bacteria oxidize the alcohol to **ethanoic acid.**
- **Air** is blown in at the bottom to supply the oxygen for the bacteria.
- The vinegar drip out at the bottom of the wood shavings and is taped off. See figure 1.17 page 20.
- This type of production is called **continuous production,** as alcohol is continuously being fed in and ethanoic acid is continuously dripping out at the bottom of the fermenter.

C. Production of Antibiotics

- The first antibiotics are all came from fungi.
- Today antibiotics are increasingly being made using genetically modified bacteria in huge fermenters.
- The stages in the process are shown in figure 1.18 page 21.
- Genetically modified bacteria are also used to produce:

1 .Insulin 4 Human Growth hormone

2. Antibiotics 5. Enzymes for washing powders

3. Homan vaccines, e. g. vaccine against hepatitis

D. Sewage Treatment

- All types of sewage treatment rely on the action of **micro-organisms to oxidize the organic matter** present in the in the sewage.
- There are two main methods: 1. Percolating filter method 2. Activated sludge method.

In the percolated filter method

1. Sewage is screened to remove large pieces of debris
2. It stands in a large settlement tank to allow suspended matter to settle out.
3, It is then allowed to trickle through a bed of stones, each of which is covered in a layer of micro-organisms (bacteria, fungi and protozoa)
4. As the sewage trickles through the filter bed, the micro-organisms digest the organic matter and absorb the products.
5. By the time of liquid reaches the bottom of the filter bed, the polluting organic matter will be removed.

In the activated sludge method

1. Sewage is screened and allowed to stand in settlement tanks, as in the percolating filter method.
2, It is then pumped into treatment tanks, where ----activated sludge, rich in micro-organisms, is added.
3, Oxygen is blown through the mixture
4. In the oxygenated mixture, the micro-organisms from the added activated sludge oxidize the polluting organic matter, reproducing as they do so.
5. Some of the sludge formed is recycled to seed new tanks. See figure 1.20 page22.

How are Bacteria Genetically Modified?

- **Genes** are the sections of the DNA of an organism that code for a particular protein.
- So, if a gene can be transferred successfully from one organism into a bacterium, the genetically modified bacterium will now make the protein that its ¨new gene¨ codes for.
- The development of **three main techniques** made genetic engineering possible.

1. The discovery that genes can be cut of as a DNA molecule using enzymes called **restriction endonuclease.**
2. The discovery that genes can be transferred (tied) into another DNA molecule using a **ligase enzyme.**
3. Genes can be transferred into other cells using **vectors.**

The vectors may be either **plasmids** (small pieces of circular DNA found in bacteria), or **viruses**.

- Once the gene has been inserted into the new bacterium, the bacterium becomes the genetically modified organism or a **transgenic organism**. Read page 23 and see figure 1. 21.
- **Genetic Engineering:** is the practice of transferring genes from one organism to another organism (either belonging to the same species or belonging to a different species).
- This is done by taking DNA from the first organism and transferring it to the second organism.
- Genetic engineering has only been practiced since **1980.**
- **Vector**:-is a means of transferring something.
- In genetic engineering viruses are used as vector to transfer genetic information between different organisms.

Steps of transferring Genes

1. Plasmids are isolated from a bacterium
2. Plasmids are opened with a specific **restriction endonuclease** enzyme (page 23).
3. The gene to be transferred is **cut** from the donor DNA using the **same** restriction endonuclease enzyme.
4. The opened-up plasmids and the isolated gene are mixed with a **DNA ligase** enzyme to create recombinant plasmid.
5. Bacteria are incubated with the recombinant plasmids. Some bacteria will take up the plasmids.
6. The bacteria that have taken up the plasmid now contain the gene from the donor cell.
   - This could be a gene controlling the production of human insulin (figure 1.21 page 23).
   - Bacteria are not the only organisms that have been genetically modified. Many crop plants have also had foreign genes inserted into them. These give the plants new properties, such as:
     1. resistance to infectious disease
     2. longer shelf-life before decaying 3. resistance to animal pests
   - Genetic engineering of plants posed problems for biologists, as plant cells will NOT accept plasmids in the same way as bacterial cells do.
   - However, they discovered that one bacterium, called ***Agrobacterium tumefaeciens,*** regularly infects plant cells.
   - This bacterium can act as a vector to carry genes that have been inserted into a genetically modified *Agrobacterium* into plants. Figure 1.22 page 24.shows how this is done.

Steps:

1. DNA from another species cut with restriction enzyme to isolate **designed gene.**
2. Plasmids are isolated from (*Agrobacterium*) and cut open with restriction endonuclease enzyme.
3. Cut plasmids **joined to desired gene** using ligase.
4. Leaf discs obtained from the plant to be modified are put in the nutrient medium (in the petri dish) and plasmids also put in

the petri dish.

5. Leaf discs floated on liquid containing the plasmids; some will take up the plasmids.

6. Leaf discs cultivated on a nutrient medium =**micro propagation**

7. Plants grow into whole plants whose cells now contain the foreign gene.

- However, *Agrobacterium* **cannot** be used to genetically modify all types of plant. It will **not** infect cereals such as maize.
- To solve this problem, biologists developed the **Gene Gun**.
- The **Gene Gun** literally shoots the genes into cells of plants using tiny bullets of **GOLD** that are covered with DNA. We could think of it as the **Golden Gun** (page 24 figure 1.23).
- The **gene gun** had made it possible to genetically modify plants such as maize, tobacco, carrots, soybean and apple.

For example maize has had genes inserted into it that causes it to:

1. produce a pesticide that makes it resistant to some insect pests
2. be resistant to some fungal diseases

- Answer Review Questions (page 25-26)

Viruses

- A **virus particle** (sometimes called a viron) is nothing like either a prokaryotic cell or a eukaryotic cell.
- **Viruses**: are much smaller than even a smallest bacterium.
- Most viruses are between 0.01 and 0.1 micro meter in length or diameter.
- This makes them at least 1000 time smaller than the smallest bacterium and 1,000,000 times smaller than most human cells.
- All virons (viruses) contain at least two components: 1. A protein shell or capsid
  2. DNA or RNA as genetic material.

Some also have: 1. a membrane made from lipid and proteins outside the capsid
2. others proteins and enzymes inside the capsid. (page 27)

Table: 1.3 Characteristics of viruses

Feature	***Viron (Virus Particle)***
Size	*0.01----0.001 micro meter*
Nucleus	*Absent*
DNA	*Tiny amount of tiny DNA in some; others contain RNA but no chromosomes*
Other cell organelles	*Absent*

- Viruses enter living cells and disrupt the metabolic system of the cell.
- The genetic material of the virus becomes incorporated with that of the cell and instructs to produce more viruses.
- Viruses **cannot** be treated with antibiotics as they are not true cells and are only active inside cells.
- Viruses are totally parasitic. Examples of diseases caused by viruses are:-

  1. Influenza (flu) 2. Measles 3. AIDS 4. Common cold 5. Chicken pox

- Because viruses **do not** have the major organelles that are present in living cells, they **cannot** carry out any of the normal metabolic processes of cells such as:

1. respiration
2. protein synthesis
3. photosynthesis
4. DNA replication
5. Active transport
6. facilitated diffusion, etc.
7. Any other processes requiring control by enzymes or the presence of proteins.

==As a result all viruses are **parasites.**

- The only way they reproduce is to invade cells, ″hijack‟ the normal metabolic processes of those cells, and make the cells produce more viruses.
- Once produced, the viruses escape from the cell and infect other cells. Figure 1.25 page 28 shows how this happens in two different types of viruses.
- Other viruses adopt different strategies.

Classifying Viruses

Due to great variation in shape and the way in which they infect cells, it is difficult to classify viruses.

However, they are classified into **3 main groups,** based on the nature of their genetic material and the way in which it is expressed. These groups are:

1. DNA viruses------E.g. Herpes, cause cold sores
2. RNA viruses -----E.g. HINI viruses, cause swine flu
3. Retroviruses-----E.g. HIV, cause AIDS

A. DNA viruses---when they infect a cell, the viral DNA can replicate itself and can also control the synthesis of virus proteins, so that the new DNA and new protein can be assembled into new virus particles.

B. **RNA viruses**: ---When they infect a cell, their RNA can be used to synthesize more viral proteins, including an enzyme that controls the synthesis of more RNA.

The new RNA and new proteins can be assembled into new viral particles.

- With the exception of RNA viruses, all organisms store permanent information in DNA, using RNA only as a temporary messenger for information.

DNA --- is quite a stable molecule,

---is NOT very reactive with other molecules,

---replicates very accurately.

- In contrast, **RNA** is quite **unstable** and **makes frequent mistakes** during copying.
- But these properties make RNA ideal for the storage of viral information.
- Once the host's immune system has learned to recognize an infecting virus and to create antibodies against it, it can quickly destroy it, and the virus needs to change its nature so that the host's immune system will no longer recognize it---it must mutate.
- The unstable nature of RNA allows RNA viruses to evolve far more rapidly than DNA viruses, frequently changing their surface structure.

C Retroviruses: also contain RNA, but replicate in a different way.

- When they infect cells their RNA and an enzyme that causes it to be ‘reverse transcribed’ into DNA.
- Then this controls the formation of more viral protein and RNA that can be assembled into new virus particles.
- We say that the RNA is **reverse-transcribed** because, in cells, DNA is normally transcribed into RNA as part of the process of protein synthesis. Carrying out the process in the opposite direction is **reverse transcription**

Viruses can also be classified by the type of organisms they infect:

1. Animal infecting viruses
2. Plant infecting viruses
3. Bacterial infecting viruses---Bacteriophages (page.29)

Virus multiplication

Most of our knowledge about how viruses are reproduced comes from Bacteriophages.

One bacteriophage in particular, called $\mathbf{T_4}$ has been studied more than any other. Its reproductive cycle is shown in fig 1.27 page30

The steps in the Reproductive Cycle of Bacteriophage

1. Bacteriophage attaches to host cell
2. Bacteriophage injects its DNA into bacterium
3. Virus-DNA controls the production of more virus DNA and protein coat.
4. Bacterial chromosome is **switched off** or even destroyed.
5. DNA and protein coats assembled into new virus particles
6. Host cell **bursts** open, releasing new virus particles.

- ♥ This type of life cycle is called a **lytic life-cycle** because it causes the rupture (**lysis**) of the host cell (p30).
- ♥ From research on bacteriophages, we know that this is NOT the only reproductive cycle type in viruses.
- ♥ Sometimes instead of causing the cell to burst and release the viruses all at once, **a few at a time** are released by exocytosis through the plasma membrane.
- ♥ This type of life cycle is called a **chronic release** because of the release of new viruses is **chronic (ongoing)**.
- ♥ In other cycles the viruses' DNA is **incorporated** into the DNA of the host cell.
- ♥ Each time the cell divides, the DNA is replicated, and each daughter cell gets a copy of the cell's DNA, which now includes the virus DNA.
- ♥ This can continue for many generations until some factor in the environment triggers the virus DNA to start producing virus proteins.
- ♥ Then whole viruses are assembled, which then leave the cell either by causing cell lysis (splitting) or by chronic (ongoing) exocytosis from the plasma membrane.
- ♥ This type of life cycle is called **lysogenic life cycle.**
- ♥ These different reproductive strategies are summarized in fig.1.28 page 31.

Reproductive strategies of viruses:		
1. Lytic life cycle	*2. Chronic release life cycle*	*3. Lysogenic life cycle*

Modes of Virus Transmission

As well as having different reproductive strategies inside the host cell, different viruses also enter cells in different ways:

1. The bacteriophage injects just its DNA; the rest part of the virus remains outside the cell.
2. Many (but not all) animal viruses manage to get the **whole** virus inside the cell.

- ❖ This is done by tricking the cell by bringing the virus into the cell in the same way as it would with any large protein molecule by using the process of **endocytosis.**

HIV and AIDS

HIV (Human Immuno deficeincy virus): is one of the retroviruses.

- ❖ This is transcribed to DNA by the enzyme reverse transcriptase, which HIV contains together with the RNA.
- ❖ Read the structure of HIV in page 32 figure 1.29
- ❖ HIV targets cells that form part of the immune system.
- ❖ Its main target is a type of cell called CD4-**Lymphocytes.**
- ❖ These cells are also called **T-helper cells,** because they **'help' other cells** in the immune system to mount an immune response to pathogens in the body.
- ❖ Without this response, pathogenic micro-organisms can multiply in the body and cause disease.

HIV--- has spikes on its surface, the **heads** of which are made from the glycoprotein known as $\mathbf{Gp_{120}}$

$\mathbf{Gp_{120}}$ sticking out of HIV virus particle connects with a **CD4** sticking out of a cell like an egg fitting into an egg cup.

- ♥ Once the virus has attached to a cell, it can go to the next stage and merge with the host cell. Read HIV infection of CD4 in page 32 fig.1.31.
- ♥ Besides the T-helper cells, there are other types of cells that carry CD4 on their surface such as macrophages and some **natural killer cells**.
- ♥ **T-helper cells** --are the most important because they are coordinators of the immune system.
- ♥ If their activity is impaired, it can have serious effects on the body's response to infections by other microorganisms.

How Does HIV Reproduce and Cause AIDS?

After HIV has bound to the CD4 receptors on the surface of T-helper cells, the following events occur:

1. It fuses with the plasma membrane and then releases its **RNA** and **reverse transcriptase** enzyme into the cell.
2. The reverse transcriptase converts the RNA into DNA using building blocks called **nucleotides**, which are provided by the cell.
3. The viral DNA becomes incorporated into the cell's DNA.
4. The viral DNA is transcribed to **viral RNA** which starts producing **viral proteins,** including the **reverse transcriptase.**
5. The RNA , proteins and reverse transcriptase molecules are assembled by the cell into new HIV particles that escape by budding from the cell membrane----this is an example of **chronic release.**
6. The viruses infect other T-helper cells;

- ⌗ Some HIV proteins remain on the surface of the infected CD4 cell and are recognized by the immune system--these cells are destroyed.
- ⌗ The cycle of infection, reproduction and destruction of infected cells repeats itself for as long as the body can keep replacing the CD4 -lymphocytes (page 33 fig. 1.32).
- ⌗ Eventually, the body will not be able to replace these cells, and the number of free viruses in the blood will **increase** dramatically
- ⌗ Now, once again, **HIV** may infect other areas of the body, including the **brain**.
- ⌗ Because of the drastic destruction in the number of T-helper cells, the immune function is severely reduced and many opportunistic infections may occur (including pneumonia and tuberculosis), together with rare cancers like **Kaposi's sarcoma**.
- ⌗ Figure 1.33 page 34 summarizes these changes.
- ⌗ The period when the body keeps replacing the CD4 lymphocytes as fast as they are destroyed is called **latency period** and can last for many years.

Latency----means present but not noticed. As well as infected cells being destroyed by natural killer cells, other lymphocytes make antibodies that target any free HIV in the blood.

- The presence of these antibodies can be detected, and the person is diagnosed as being **HIV-positive.**

Can AIDS be treated?

- There are a number of drugs called **anti-retroviral drugs.**
- These drugs work by **blocking** the reproduction of the virus in the CD4 -lymphocytes.
- There are also several different drugs that act in different ways at **different stages** of the cycle of HIV reproduction.
- Because of the drugs action on different stages of the HIV life cycle, the most effective treatment is obtained when they are used together.
- This called **HAART** (**H**igh **A**ctive **A**nti-**R**etroviral **T**reatment).
- Although it is effective against HIV, it does have unpleasant side effects.
- Please read figure 1.34 page 35 (The effects of different anti-retroviral drugs).

Microphage (also called **white blood cell**) is a cell that surrounds and destroys pathogens.
DNA virus contains genetic information stored in the DNA **RNA virus** contains genetic information stored in the RNA
AIDS is a disease that causes its victim's immune system to degenerate leaving them vulnerable to infectious diseases and some type of tumor

Social and Economic Impact of AIDS

1, Shame associated with admitting to being infected (which is connected with the taboo on speaking about sexuality)

2. Fear of being isolated (or putting the family under pressure)

3. Fear of losing a job, etc.

4. An increasing amount of money for medical treatment and burials,

5. The number of bread winners is decreasing.

Nationally, AIDS has a serious economic impact in two main ways (areas)

1. Labour supply-----the loss of young adults in their most productive years will affect overall economic output

2. Costs

- **Direct cost** --including expenditure for medical care, drugs and funeral expense
- **Indirect costs**- including lost time due to illness, recruitment and training costs to replace workers, and for care of orphans

= If costs have financed out of savings, then the reduction in investment could lead to a significant **reduction in economic growth**

The spread of AIDS can be limited by:

1. responsible sexual behavior --limiting the number of sexual partners using condoms
2. Male circumcision ---this reduces the risk of males acquiring the disease.
3. Answer Review Questions page 37--38

- The **spikes** on the surface of HIV are made from **three gp120** glycoprotein molecules attached to another molecule called **gp41.**
- The shape of these spikes allows them to **bind with CD4** receptors on the **T-helper cells.**
- Because they have this particular receptor on their surface, they are called **CD4 lymphocytes.**

Review questions

I. Say True or False

1. Deficiency disease can be caused by the entry of pathogenic micro-organisms into the body
2. Human induced diseases are caused by life style or working conditions
3. Infectious diseases are caused by lack of specific nutrients
4. Degenerative diseases are often caused by ageing
5. Genetic diseases are often caused by mutant alleles (genes)
6. Alcoholism and drug addiction can cause social diseases
7. Bacteria are different from other micro-organisms because they do not have cellular organelles and cannot carry out any metabolic processes.
8. Bacteriophages are a type of bacteria with DNA as their genetic material.
9. The CD4 receptor on HIV binds with the glycoprotein (gp120) on T-helper cells.
10. AIDS is often treated by HAART in which several anti- retroviral drugs are combined to target in different ways at different stages of the cycle of HIV reproduction.
11. The Bacteriophage injects just its DNA; the rest of the virus remains outside the cell.
12. AIDS **increases** the body's immune response by reducing the number of T-helper cells.
13. When the body is replacing the helper cells as fast as they are destroyed, the person is said to be in the latency phase of infection.

II. Choose the correct answer

14. Genetically modified bacteria are used to produce
    A. insulin B. Antibiotics C. Human growth hormone D. all
15. Vinegar is too acidic for most micro-organisms to grow and multiply, so keeping foods in vinegar is a good way of preserving them. This method of preserving food is called:
    A. pasteurization B. pickling C. vinegaring D. acidifying
16. Sulphur is released from proteins of dead matter as
    A. SO_4 B. SO_3 C. H_2S D. SH
17. Which of the following does not contain nitrogen?
    A. carbohydrates B. ATP C. proteins D. RNA E. DNA
18. Which of the following diseases cannot be transmitted through sexual intercourse?
    A. Salmonellosis B. Syphilis C. Candidiasis D. Gonorrhea
19. Which of the following can be considered as a reservoir of infection?
    A. Humans and other animals B. Soil and air C. Food and water D. All of the above
20. Which of the following is **not** the result of genetic engineering in most plants?
    A. Conversion of monocots to dicots C. Resistance to animal pests
    B. Resistance to infectious diseases D. Resistance to animal pests
21. Which of the following occurs in viruses?
    A. Respiration and photosynthesis C. Protein synthesis
    B. Possession of life outside living cell D. Possession of genetic material
22. HIV is an example of: A. DNA virus B. retrovirus C. Bacteriophage D. A and B
23. Which of the following is correct?
    A. HIV has spikes on its surface, the heads of which are made from the glycoprotein known as **gp**120
    B. gp120 binds with CD4, a protein that protrudes from various types of human cell.
    C. A gp120 sticking out of an HIV virus particle connects with a CD4 sticking out of a cell
    D. Once the virus has attached to a cell, it can go on to the next stage and merge with the host cell.
    E. All of the above
24. Which of the following is NOT the social and economic impact of AIDS?
    A. Immunity from animal diseases B. Fear of losing a job
    C. Fear of being isolated D. Shame associated with admitting to being infected
25. Which of the following is an example of protozoa?
    A. Chlamydomonas B. Lactobacillus C. Streptococcus D. Plasmodium
26. What does reverse transcriptase do?
    A. It synthesizes proteins from mRNA C. It synthesizes DNA from RNA

B. It synthesizes tRNA from DNA D. It synthesizes RNA from DNA

27. Which of the following is the correct sequence of the stapes in the process of viral infection?
A. Attachment→ penetration→ assembly→ release→ replication
B. Attachment →penetration→ replication→ assembly→ release
C. Penetration →attachment →replication →release→ assembly
D. Assembly →replication →penetration →release→ attachment

28. Which of the following characteristics makes viruses living?
A. Presence of nucleic acid C. They show mutability
B. They reproduce within the host cell D. All of the above

.29. Though the various types of viruses differ in many ways, all are alike in possessing:
A. Nucleic acid B. Ribosomes C. RNA transcriptase D. Mitochondria

30. When a virus acts as a vehicle for the transfer of genes from one bacterium to another, the process is called:
A. Transduction B. Transformation C. Transcription D. Translation

Answer for Review Questions (Unit 1)

1	**F**	**4**	**T**	**7**	**F**	**10**	**T**	**13**	**T**	**16**	**C**	**19**	**D**	**22**	**B**	**25**	**D**	**28**	**B**
2	**T**	**5**	**T**	**8**	**F**	**11**	**T**	**14**	**D**	**17**	**A**	**20**	**A**	**23**	**E**	**26**	**C**	**29**	**A**
3	**F**	**6**	**T**	**9**	**F**	**12**	**F**	**15**	**B**	**18**	**A**	**21**	**D**	**24**	**A**	**27**	**B**	**30**	**A**

Unit Two
Ecology

Ecology: is the study of how living things interact with each other and with their environment.

- ♥ It is the e branch of biology concerned with the study of the balance of nature.
- ♥ The study of the **single** species is called **autecology**.

Synecology: is the study of the complete ecosystems consisting of **many species** which interact with each other and with their non-living surroundings.

The earth's environment consists of **three zones**. These are:

1. Lithosphere (**land**) **2**. Hydrosphere (**water**) **3.** Atmosphere (**air**)

The part of the earth that contains life is known as **biosphere.**

The major components of the biosphere are:

1. Biotic factors (living things) **2.** Abiotic factors (non-living things)

- ♥ The biosphere is divided into large, stable ecological units each having a characteristic distribution pattern of living things. These units have been referred to as **biomes**.
- ♥ Each biome is designated by the dominant plant life and owes its existence to major environmental factors such as:

1. Climatic zones, 2. Rain fall 3. Soil type and 4. Hydrologic conditions.

- ♥ **Life** and its systems are organized at different levels called **levels of biological organization**.
- ♥ This can be represented as follows:
- ♥ **Cell→ Tissue→ Organ→ Organ system→ Organism→ Population→ Community→ Ecosystem→ Biosphere**
- ☞ Ecology studies those levels **beyond the organism**.
- ☞ This means, ecology deals with biological principles governing the **population**, the **community** and the **ecosystem.**

Population: is a group of closely related organisms that normally interbreed (same species) and live together.

Community: is composed of all the populations in a given area.

Ecosystem: is the most fundamental level of biological organization above the organism level, consisting of the living components plus the non-living factors of the environment.

E**cosystem** is a natural unit in which energy **flows** from the source to producers, consumers and decomposers, and nutrients **circulate** from the soil through plants, animals and back to the soil through the action of **micro-organisms.**

Habitat: is a place in an ecosystem where individual organisms normally live.

Microhabitat: is a particular location within the same overall habitat having the own special conditions.

- The bark of a rotting log in a fallen tree for example, is considered as a microhabitat where organisms like the woodlouse live.

Ecological niche: refers to the populations' **role** in the community, including all the biotic and abiotic factors under which the species can successfully survive and reproduce.

Niche is an area or position which is exactly suitable for a given population.

- **Ecosystem** is a dynamic unit through which substances are constantly flowing.
- **Ecosystem** is provided with sufficient amount of **energy** to allow the flow of substances to take place.
- The ultimate source of energy in any ecosystem is the **sun.**
- Organisms can be placed under the groups as: 1. **Autotrophs (producers)** and
  2. **Heterotrophs (consumers**)
- There is a finite amount of each nutrient in an ecosystem and so the same atoms must constantly be re-used, over and over again.
- This happens at the ecosystem level and so globally.
- Ecosystems look unchanging, but they are in fact **always changing (dynamic)**.
- Materials are always being 'moved around' within an ecosystem.
- Nutrients are always being taken in by organisms and materials are **lost** when the organisms breathe and excrete.
- What is a **waste product** to one organism becomes a **vital** nutrient to another organism.
- All the organisms in the ecosystem are **interdependent** and interact with their physical environment.
- Materials are moved around an ecosystem when organisms:
  1. feed **2**. excrete **3**. respire and breathe. **4**. die and decomposed
- The molecules that are moved around, particularly the organic molecules, store large amounts of energy in the bonds holding the atoms together.
- So, as materials are moved, energy is transferred also.
- But, energy is eventually lost from the ecosystem as heat and must be replaced as **light** (energy is **not** recycled).
- The nutrients just keep on being recycled.
- **Decomposers** (bacteria and fungi) are a key in returning nutrients to the ecosystem.
- Important mineral elements such as **nitrogen** and **phosphorus** are returned to plants as a result of the action of decomposers.
- **Decomposers** feed by a method known as **saprophytic nutrition.**
- They feed on dead matter. To do this, they secrete enzymes onto the dead matter.
- The **enzymes** digest the complex organic molecules into, simpler smaller ones and the micro-organisms absorb these products of digestion.
- Unlike us, their **extracellular digestion** does not take place in a gut, it takes place in the **soil**, or wherever the dead matter happens to be.

- ➲ However, besides hydrolytic enzymes that break down complex organic molecules many micro-organisms have enzymes for other purposes.
- ➲ For example, many of the decomposers have an enzyme that **releases the amino group** from amino acids and convert it to **ammonia.**
- ➲ This is known as **ammonification** and is important in the **nitrogen cycle**.
- ➲ Ammonification is carried out by a range of **bacteria** and **fungi** as a way of obtaining energy from organic, nitrogen-containing compounds.
- ➲ The ammonia, vital to the nitrogen cycle, is just a useless by-product to these micro-organisms.
- ➲ This is typical of many of the chemical reactions that take place in all the nutrient cycles.
- ➲ These reactions are primarily energy-releasing reactions for a particular type of micro-organism.
- ➲ It is a´ happy chance ' that the reactions produce a **by-product** that can be processed in the next stage of the nutrient cycle.

What are the Main Stages in the Carbon cycle?

The main processes involved in cycling carbon through the ecosystem are:

1. Photosynthesis
2. Feeding and assimilation
4. Combustion of fossil fuels
5. Fossilization
6. Respiration

1, Photosynthesis: the process that fixes carbon atoms from an inorganic source (CO_2) into organic compounds (e.g. glucose).

2, Feeding and assimilation: animals consume plants directly or indirectly, and make their own protein.

- ❖ Feeding passes carbon atoms already in complex molecules to the next trophic level in the **food chain** where they are assimilated into (become part of) the body of that organism.

3, Respiration: this releases **inorganic carbon dioxide** from organic compounds to the atmosphere.

4, Combustion of fossil fuels: fossil fuels are burned, releasing carbon dioxide into the atmosphere.

5, **Fossilization**: sometimes living things do not decay fully when they die due to the conditions in the soil, and fossil fuels (e.g.coal, oil and peat) are formed ---See page 47

The cycling of carbon is essential to the living world as all the organic molecules found in living organisms are based on carbon.

We often talk about the Earth having '**carbon-based life forms**'.

What are the Main Stages in Nitrogen Cycle?

Nitrogen is present in **proteins**, **amino acids**, **DNA**, **RNA**, **ATP** & **ADP.**

Without nitrogen organisms **could not synthesize:**
1. Their genetic material (DNA)
2. Their principal structural materials (proteins) and
3. Their principal energy transfer molecule (ATP)

The main processes in the Nitrogen cycle are:

1. Plants absorb nitrates (NO_3) from the soil
2. The nitrates are then used to form amino acids, which are used to synthesize proteins
3, Plants are eaten by animals, the proteins digested and the amino acids absorbed and assimilated into animal proteins.
4, Both plants and animals die, leaving a collection of dead materials (detritus) which contain the nitrogen still fixed in organic molecules; in addition, excretory products such as **urea** also contain nitrogen

5. Decomposers decay the excretory products and detritus, releasing ammonium ions (NH_4^+) into the soil; this process is often referred to as **ammonification.**

6. **Nitrifying bacteria** oxidize the ammonium ions to nitrates (NO_3^-) and the process is called **nitrification**. In this process there is an intermediate product called **nitrite** (NO_2^-).

- ♥ The **nitrate (NO_3^-)** once again is taken by plants to produce amino acids and proteins and the cycle completes here.

Note: The conversion of ammonium ions to nitrite ions involves **oxidative reactions**, because the nitrogen atoms in the original ammonium ions **gain oxygen** atoms and lose **hydrogen** ions as the simple equation like:

$$\mathbf{NH_4^+ + 2O_2 \longrightarrow NO_2^- + 2H_2O}$$

The hydrogen ions lost must go somewhere and the oxygen atoms must have come from somewhere, so something else is being reduced.

In actual fact, it is a much more complex reaction as the next equation shows:

$$\mathbf{55NH_4^+ + 76O_2 + 109\ HCO_3^- \longrightarrow C_5H_7O_2N + 54NO_2^- + 57H_2O + 104H_2CO_3}$$ (carbonic acid)

- The hydrogen ions reduce the hydrogen carbonate ions to **carbonic acid**.
- The oxygen atoms that join the nitrogen atom are themselves reduced in the reaction. **Reduction** and **oxidation** always occur together.
- These processes recycle nitrogen that is already in biological molecules of one kind or another.
- But, besides this, **two** other processes, **denitrification** and **nitrogen fixation**, decrease or increase, respectively, the amount of nitrogen in the circulation.

1. **Denitrifying bacteria**: reduce nitrate to nitrogen gas that escapes from the soil. This decreases the total amount of nitrogen available to the plants, and, therefore, to all organisms also.

2. **Nitrogen fixing bacteria**: 'fix' nitrogen gas into ammonium ions. This happens in two main situations:

- Nitrogen fixing bacteria free in the soil (belonging to genera Azotobacter and Klebsiela) reduce nitrogen gas into **ammonium** (in the soil).
- Theses ammonium ions (NH_4^+) can be oxidized immediately into nitrates by nitrifying bacteria, adding to the amount of the nitrogen to the plants and, therefore, the other organisms also.
- **Nitrogen fixing bacteria** (belonging to the genus Rhizobium) in root nodules of the leguminous plants form ammonium ions (NH_4^+) that are passed to the legumes and used by them to synthesize amino acids.
- The extra nitrogen only becomes available to other organisms when the legumes **die** and are **decomposed**. See figure 2.7A and 2.7B page 49.
- **Ammonification**:- is removal of amino group from amino acids, (decomposition of proteins)
- Ammonification releases ammonia, and this is subsequently converted into nitrite and nitrate.

Amino acids $\xrightarrow{a}$ NH_3 $\xrightarrow{b}$ NO_2 $\xrightarrow{c}$ NO_3

a—enzymes in ammonifying bacteria b—enzymes in Nitrosomonas c—enzymes in Nitrobacter

Nitrates are absorbed by plants, and assimilated (fg.2.6 page 48).

Phosphorus Cycle

Phosphorus is present in organisms in the form of **phosphates (PO_4).**

1. Phosphate is absorbed from the soil (or water) by plants
2. These are passed along food chains to various herbivores and carnivores
3, On death, their bodies are decomposed and phosphate ions are released from compounds like phospholipids, ATP, DNA and RNA and are returned to the soil or water.

4, Phosphates also enter the soil or water as a result of weathering of rocks and in the form of fertilizers, which, themselves, contain phosphates that have been obtained from rocks.

5. Over millions of years, phosphate ions can leach into the seas and become part of newly forming sedimentary rock. See fig.2.8 pp. 50.

Sulphur Cycle

- ♥ As with phosphorus cycles, the **sulphur** cycle is between the soil, plants, animals and special decomposers.
- ♥ There are also components that relate to long term rock formation and weathering as well as the formation of **sulphur dioxide** when fossil fuels are burned. See figure 2.9 page 51.

1. **Sulphate ions** (SO_4) in the soil are taken up by plants and incorporated in plant tissue (many proteins include some sulphur-containing amino acids, such as methionine and cysteine)

2. These **ions** (SO_4) are **passed** to animals by feeding and digestion

3. On **death** of plants and animals, sulphur-reducing bacteria release the sulphur in the proteins in the form of hydrogen sulphide (with the smell of rotten eggs); the most important genus of bacteria involved in this process is Desulphovibrio; this process requires anaerobic conditions.

4, In some aquatic environments the hydrogen sulphide is **oxidized** to sulphur by photosynthetic sulphur bacteria; this reaction **photolysis** of water in **photosynthesis** of higher plants.

5, **Sulphur-bacteria**, mainly of the genus ***Thiobacillus***, then oxidize the hydrogen sulphide (or sulphur) to sulphate (SO_4^{2-}), with sulphite (SO_3^{2-}) as an intermediate step; this is an oxygen requiring process that needs **aerobic conditions** and makes the sulphate ions available once again to be taken up by plant roots from the soil.

6. Sulphur can also become **incorporated with rocks**, including those that yield fossil fuels.

7. Combustion of fossil fuels **oxidizes the sulphur to sulphur dioxide(SO_2);** this is a series pollutant of the atmosphere and a major contributor to the formation of acid rain.

8. In the atmosphere, the sulphur dioxide becomes further oxidized to **sulphite** and **sulphate** which dissolve in **rain water** to form a mixture of **sulphurous** and **sulphuric acid**.See figure 2.9 pp. 51.

Water Cycle

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

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

In addition, we use water in many ways in our daily lives:

1. To wash our clothes, our dirty dishes and our dirty selves
2. To flash away waste
3. To make products such as paper, steel and beer
4. To generate electricity using a range of devices that converts the motion of water into electrical energy
5. In a system, called **hydroponics**, to grow plants in soil-free medium.

What is Succession?

- ❖ The ecosystems that exist today did not always exist. They have developed from other previous systems by **succession.**
- ❖ And many of them began on completely **bare ground.**
- ❖ Bare rock does not remain bare for long. Very soon, lichens can be seen growing on the surface of rocks.

- ❖ These extremely resilient (able to recover quickly) organisms are able to colonize harsh environments and reproduce there. They are **pioneer species.**

The essence of succession

1. Organisms organize and colonize an area.
2. They change the abiotic (physical) conditions in an area.
3. The changed abiotic conditions allow other species to colonize the area
4. The species compete with the ones there before and become **dominant.**
5. They also change the biotic conditions, more species enter and the process continues.

- The various stages in the succession are called **sere.**
- As successive producers colonize the area, they create more and different habitats and niches for other organisms to occupy.
- As a consequence, succession usually involves an increase in the **complexity of food webs.**
- The final, most complex, state of a succession is the **climax community.**

The following trends occur in any succession

1. The total biomass of the community increases
2. The species diversity increases
3. The number of ecological niches increases
4. Food webs become complex
5. The community becomes more stable--can accommodate small changes (losses) more easily.

- ❖ A woodland climax can arise through a totally different succession.
- ❖ A lake or pond can undergo a succession that results in the water being replaced by sediments allowing land plants to grow and giving rise to a succession those results in woodland. Figure 2.14 page 56.
- ❖ An open water area with little obvious vegetation can support animal life because of plankton in the water and smaller animals in the mud at bottom.
- ❖ Submerged plants become established in the sediment formed by the dead animals.
- ❖ They increase the amount of sediment as they die and larger plants become established.
- ❖ The succession that takes place from rock is called a **xero sere.**
- ❖ The succession that takes place (starts) from **water** is called a **hydro sere.**

Why do different areas have different climax communities?

- **Forest climax** communities in Europe do not become as complex as tropical rain forest because of the **climate.**
- Because of this they are said to be **climatic climax communities.**
- Grassland in many areas would revert to woodland or forest if it were **not** grazed.
- Other factors that could influence the type of climax community formed include:
  1. temperature 2. Soil type 3. soil depth 4. precipitation (rain fall)

- ❖ If a succession starts from **bare**, previously **uncolonized ground** or from a **newly formed pond** with no life, the succession is called a **primary** succession.
- ❖ Sometimes, communities are destroyed by **fire** or by farmers ploughing a field or by some other human intervention.
- ❖ When a new succession begins in such an area, it is called a **secondary** succession.
- ❖ **Secondary successions are usually much quicker** than primary successions because:

1. The succession is **not** starting from bare rock/or open water

2. There is a seed bank of many of the climax plant types available in remaining undamaged plants.

3. The soil is already present. Assignment: Answer Review Questions page 57-58

Biomes

Biome is a geographical or regional area with:

1. Specific climate,

2. Specific soil type, and

3. Specific plants and animals that are adapted in similar ways to the abiotic conditions within the area.

In 1875, the geologist **Eduard Suess** first coined the term **biosphere**.

He used this to describe the layer of the Earth's surface where life is found. We divide the biosphere into a number of biomes.

There are several biomes to be found within Ethiopia.

1, **Wetter portions** of the western highlands consist of **tropical montane** vegetation with dense, luxuriant forests and rich undergrowth (pp. 60).

2. **Drier sections** at lower elevations of the western and eastern highlands contain **tropical montane forest mixed with grassland.**

3.**Temperate** grasslands cover the higher altitude of the western and eastern highlands.

4, Tropical dry forest is found in the rift valley and eastern lowland together with some dry grassland areas.

5. **Dry grassland** also covers portions of Denakil Plain

Temperature and **precipitation** (rain fall) are the most significant climatic factors in determining biome type.

- These, in return, are determined to a very large extent by **geographical location.**
- For example, it is never anything but **cold at the poles**, and these areas also receive little precipitation.
- It is never anything but hot at the equator and equatorial regions receive **high precipitation.**

Two Main types of Biomes

- 1. **Terrestrial biome** 2. **Aquatic Biomes**
- A **Terrestrial biome**: is defined by temperature, rain fall, soil type, flora and fauna (plants and animals)

---See table 2.1 page 60

Table: 2.1 the characteristics of the major terrestrial biomes

Biome	***Precipi-Tation***	***Temperature***	***Soil***	***Plants***	***Animals***
Desert (hot)	*Almost None*	*Hot*	*Poor*	*Sparse -succulents, (E.g. cactus), Sage brush*	*Sparse insects, arachnids, reptiles & birds*
Desert (cold)	*Almost None*	*Cold*	*Poor*	*Sparse micro-organisms & some lichens*	*Sparse -polar bears, seals*
Thorn Forest (Scrub)	*Dry summer & Rainy winter*	*Hot summer, Cold winter*	*Poor*	*Shrubs, some woodland (Like scrub oak*	*Drought & fire adapted animals*
Tundra	*Dry*	*Cold*	*Frozen soil (Permafrost)*	*Lichens & mosses*	*Migrating animals*
Boreal Forest (taiga)	*Adequate*	*Cool year Round*	*Poor, rocky soil*	*Conifers*	*Many mammals, birds, insects, arachnids,etc.*
Temperate Deciduous Forest	*Adequate*	*Cool season warm season*	*Fertile soil*	*Deciduous trees*	*Many mammals, birds, insects, reptiles, etc*

Tropical Montane Forest	*8-9 wet months Air always humid*	*Always warm*	*Fertile soil*	*Ferns, tree ferns, Large deciduous trees Epiphytes*	*Many Animals*
Tropical Rain forest	*Very wet*	*Always warm*	*Poor, thin soil*	*Many plants, epiphytes Common*	*Many Animals*

Aquatic Biomes

1. Marine water **2. Fresh water**

Table 2.2 The main features of the aquatic biomes

Biome	Salt content	Moving or Standing	Other features	Animals and plants
1. Marine				
Oceanic, Plagic	*High*	*Moving*	*The region of the ocean where light penetrates*	*Many fish mammals & plankton*
Oceanic, Abyssal	*High*	*Less movement*	*The region of the ocean where no light penetrates*	*Algler fish, sulphur bacteria at vents*
Coral reef	*High*	*Moving*	*Most diverse of all marine habitats Has many strata like rain forest*	*Corals, many fish, many sea weeds*
Estuarine	*Inter-mediate*	*Extreme movement*	*Unique habitat due to mixing of salt water & fresh water*	*Shore birds, fish, crabs, mangroves, kelps, sea grass*
2. Fresh water				
Pond and lakes	*Fresh water*	*Standing*	*Are stratified as top layer absorbs more heat and light*	*Large numbers of plankton, plants and animals in top layer*
Streams and rivers	*Fresh water*	*Moving*	*Water is highly oxygenated*	*Algae, plankton, plants and fish*
Wetlands	*Fresh water*	*Standing*	*Water is very nutrient rich*	*Many plants and animals Highest of all aquatic biomes*

Biodiversity

- The word **biodiversity** is used to describe the number, variety, and variability of living things.
- **Biodiversity** can be seen at hierarchical categories usually at the levels of genes, species, ecosystems and culture.
- The diversity of living things is dynamic. It increases when new genetic variation (new species) is produced.
- It decreases when the genetic variation within species decreases.
- The most useful way to think about **biodiversity** is in terms of **species richness**.

Species richness is quite simply the number of different species that are present in an ecosystem.

- ❖ The more useful concept is **species diversity.**
- ❖ This takes into account, not just how many different species are present, but the success of each species in the ecosystem.
- ❖ An index of diversity can be calculated and this can be used to give a picture of the ecosystem as a whole---Table 2.3 page 64.
- ❖ One index of biodiversity is **Simpson's index of diversity** and is commonly used to evaluate the species diversity in a given habitat and calculated from the formula:

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

Where d= index of diversity
N= total number of organisms in an area
n= total number of organisms of each species

Table: 2.3 three invented ecosystem

Species	*Number of organisms of each species*		
	Area 1	***Area 2***	***Area 3***
A	*86*	*16*	*23*
B	*5*	*17*	*25*
C	*2*	*16*	*27*
D	*3*	*17*	*5*
E	*1*	*17*	*12*
F	*3*	*17*	*8*

- A **higher** diversity index suggests a number of **successful species** and a **more stable ecosystem**.
- When more ecological niches are available, the environment is likely to be **less** hostile.
- Environmental change is likely to be less damaging to the ecosystem as a whole unless it affects all the plants present.
- **Tropical rain forests** provide an example of a **stable ecosystem** with high species diversity.

1. In area 1, only species **A** is really successful and dominates the area.
2. In area 2, **all** the species are more or less equally successful.
3. In area 3, three of the six species dominate the area.

For area 1: $d = \frac{100(100-1)=100x(100-1)}{(86x85) + (5x4) +(2x1) + (3x2) +(1x0)+(3x2)} = \mathbf{1.348}$

For area 2: $d = \frac{100 \times (100-1)}{(16x15)+(17x16)+(16x15)+(17x16)+(17x16)+(17x16)} = \mathbf{6.314}$

For area 3: $d = \frac{100 \times (100-1)}{(23x22)+(25x24)+(27x26) + (5x4) +(12x11)+(8x7)} = \mathbf{4.911}$

- A low value for the index of diversity suggests an area dominated by **one** or **just a few** species.
- If there are more successful species with **no** species completely dominated the area , the value for the index of diversity will be **higher.**

A low value for the index of diversity, suggesting only a few successful species, and this could be the result of a hostile environment with only a few organisms being really well adapted to that environment.

- Changes in the environment would probably have quite serious effects.
- If those **few species** that can survive are seriously affected, then the whole ecosystem may be disrupted (read page 64-66).
- However, biodiversity is not just about the numbers of different species and how well they are doing.
- It is also about the diverse ways in which these different species are found.

So we must also consider:

1. The ecological diversity of each species----how many different ecological niches has it managed to colonize?
2. The genetic diversity of each species --is there just one strain of the species with essentially one set of genes (the gene pool) or are there several different (but related) gene pools because there several different (but related) populations of the species living in different areas?

So, biodiversity is a measure of the overall variability of life on the planet (or a local area) and it includes:

1. The species richness and species diversity of the planet (or the local area)
2. The ecological variability of each species
3. The genetic variability of each species

Biodiversity: refers to the number, variety and variability of living organisms (plants, animals and micro-organisms).

Biodiversity is usually seen at the levels of genes, species, and ecosystems and culture that describe different aspects of living systems.

- The biodiversity can **increase** when the new genetic variation is produced, new specie is created, or a new ecosystem is formed.

- **Biodiversity decreases** when the genetic variation within species decrease, a species becomes extinct or an ecosystem complex is **lost**.
- **Genetic diversity**:-refers to the variation of genes within species.
- **Species diversity**:-refers to the variety of species within the region.

Such diversity can be measured in many ways like

1. Species richness, **2**. Species abundance and **3**. taxonomic diversity

Species richness: is the total number of species in the defined area.

Species abundance: refers to the relative numbers among species

Taxonomic diversity: is the variation of species from each other as seen by their taxonomic distribution in genera, families, orders, classes and phyla.

How have Humans Influenced Biodiversity

- Only for the worse. We humans have influenced our environment much more than any other species.
- This is one of the key features of human evolution.
- We have not so much adapted to our environment by natural selection, as changed the environment to suit us.
- Until relatively, recently, because of the small numbers of humans, this has not been too much of a problem.
- However, the rate of this change has accelerated with the huge increase in our population and the development of our technology.
- We have reduced biodiversity in many ways, but **two** important activities have been observed.

These are: **1**. deforestation, and **2**. the impact of agriculture

How has deforestation affected Biodiversity?

Deforestation is usually carried out for one of two main reasons:

1. to clear land for human activities, such as mining, agriculture or house building, or
2. to obtain timber to make products such as paper, charcoal, furniture, or to use as a building material.

- **Tropical rain forest**: is one of the most complex and species-rich ecosystem in the world.
- Rainforest covers about **7% of the Earth's surface** and contain **25% of the known species.**
- Although, many of the trees are very tall, the **root systems are shallow** and **trees can easily fall.**
- The shallow root systems grow in shallow, **nutrient-poor soils.**
- The soils are **nutrient-poor** because many of the minerals from the soil remain '**locked up**' in the huge trees.
- There is **no accumulation of detritus** as decomposers rapidly break down the leaves and release the mineral ions they contain.
- The roots take these up, leaving few mineral ions in the soil.
- As a result, when the forest is cleared for agriculture, crop yields are often poor after the first year and more forest must be cleared.
- Tropical rainforest is the most natural land ecosystems.
- The net primary production (biomass produced allowing for losses due to respiration) is **2.2 kg $m^{-2}y^{-1}$**, nearly **twice** that of temperate forests.

Felling tropical forests has far-reaching effects

1, There is a serious reduction in species diversity.

- Many ecological niches are destroyed when trees are felled and the species that fill these niches are lost. This **reduces** the biodiversity of the area.

2, There is reduction in the rate at which carbon dioxide is removed from the atmosphere.

- ❖ In addition, if trees are burned, then carbon dioxide is added to the atmosphere.
- ❖ The local and global cycling of carbon is therefore, affected.

3. There is a reduction in the amount of **nitrogen** returned to the soil.

- ❖ The nitrogen fixed in the proteins and other compounds in the massive tree trunks remains fixed in a table in London, New York or Addis Ababa.
- ❖ Any tree trunks not removed from the area are slow to decay and the soil is depleted in nitrate for many years.

4, A secondary succession will take place.

- ❖ If the felled areas are allowed to regenerate, the seeds of many species of plants from the shrub layer will germinate.
- ❖ Ordinarily, the shrub layer is limited because the canopy prevents much of the light from reaching lower levels.
- ❖ If the shrub layer is allowed to dominate, this could give rise to a less complex ecosystem with a lower diversity.
- ❖ The felling of trees need **not be**, totally destructive and the practice need not be halted (stopped).
- ❖ However, the rainforests must be conserved and felling and replanting in a planned cycle over a number of years can do this.
- ❖ This could give a sustainable yield of timber without endangering the species diversity of the rainforests.
- ❖ One practice that has been adopted is to fell a strip of forest approximately **20 m wide** and take the felled trunks to the saw mill for processing.
- ❖ This strip of land is not touched again for 20 years.
- ❖ In those 20 years, a secondary succession will have produced secondary forest' and the 20-year-old trees can be felled.
- ❖ For the intervening 19 years, other strips of forest are felled.
- ❖ Some areas are left completely untouched and act as a seed bank and core area, maintaining all ecological niches for the whole area.

What are the Effects of Agriculture on Biodiversity?

- ⌗ The effects of large -scale agriculture often follow the same pattern.
- ⌗ Large areas of land are given over to the production of just **one crop plant,** such as maize or another cereal.
- ⌗ This inevitably brings a reduction in biodiversity for several reasons, including:

1. The area is dominated just by **one** species, drastically reducing the number of niches for other organisms to fill.

2. Organisms that might live there are regarded as **pests**, as they reduce the crop yield and so they controlled by the use of pesticides, and

3. Hedgerows (rows of bushes) are removed to create bigger and more productive fields; this reduces still further the number of habitats and niches and, therefore, reduces the biodiversity of the area.

- ❖ Traditionally, crops were ´**rotated**´ so that in a field one year a cereal would be grown, another year perhaps a root crop such as carrots, then in another year a **legume** such as beans and perhaps one year ´**fallow**´ (just grass, no crop).
- ❖ The **rotation** would be carried out with different timings in different fields, so that all crops were always available.
- ❖ This meant that different animals could find different habitats.
- ❖ However, the intensive farming of just one crop year after year, keeping pests at bay (one part) with herbicides and pesticides, reduces the habitats available. →Such practices have been blamed for the decline and, in some cases, the local extinction of species.

What is the status of biodiversity in Africa?

- Areas that have high plant species richness often also have high mammal species richness--and vice versa
- This is because plants provide habitats and niches for animals.
- So the more different plants there are, the more different habitats and niches for animals (including mammals) there will be.
- Figures 2.25A and B page 69 show the mammal species richness and plant species richness in Africa.
- We can clearly see that the **two** (the mammal species richness and the plant species richness) are related.

What about Biodiversity in Ethiopia?

- We can see from figure 2.25A and B that biodiversity in parts of Ethiopia, compared to other African countries, is better than most, although not as high as in some nearby countries, such as Kenya.

Ethiopia is an important regional center of biological diversity.

Some of the reasons for high biodiversity in Ethiopia

1. The wide rage in altitude and climate,
2. The isolation of highlands of Ethiopia, and
3. The fact that there are so many different biomes present in the country.

- One estimate suggests that there are between 6500 and 6700 plant species in Ethiopia.
- This represents the **fifth** most diverse flora in **Africa**.
- About 10-12% of these plant species are endemic to Ethiopia (approximately 1150 plant species).
- Ethiopia is one of the **12** centers of origin (Vavilov centers) of cultivated crops.
- There are **11 cultivated crops**, which have their center of genetic diversity in Ethiopia.
- These are:

1. *Coffee arabica*----------Coffee
2. *Eragrotis tef*----------*T*eff
3. *Ensete vertriculum*----------Enset
4. *Coccinia abyssinica*----------Anchote
5. *Guizotia abyssinica*----------Niger seed (Nug)
6. *Brassica carinata*----------Ethiopian rape (Gomen zer)
7. *Carthamus tictures*----------Safflower (Suf)
8. *Sorghum spp*.----------Sorghum
9. *Hordeum spp*.----------Barley
10. *Iinum usitatissimum*----------Linseed (Telba)
11. *Ricinus communis* ----------Castor bean (Gulo)

Ethiopia is also an important center for genetic diversity of forage plants. About 46 legumes are endemic to Ethiopia. They include:

1. Species of trifolium (clover) 2. Vigna (a type of bean) 3. Lablab (all plant parts are edible)

- These plants, used as animal feed, are important because they add **nitrogen** to the soil in which they grow as they have nitrogen-fixing bacteria living symbiotically in their roots.
- The high species richness creates many diverse ecological zones with many ecological niches for animals to fill.
- Every group of vertebrate animals is well represented in Ethiopia as table 2.4 page 70 (Vertebrate biodiversity of Ethiopia).

Table: 2.4 A summary of the vertebrate biodiversity of Ethiopia

Vertebrate Group	*Number of order*	*Number of family*	*Number of genus*	*Number of species*	*Endemic to Ethiopia*
Mammals	*12*	*40*	*144*	*277*	*22*
Birds	*24*	*87*	*306*	*861*	*27*

Reptiles	*4*	*15*	*36*	*78*	*3*
Amphibians	*5*	*7*	*19*	*63*	*17*
Fish	*5*	*14*	*33*	*101*	*4*

- In terms of the biodiversity of its **avifauna (birds),** Ethiopia is one of the most significant countries in mainland of Africa.
- Again, Ethiopia's diverge ecology contributes to the tremendously diverse bird life.
- **Over 861** species are found in Ethiopia.
- At present, **69 important** bird areas (which are also important for large numbers of other groups of animals) are identified by the **Ethiopian Wild life and Natural History Society** (**EWNHS**).
- These are already existing and protected areas and there are also many other sites.
- Such protection is necessary as the diverse bird life of Ethiopia is threatened, along with the overall biodiversity of the country as a result of a number of practices.
- Some of the effects of these practices have been direct, others have been indirect.

Practices with direct effects on biodiversity

1. Deforestation
2. Fuel wood collection and illegal logging
3. Overgrazing by stock animals
4. Introduction of improved crop varieties --reduces the genetic diversity of the particular crop plant as only one 'improved ‘variety is used.
5. Overhunting (poaching)--directly reduces the numbers of the species hunted
6. Introduction of alien invasive species--these often outcompete native species for the available resources, sometimes making native species locally extinct.

Practices with indirect effects on biodiversity

1. High population growth
2. Undervaluation of the biodiversity resources
3. Legal and institutional systems that promote unsustainable exploitation
4. Disregard of traditional communal (range) land management systems

- The eastern tropical montane forests of Ethiopia have been recognized as a hotspot for biodiversity conservation because of the exceptionally high concentration of endemic species and habitat loss.
- In 2005, the Ethiopian Institute of Biodiversity Conservation in
- Addis Ababa put forward a National Biodiversity Action Plan.
- This is a significant document running to 115 pages, which reviews the current situation and makes numerous recommendations.
- Some of these recommendations are listed below in **two categories**:

1. Those based on ecological considerations and 2. Those based on socioeconomic conditions.

Ecological considerations

1. Accelerate recovery by enrichment planting of target species in degraded remnant forests.
2. Establish corridors to enhance the biodiversity and eventually the viability of fragmented forests, particularly in the central and northern high lands.
3. Establishment of buffer zones (through tree planting) to stop further degradation of isolated forest fragments.

4. Planting native woody species may be necessary on sites lacking of vegetation (e.g., steep slopes)
5. Establishment of tree plantations, which can serve as nurse crops, in highly degraded sites.

6, Establishing area enclosures that may be necessary to enhance natural regeneration and diversity of the native flora, particularly in arid and semi-arid regions.

7, Control and eradicate (where possible) alien invasive species using integrated pest management.

Socioeconomic Considerations

1, Allow meaningful participation by all stakeholders (people who have any interest in a particular course of action), including in decision making and implementation.

2, Considering local socioeconomic needs in choices of approaches and options in matters impacting on local biodiversity.

3. Strengthen local organizations

4. Make land and tree tenure completely secure.

5. Formulate policies that promote sustainable utilization and conservation of biodiversity.

Why is Biodiversity loss a concern?

- In the years leading up to the millennium (2000) a global assessment of many aspects of biodiversity was made.
- It was called the **millennium Assessment (MA).**

The millennium findings suggest that biodiversity loss contributes to:

1. Worsening of health
2. Lower material wealth
3. Increasing insecurity of food supply action
4. Increase vulnerability
5. Worsening social relations
6. Less freedom for choice

Food Security

- **Biological diversity** (the availability of many food sources) is used in many rural communities directly as insurance and coping mechanism to increase flexibility and reduce risk in the face of increasing uncertainty, shocks and surprises in the food supply.
- The availability of this food security net provides an important insurance program.
- Coping mechanisms (ħΛΛ) based on indigenous plants are particularly important for the most vulnerable people, who have little access to formal employment opportunities.

Increasing Vulnerability

- **Biodiversity** can help with physical protection.
- **Mangroves** are tropical trees which grow on muddy land and near water and put down new roots from their branches.
- Their **loss** or reduction in coverage increases the severity of flooding on coastal communities.
- Mangrove forests and coral reefs: 1. are rich sources of biodiversity and
  2. are excellent natural buffers against floods and storms

Health

- An important component of health is a **varied and balanced diet.**
- Thousands of species of plants and several hundred species of animals have been used for human food at one time or another.
- Some indigenous and traditional communities currently consume 200 or more species.
- Wild sources of food remain particularly important for the poor and landless to provide a balanced diet.

- Over exploitation of marine fisheries worldwide, and bush meat in many areas of the tropics, has led to a **reduction** in the availability of wild-caught animal protein, with obvious consequences in many countries for human health.

Social relations

- ❖ Many cultures attach spiritual and religious values to ecosystems or their components such as a tree, hill, river or grove.
- ❖ Thus loss or damage to these components can harm social relations.
- ❖ Damage to ecosystems, highly valued for their aesthetic, recreational or spiritual values, can damage social relations, both by reducing the bonding value of shared experience as well as by causing resentment (መናደድ) towards groups that profit from their damage.

Freedom of choice and action

- ❖ **Loss of biodiversity** often means a loss of choice.
- ❖ For example, local fishers may depend on mangroves as breeding grounds for local fish populations.
- ❖ Loss of mangroves therefore leads to a loss in control over the fish stock and a livelihood (source of income) they may have been pursuing for many generations and on that they value.
- ❖ They may be forced into something else.
- ❖ The benefits that humans gain from biodiversity are collectively known as **ecosystem services**.
- ❖ A **loss** of biodiversity will reduce ecosystem benefits locally and globally.
- ❖ In addition to reduction in ecosystem services described above and summarized in figure 2.27, there are other dangers that result from the loss of biodiversity. The list is huge, but here are some examples:

1. Continued felling (cutting) of forests in some countries leads to increased flooding.
2. Many medicines have been derived from plants; the oldest painkiller **aspirin** is derived from the willow tree. How many more medicines are waiting to be discovered in plants we have not been yet even named?
3. The same holds true for animals; some from South America produce anti-cancer drugs-again what other aids could there be in the millions of insects yet to be discovered?

- ☞ If the number of species continues to be reduced, then this will ultimately lead to **less complex** ecosystems.
- ☞ Less complex ecosystems are **less stable** and more prone to collapse.
- ☞ Ecosystems will function less well if there are **fewer species** making them up.

What can we do about it?

- ❖ Figure 2.28 shows that, if we do nothing, and allow species extinctions to continue at the present rate, then there will be a **serious reduction in biodiversity by 2050**.
- ❖ Our biodiversity has fallen from **99%** of its potential in 1900, to **70%** in 2000 and it is projected to fall to **60% by 2050** and, carrying on the projection, to **50% by 2100**, with most of this biodiversity in areas such as desert and tundra that are difficult to exploit.

We are **losing 10%** of our biodiversity **every 50 years**.

- To help visualize this, if this loss of biodiversity were concentrated in just one place, it would represent an area just larger than all of the USA.
- And this is assuming that things don't get any worse--just that we continue to lose our biodiversity at the same alarming rate that we are losing it now.
- However, there is considerable evidence to suggest that the rate of species loss (and therefore loss of biodiversity) will actually increase in the future, as figure 2.29 (page 75) shows.

- We cannot allow this to continue. We must **conserve** our biodiversity for future generations and appreciate that we have a duty of care to do so.
- Every future generation of humans has a right to enjoy and make use of the biological resources of the planet that are available to us today.
- This is the **core principle** of conservation.
- Conservation **does not** preach that we should not make use of the biological resources available, in fact it encourages us to make use of as many as possible.
- However, conservation demands that we use the resources in a **sustainable manner** so that future generations may do the same.
- Action is needed at individual, local, national and international levels to achieve this.

There are three guiding ideas of conservation

1. **Research**--we must know what we are doing

2. **Minimum intervention**--the balances within and between ecosystems are delicate and can easily be upset, and

3, Repair rather than replace--it is always better to try to help an ecosystem to repair any damage rather than try to replace it.

➢ The ecological principles that form the basis of conservation of biodiversity are:

1, Any protection of species and varieties of species will support biodiversity

2. Maintaining habitats is fundamental to conserve species

3. Large areas usually contain more species than smaller areas with similar habitats

4, Disturbance to habitats shape the characteristics of populations, communities and ecosystems, and

5. Climate change will increasingly influence all types of ecosystems

- The key to maintain biodiversity will be to **maintain habitats**.
- If we can maintain habitats, the organisms will continue to visit them and live there.
- This will become increasingly difficult because of climate change, but, where possible, we should not allow existing habitats to become eroded and, if at all possible, should extend them.
- To help conserve our biodiversity, we should also use our resources in a sustainable way. This means that we must NOT continue to:

1. Overfish the oceans--we must take only an agreed quota each year-but the types of fish eaten must become more diverse to provide the sheer (pure, unmixed) tonnage (weight in tones) demanded.

2. Fell rainforest in the current manner -it must be felled sustainably, by strip-felling, for example.

1. Reduce the genetic diversity of stock animals and crop plants by breeding only those that produce certain desired traits (lean meat, high milk yield, high grain yield).

2. Grow fast areas of cereals in monoculture

What can we do for Ethiopia?

- We can plant a tree. Now. Not next year--now.
- If we plant a tree now, and ensure that it grows, then in 20 years time there will be a mature plant that provides a habitat for a whole range of other organisms.
- We will see birds feeding and may be nesting in our tree --but that is the very least of the increase in biodiversity that we will have encouraged.
- A complex **food web** in the soil will begin to develop because we planted the tree.

Populations

A **population**:- is all the individuals of a particular species in a particular habitat at a particular time.

- Populations are **not static**. Like ecosystems they are constantly changing.
- And like ecosystems, populations that are there now have not been there all the time.
- As environment is modified (abiotic factors change) by plants present in an area, new species of plants colonize the area, establish themselves and outcompete the organisms that were there before and brought about a change.

How can several populations live in the same area?

❖ In a pond, there are populations of many different organisms.

❖ They are able to live in the same area because each exploits a different habitat in that area. For example:

- Plankton exploit the open water regions of the pond
- Decomposers inhabit the detritus found at the bottom of the pond
- Snails browse the surface of the sediment at the bottom of the pond and graze small organisms.

❖ A **habitat**:- is an area where a population lives and finds the nutrients, water, living space and other essential resources it needs to survive.

❖ **Ecological range**:-is part of the Earth's surface where members of a particular species live

- Sometimes, different organisms can share the **same habitat**.
- However, they may make different demands on that habitat.
- The combination of habitat and the **demands** made is called the **ecological niche.**
- The ecological niche of an organism describes **its role** within a habitat.
- For example, both floating plants and tadpoles are found in the open water habitat. But the plants use sunlight, carbon dioxide, water and minerals from the water, whereas the tadpoles feed on the larvae of insects.
- They have different ecological niches.
- In another example, both blue tits and great tits spend much of their time foraging in trees for insects and larvae.
- **Tits** are small active song birds with a short beak and strong feet.
- When one or the other species is present, they forage at about the same height .
- However, if both species are present in the same trees, they forage at different heights and so avoid competing for the same niche.

What factors influence the size of population?

- As we have said, a population is all the individuals of a certain species in a certain habitat at a certain time.
- Anything which influences these numbers clearly affects the size of the population.

There are **three factors** that directly affect numbers:

1. Natality-----birth rate 2. Mortality---death rate 3. Migration

---movement into the area = immigration and

--- movement out of the area = emigration.

Natality and **mortality** are clearly linked in their influences:

- If natality exceeds mortality (**more are born than die**), the population numbers will increase.
- If mortality exceeds natality (**more die than born**), the population numbers will decrease.
- If mortality and natality are **equal**, the population numbers will remain the **same.**

In a similar way, immigration and emigration are linked in their influence

1, If immigration exceeds emigration (more enter than leave), the population numbers will increase.

2, If emigration exceeds immigration (more leave than enter), the population numbers will decrease.

3, If emigration and immigration are **equal**, the population numbers will remain the **same.**

Other factors that influence the size of population include:

1. **Biotic factors**---the effects of other organisms of the same species or of a different species
2. **Abiotic factors**---the effects of factors in the physical environment (light, temperature, carbon dioxide concentration, oxygen concentration, physical space, etc.).

Biotic Factors

Some of the main biotic factors are:

1. **Predation**:- The presence of a carnivores (predators) or herbivores in the case of plants.
2. **Disease**:-infection by micro-organisms can reduce productivity and may be fatal.
3. **Intra-specific competition** == is the competition between members of the same species for some resource (often food) in the same habitat.
4. **Inter-specific competition** == competition between the members of the different species.

The ways in which biotic factors can affect population growth are summarized in table 2.5(below).

Table 2.5 The ways in which biotic factors can affect population growth

Biotic factors	***How they affect population size***
1. Predation	*The presence of a predator (or herbivore in the case of plants) will effectively increase mortality and reduce the numbers in a population.*
2 Disease-causing Organisms	*If disease is wide spread, then mortality will be increased and population growth will be slowed.*
3, Intra-specific Completion	*Competition between members of the same species can operate in two main ways:* *1, reducing resources to all of the population can reduce their fertility and so reduce population growth,* *2, reducing resources to just some of the population (as others compete more effectively) means that they die whilst the others reproduce, but population growth is still reduced.*
4, Inter-specific completion	*Although the competitive exclusion principle states that two species cannot occupy the same niche, this is not absolute. The following can happen in appropriate circumstances:* *1, One of the two species outcompetes the other, which may die out.* *2, Both species suffer a reduction as they are nearly equal in their ability to 'harvest' the resource and the effects of intra-specific competition for a reduced resource also come into play, or* ***3**. The species are able to coexist.*

Intra-specific competition is a major factor in controlling the populations of predators.

- In a typical predator-prey relationship when the population of prey begins to fall, there is intra-specific competition between the predators for the remaining prey, leading to a population decline. This allows the numbers of the prey to recover. Read page 83-84.

Inter-specific competition

- This occurs when two different species compete for the **same resource** in the same habitat.
- Although most organisms have their own ecological niche, there is very often some overlap between the niches of two species.
- For example, inter-specific competition occurs in some areas of Ethiopia between the Ethiopian wolf and domestic dogs. In these areas both animals hunt rats and so compete with each other.

Population Growth Limiting Factors

- The components of an organism that affect it at least during one stage of its life cycle are collectively called **Environmental Factors**.
- Any environmental factor that tends to slow down the potential growth of the organism is called **Limiting Factor**.

- The survival and reproduction of an organism depends on adequate supplies of nutrients and the ability of the organism to withstand many of the abiotic factors in the environment.
- In the mid-1800s, the German Chemist Justice Von Liebig noted that plants require essential substances for growth and development.
- If any one of these substances (environmental factors) is reduced below the required concentration, the development of the plant will be affected regardless of the amounts of the other substances.
- This principle is known as the **Law of the Minimum**.
- Later, in 1913, **Victor Shelfold** noted that not only too little, but also an excess of environmental factors such as nutrients could negatively affect the organism's survival.
- This principle is referred to as the **Law of Tolerance.**

Eventually it was determined that an organism will grow only within an optimum range between the upper and lower limits of environmental factors.

Density dependent and density independent factors

1, Density dependent factors:-are seen when the population **size** is **large** (related to population size).

These include: 1. Space (overcrowding) 3. Predation
2. Competition 4. Disease and parasitism 5. Human activity

2, Density-independent factors are NOT related to the size of the population.

These factors are usually **abiotic** factors and include the following:-

1. Water salinity and nutrients
2. Topography (aspect, gradient) altitude.
3. Atmosphere (air content, air pressure, weather system)
4. Edaphic factors
5. Light (quantity, intensity and duration)
6. Temperature
7. Rain and humidity

How do populations grow?

- All populations show the same pattern of growth.
- After an initial ´establishing´ phase, they show what is called **exponential growth**, until they are limited by the environment. The difference between exponential and arithmetic growth is illustrated in table 2.7 page 85.

Table 2.6 Arithmetic and exponential population growth

Time period	*Number in population*	
	Arithmetic growth	*Exponential growth*
0	*10*	*10*
1	*15*	*20*
2	*20*	*40*
3	*25*	*80*
4	*30*	*160*
5	*35*	*320*
6	*40*	*640*
7	*45*	*1280*
8	*50*	*2560*

- In **arithmetic growth**, the numbers increase by same **fixed** amount in each time period.
- This produces a uniform rate of growth over the time period.
- In exponential growth, the population doubles in each time period, producing an ever-increasing growth rate that is clearly **not** sustainable in nature. Figure 2.38 shows populations increasing with:

1. a low rate of exponential growth (orange line)
2. a fast rate of exponential growth(green line **3**. arithmetic growth (red line)

Most populations develop through 4 main stages (fig.2.39 page 86).

Table: 2.7 the main phases of the growth curve

Phase	***What is happening***	***Effects on population size***
*1.**Lag***	*Population establishing itself; some organisms are not adapted to the environment and die, others reproduce*	*Numbers remain low and static or increase slowly*
*2. **Log***	*All are adapted and reproduce rapidly due to plentiful resources*	*Numbers increase rapidly*
*3.**Statioary***	*The carrying capacity is reached;* *The same numbers dying as are produced in reproduction*	*Numbers remain fairly constant; they fluctuate about a mean level*
*4. **Decline***	*Nutrients exhausted, a new disease strikes or toxic excretory products accumulate*	*Numbers decline rapidly*

What about Human Population?

- Figure 2.41 shows the change in the human population over the past 500,000 years.
- We have come from a population of less than **5 million 10,000 years ago** to a population of **6.8 billion at the end of 2009.**
- The population has been increasing particularly quickly over the past two hundred years, because we have (generally) increased the **quantity and quality of food** available and we have decreased the impact of disease-causing organisms with improved sanitation and medical care.
- However, there can be no doubt that human population has **increased** far too much and far too quickly.
- In countries with the **highest population growth rates**, the **high growth rate** is one factor in preventing or slowing development.
- The sheer weight of numbers makes it much more difficult to implement:

  1. Education programs 2. Health programs 3. Proper sanitation and all similar measures.

  See the annual increase in the human population fig. 2.42 page 87.
- The human population is subject to the same checks as other populations; the various biotic and abiotic factors still influence population size.
- However, the human population is subject to other factors affecting its development.
- These include the point at which the particular country or region develops agriculture and industrialization. This affects: 1. **growth rates** 2. **death rates** and 3. **life expectancy**
- These changes are called the **demographic transition**
- The stages of the demographic transition are shown in **figure 2.43** page 88.
- **Demographic transition**=is a model that seeks to explain the transformation of countries from having high birth rate and high death rate to low birth rate and low death rate. See figure 2.43 The stages of the demographic transition
- Demographic transition has three major stages:

Stage 1: Societies with high birth and death rates, population growth is very slow, or stable. Example Remote groups that are far from civilization

Stage 2: Societies in countries at this stage show high birth rate and low death rate, but both rates are decreasing (falling). Population size is increasing. Example: India, Kenya, Brazil, Egypt, etc.

Stage 3: Countries at this final stage show low birth and death rates with stable population.

- There may be slow increase or decrease in size, but on the average, population size is constant. Example: Germany, USA, Japan, France, UK, etc.
- Generally, population size is **increasing in developing countries**.

- ❖ It is **stable** in **developed** nations.
- ❖ During demographic transition, the relative number of young and old people changes, and these are illustrated by **age pyramids**. See figure 2.45A and 2.45B (page 89).

Pyramids of **developing** countries are **broad at the base**. This shows that there are more children.

The **narrow tip** of pyramids of **developing** nations shows **short life expectancy** as there are **few old people** in the societies.

The pyramid of **developed** countries is relatively **rectangular.**

This is an indication that there are **fewer gaps** between the different age groups.

Life expectancy is **longer**, and population size is **stable.**

Note: During demographic transition, median age and percentage of older population **increases**, overall shape of age pyramids becomes more rectangular, and population size stabilizes.

Table 2.8 the stages of the demographic transition

Stage	1, Preindustrial	2,Mechanization/ urbanization	3, Mature industrial age	4, Post-industrial age	5, Post-Industrial age
Birth and death rates					
Examples	A few remote group	Egypt, Kenya, India	Brazil	USA, Japan, France, UK	Germany
Birth rate	High	High	Falling	Low	Very low
Death rate	High	Falls rapidly	Falls more slowly	Low	Low
Natural increase	Stable or slow increase	Very rapid increase	Increase slows down	Stable or slow Increase	Slow increase
Reason for changes in birth rate	Many children needed for farming. Many children die at an early age. Religious/Social encouragement. No family planning		Improved medical care and diet. Fewer children needed	Family planning, Good health, Improved status of women, Later marriages	
Reason for changes in death rate	Disease, famine, poor medical knowledge so many children die.		Improvement in medical care, water supply and sanitation	Good health care Reliable food supply	

- ❖ Notice that in the **second** and **third** stages of the demographic transition, death rates fall before birth rates.
- ❖ This creates a period when the population is **increasing**.
- ❖ In the final stages, birth rates and death rates are **low** and the population is **stable**, with either a **slow increase** or a **slow decrease**.
- ❖ Most **developed** countries are in one of these two final stages of the demographic transition, whereas developing countries are still one of the two middle stages.
- ❖ As a result most of the population growth is occurring in developing countries.
- ❖ **Rapid growth** slows the transition to the <u>later stages.</u>
- ❖ In the demographic transition, the relative numbers of young and old people changes. These are best shown in **age pyramids**.
- ❖ Figure 2.44 shows age pyramids for **Afghanistan** (a country still developing) and the **USA** and **Italy** (developed countries).
- ❖ The **broad base** to the population in Afghanistan shows that the population is **increasing.**

- In the demographic transition, the relative numbers of young and old people changes. These are best shown in **age pyramids**.
- Figure 2.44 shows age pyramids for **Afghanistan** (a country still developing) and the **USA** and **Italy** (developed countries).
- The **broad base** to the population in Afghanistan shows that the population is **increasing.**
- The structure in the **USA** is different.
- There are similar numbers in all the age groups until about **age 60**.
- This suggests that the numbers being born are slightly greater than those dying and the population numbers are increasing slowly.
- Can you explain the lack of growth in Italy? Notice also that life expectancy is greater in **Italy** and the **USA**.
- This is true of most **developed** countries.
- Figures 2.45A and B show the population pyramids for Ethiopia in 2000 and the projected population pyramids for **2025**.
- Note that, although the population has increased (predicted by the structure of the population in 2000), the rate of increase is **slowing**.
- The base of new pyramid shows several age bands of more or less the **same size**--typical of populations showing **no growth**.

What can we do about the growth of population?

- Whether the global human population increases or decreases depends on the balance between global **natality** and global **mortality**.
- There are **no** migration issues. We are not going anywhere. So the mathematics is fairly simple; to reduce global population, either:

1. Mortality will increase; this is the do-nothing option and we can wait until the population crashes or war is rife from competition for resources because we are so far over our carrying capacity, or
2. Natality must decrease--this is the only option we really have and one we can control; we must control the numbers of children being born if we are to stop the run-away growth of the human population.

Many populations now encourage some kind of population control. A few of these are described in table 2.9 page 90

Table 2.9 The effects of population control policies

Country	Way of reducing numbers born	Effect on population
China	In 1979 a policy was introduced which discourages more than one child per family; an unwanted pregnancy is punished with a fine	Population is still increasing but there has been a huge slowing of the rate of increase
India	Only people with two or fewer children may serve in local government. Contraception has been introduced.	Population is still increasing, but rate of increase has been slowed.
Iran	Compulsory contraception courses for males and females before a marriage license can be granted	Rate of population increase has decreased from 4% in 1980 to1.3% in 2008
USA	Free contraception available as well as free sex education; priority is given to these who are poorest	Population is stable and increasing only slightly

- At the moment **Ethiopia** has one of the highest birth rates in Africa, but there are some hopeful signs that this is changing.
- It is progressing through the demographic transition, and, as it does so, death rates and birth rates will fall as more resources become generally

- ❖ They also give some limited prevention against the transmission of HIV.
- ❖ Fewer children will be needed, particularly in rural communities, if more of them live longer.
- ❖ Good health alongside education will help to reduce the rapid increase in population growth that characterizes Ethiopia at the moment.
- ❖ It is vital that the government makes available as many resources as possible to help local communities particularly rural communities with:

1. Sex education **3**. Access to contraception

2. General education to enable students to consider other options in their futures.

- ❖ All of these help in reducing the rapid growth rate.
- ❖ In addition, help with the following will improve general health, which is usually associated with lower reproduction rates: **1**. Education about diet

2. Resources to improve the quantity and quality of crops grown and stock reared in rural communities.

REVIEW QUESTIONS

1. Biodiversity includes:
A. The species richness and species diversity of the planet (or the local area)
B. The ecological variability of each species C. The genetic variability of each species D. All of the above

2. It is vital that the government makes available as many resources as possible to help local communities particularly rural communities with:

A. General education to enable students to consider other options in their futures.
B. Sex education C. Access to contraception D. All the above

3. The sheer weight of population numbers makes it much more difficult to implement
A. education programs B. health program C. proper sanitation and all similar measures. D. All

4. What factor/s influence/s the size of population?
A. Natality rate B. Migration C. Mortality rate D. All

5. Not only too little, but also an excess of environmental factors such as nutrients could negatively affect the organism's survival. This principle is referred to as:
A. Law of Tolerance. B. Law of Dependence C. Law of obesity D. Law of hunger

❖ For the following four questions insert one of the three population phases
1. Log 2. Lag 3. Stationary 4. Decline

6. The carrying capacity is reached and the same numbers dying as are produced in reproduction
A. 1 B. 2 C. 3 D. 4
7. Nutrients exhausted, a new disease strikes or toxic excretory products accumulate.
A. 1 B. 2 C. 3 D.4
8. Population establishing itself; some organisms are not adapted to the environment and die, others reproduce.
A. 1 B. 2 C. 3 D.4
9. All are adapted and reproduce rapidly due to plentiful resources and numbers increase rapidly.
A. 1 B. 2 C. 3 D.3
10. What is/are the reason/s for the presence of high biodiversity in Ethiopia?
A. The wide rage in altitude and climate, C. The isolation of high lands of Ethiopia
B. The presence of many different biomes present in the country D. All of the above
11. Which of the following practices **effects** biodiversity?
A. Deforestation D. Fuel wood collection and illegal logging
B. Overgrazing by stock animals E. Introduction of improved crop varieties F. High population growth
C. Introduction of alien invasive species many different biomes present in the country. G. All of the above
12. Which of the following practices is **direct effect** on biodiversity?
A. Overhunting (poaching)
B. Legal and institutional systems that promote unsustainable exploitation
C. Disregard of traditional communal (range) land management systems
D. Undervaluation of the biodiversity resources
13. The millennium findings suggest that **biodiversity loss** contributes to:
A. Worsening of health and increasing vulnerability

B. Increasing insecurity of food supply and lower material wealth
C. Worsening social relations and less freedom for choice and action
D. All of the above

14. Which of the following is/are INCORRECT about rain forest?
A. It covers about 7% of the Earth's surface and contains 25% of the known species.
B. Many of the trees are very tall, the root systems are shallow and trees can easily fall.
C. The shallow root systems grow in shallow, nutrient-poor soils.
D. The soils are rich in nutrient because many of the minerals from the soil remain 'locked up' in the huge trees.
E. There is more accumulation of detritus as decomposers rapidly break down the leaves and release the mineral ions they contain.

15. Which of the following is NOT density independent factor?
A. Water salinity and nutrients C. Atmosphere (air content, air pressure, weather system)
B. Topography (aspect, gradient) altitude. D. Edaphic (soil) factors F. Rain and humidity
C. Light (quantity, intensity and duration) E. Temperature G. Parasitism

16. Density-dependent factors include:
A. Space (overcrowding) B. Competition C. Disease and parasitism D. Predation E. All of the above

17. Which of the following **does not** happen due to felling (cutting) tropical forests?
A, There is a serious reduction in species diversity.
B, Many ecological niches are destroyed.
C. There is an increase in the rate at which carbon dioxide is removed from the atmosphere.
D. The local and global cycling of carbon is affected.

18. The guiding ideas of conservation include:
A. Research--we must know what we are doing
B. Minimum intervention--the balances within and between ecosystems are delicate and can easily be upset,
C. Repair rather than replace--it is always better to try to help an ecosystem to repair any damage rather than try to replace it. D. All of the above

19. The ecological principles that form the basis of conservation of biodiversity include:
A. Any protection of species and varieties of species will support biodiversity
B. Maintaining habitats is fundamental to conserve species
C. Large areas usually contain more species than smaller areas with similar habitats
D. All of the above

20. Biome is a geographical or regional area with:
A. Specific climate B. Specific soil type
C. Specific plants and animals that are adapted in similar ways to the abiotic conditions within the area D. all

21. The existence of biomes is based on
A. Rain fall B. Climate C. Soil type D. Hydrological conditions E. All

22. ------ refers to the population role in the ecosystem.
A. Biosphere B. Community C. Ecological niche D. biome

23. -------- is the study of how living things interact with each other and with their environment
A. Botany B. Ecology C. Biotechnology D. Zoology

24. The part of the earth that contains life refers to as:
A. Lithosphere B. Hydrosphere C. Biosphere D. Atmosphere

25. Ecology mostly studies those biological levels beyond the
A. organism B. Tissue C. Organ system D. Biosphere

26. Which of the following is not a biological factor?
A. Animals B. Decomposers C. Plants D. Climatic condition

27. Which of the following is NOT correct about plants? They are:-
A. Producers B, Heterotrophs C. Autotrophs D. First trophic level

28. Which of the following consists all the others?
A. Carnivores B. Consumers C. Herbivores D. Omnivores

29. Materials are moved in the ecosystem when organisms:
A. feed and excrete B. respire and breathe C. die and decompose D. All the above are answer

30. ----------is the study of the single species.
A. Ecology B. synecology C. Autecology D. Psychology

31. ----------is composed of all the organisms in an area.
A. Community B. Ecosystem C. Population D. Habitat

32. Energy in the ecosystem is lost in the form of
A. Light B. Heat C. Chemical energy D. potential energy

33. Which of the following is INCORRECT about ecosystem?
A. It contains both biotic and abiotic factors C. It contains plants, animals and microorganisms only
B. It is a dynamic unit D. Organisms interact with each other and with their surroundings.

34. Which of the following does not contain Nitrogen?
A. RNA B. Protein C. DNA D. Carbohydrate
35. Which of the following does not increase nitrogen in the ecosystem?
A. Ammonification B. Nitrification C. Nitrogen fixation D. Denitrification
36. The suitable form of nitrogen that can be used by plants is
A. N_2 B. NO_2 C. NO_3 D. NH_3
37. An ecosystem is a natural unit in which energy flows from the source to:
A. producers B. decomposers C. consumers D. All of the above
38. Which of the following is an inorganic substance?
A. Glucose B. Protein C. Water D. Lipids
39. In the ecosystem, the balance of oxygen and Carbon dioxide is kept constant by two reactions called.
A. Photosynthesis and respiration C. Digestion and absorption
B. Absorption and excretion D. None
40. Extracellular digestion is common in:
A. Humans B. Decomposers C. Plants D. Large animals
41. Which of the following is vital to nitrogen cycle?
A. Ammonia B. Sulphur C. Phosphorus D. Carbon dioxide
42. Which of the following **decreases** the amount of carbon dioxide in the ecosystem? .
A. Photosynthesis B. Nitrogen fixation C. Respiration D. burning of fossils
43. Which of the following processes is not involved in carbon cycle?
A. Photosynthesis and respiration C. Fossilization and combustion
B. Feeding and assimilation D. Ammonification
44. The process by which decomposers decay the excretory products and detritus, releasing ammonium ions into the soil is called A. Nitrogen fixation B. Ammonification C. Denitrification D. Excretion
45. Which of the following is correct about nitrogen fixing bacteria?
A. Nitrogen fixing bacteria free in the soil (belonging to genera Azetobacter and Klebsiela) reduce nitrogen gas into NH_3 in the soil.
B. Ammonium ions can be oxidized immediately into nitrates by nitrifying bacteria.
C. Rhizobium bacteria in the root nodules of leguminous plants form ammonium ions that are passed to the legumes and used by them to synthesize amino acids.
E, The extra nitrogen becomes available to other organisms when the legumes die and are decomposed.
F. All are answers.
46. Which of the following is INCORRECT about phosphates?
A. Over millions of years phosphate ions can leach into the seas and become part of newly forming sedimentary rocks
B. Phosphates enter the soil or water as a result of weathering of rocks and in the form of fertilizers, which, themselves contain phosphates that have been obtained from rocks.
C. The dead bodies of herbivores and carnivores are decomposed and phosphate ions are released from compounds like phospholipids, ATP, DNA, and RNA and are returned to the soil or water. D. None
47. Which of the following is correct about sulphur cycle?
A. Sulphate ions in the soil are taken up by plants and incorporated in plant tissues.
B. Sulphate ions from plants are passed to animals by feeding and digestion
C, On death of plants and animals, sulphur reducing bacteria release the sulphur in proteins in the form of H_2S
D, Thiobacillus (sulphur bacteria) oxidize H_2S to sulphate. E, All of the above are correct.
48. Which of the following is <u>incorrect</u> about water?
A. It is an essential product of photosynthesis
B. It is the basis of all transport systems in organisms
C. It provides a means of removing excretory products.
D. Used in systems called hydroponics to grow plants in soil free medium.
49. Which of the following is INCORRECT in any succession?
A. Organisms organize and colonize an area.
B. They change the abiotic (physical) conditions in an area.
C. The changed abiotic conditions allow other species to colonize the area
D, The species compete with the ones there before and become dominant.
E, They also change the biotic conditions, more species enter and the process continues.
F, The final, most complex state of a succession is the pioneer Community
50. Which of the following is NOT advisable?
A. Overfish the oceans. C. Fell rainforest in the current manner.
B. Reduce the genetic diversity of stock animals and crop plants by breeding only those that produce certain desired traits (lean meat, high milk yield, high grain yield). D. Grow fast areas of cereals in monoculture
D. All of the above

51. Which of the following trends is NOT correct in any succession?
A. The total biomass of the community increase D. The species diversity increases
B The number of ecological niches increases E. Food webs become complex
C. The community become more stable and can accommodate fast changes.
52. Which of the following is correct about population?
A, Population is all the individuals of a particular species in a particular habitat at a particular time.
B, Populations are not static. Like ecosystems they are constantly changing.
C, Like ecosystems, populations that are there now have not been there all the time. D. All of the above
53. Factors that could influence the type of climax community include:
. A. temperature B. soil type C. soil depth D. precipitation (rain fall) E. All the above
54. Secondary successions are usually much quicker than primary successions because:
A. The succession is not starting from bare rock/open water
B. There is a seed bank of many of the climax plant types available in remain in undamaged plants.
C. The soil is already present D. All of the above
55. The main difference between the transfer of energy and nutrient in the ecosystem is that
A. The pattern of energy transfer is cyclical C. The pattern of nutrient transfer is cyclical.
B. The pattern of energy transfer is uni-directional D. B and C E. A and C
56. One of the following processes DOES NOT replace carbon back to the Atmosphere
A. Combustion B. Decay C. photosynthesis D. Respiration
57. What will happen if all photosynthetic plants were removed from the earth's surface?
A. Increase in the level of atmospheric CO_2 C. Global warming
B. Decrease the level of carbon dioxide in the atmosphere D. A and B E. B and C
58. Which of the following bacteria species involves in the conversion nitrate into atmospheric nitrogen?
A. Azotobzcter B. Rhizobium C. Pseudomonas D. Klebsiella
59. In which one of the following aspects is the tropical rain forest biome poor?
A. Species diversity B. Amount of sun light C. Annual precipitation D. soil fertility
60. The type of ecological succession that occurs after fire in woodlands and forests is referred to as
A. Secondary succession B. Xerosere C. Primary succession D. Hydrosere E. A and C
61. The term biodiversity describes
A. the number of living things C. the variability of living things
B. the dynamicity of living things D. all of the above
62. The biodiversity of Africa is threatened by:
A. population pressure C. climatic changes
B. backward food production methods D. introduction of exotic species E. all of the above
63. The **variety of species** within a region can be measured by:
A. Species richness B. Taxonomic diversity C. Species abundance D. All of the above
64. Which one of the following ecological pyramid presents the weight of living materials available at different trophic levels? A. Pyramids of numbers C. Pyramid of biomass
B. Pyramid of energy D. Inverted pyramid of numbers
65. Each stage of the food chain is: A. trophic level B. Grazer C. Consumer D. Predator
66. The major producers in aquatic environment are: A. blue green algae B. mosses C. phytoplankton D. algae
67. Which of the following contains members of a single species only?
A. Biosphere B. Ecosystem C. Population D. Community
68. Depending on the magnitude or degree of ecological interactions, different levels of interactions exist in the environment. Which of the following is at its highest level of complexity?
A. Population B. Ecosystem C. Community D. Individual organism
69. Light, temperature, rain fall, and wind make up:
A. Biotic factors of the environment C. Climatic factors of the environment
B. Edaphic factors of the environment D. Topographic factors of the environment
70. What does an ecosystem possesses that a community does not?
A. All linving things in the habitat C. Biotic components of the ecosystem
B. Non-living components of the ecosystem D. A and C
71. Which of the following processes does not return co_2 to the atmosphere?
A. Respiration B. Combustion C. Photosynthesis D. Decay E. C and D
72. A particular terrestrial ecosystem (biome) is characterized and recognized wherever it occurs by
A. Climate type B. Soil type C. Distinctive fauna and flora D. All of the above
73. Which of the following characterizes tropical rain forest?
A. Large areas of grasses with scattered trees C. Ever-green and broad-leaved trees
B. Trees that shed their leaves D. Trees with needle like leaves
74. The biome characterized by low rainfall and sparse vegetation cover where xerophytes like cacti and euphorbia grow is
A. tundra B. grassland C. desert D. savanna

75. Which of the following aquatic biomes have many strata like that of equatorial rain forest?
A. Wetland B. Pelagic zone C. Estuarine D. Coral reef
76. What is the best term used to refer to the association of different species of organisms interacting and living together?
A. Niche B. Ecology C. community D. Pyramid
77. The highest productivity in a given ecosystem is expected from
A. producers B. predators C. consumers D. herbivores
78. Which of the following is NOT true of the nitrogen cycle?
A. Plants absorb ammonia from the soil C. Plants absorb nitrogen gas directly from the atmosphere
B. animals obtain nitrogen by eating other organisms D. Bacteria convert nitrogen gas into ammonia
79. Of the following structures of a plant, which one plays a role in nitrogen fixation?
A. Root hair B. Root nodule C. Root cap D. Root tuber
80. If destroyed which of the following would result in the biggest loss of the world biodiversity?
A. Tropical rain forest C. Temperate deciduous forest
B. savanna woodlands D. temperate ever green forests

Answer for Review Questions (Unit 2)

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

UNIT 3
GENETICS

The delivery of characteristics from parent to offspring is called heredity. The scientific study of heredity, is known as **genetics.** The modern science of genetics was founded by an Austrian monk named Gregor Mendel. Gregor Mendel is the father of genetics.

Mendel carried out his work with ordinary garden peas, partly because peas are small and easy to grow.

A single pea plant can produce hundreds of offspring. **Pea flowers** are normally self-pollinating, which means that sperm cells fertilize egg cells within the **same** flower.

Mendel's monastery garden pea plants are **"true-breeding**," meaning that they were self-pollinating, and would produce offspring identical to themselves.

A **trait** is a specific characteristic, such as seed color or plant height, of an individual.

Mendel decided to "cross" his stocks of true-breeding plants—that is, he caused one plant to reproduce with another plant.

- To do this, he had to prevent self-pollination, by cutting away the pollen bearing male parts of a flower. He then dusted the pollen from a different plant onto the female part of that flower.
- This process, is known as cross-pollination.
- Cross-pollination produces a plant that that has two different parents.
- Mendel studied seven different traits of pea plants.
- Each of these seven traits had **two contrasting** characteristics, such as green seed color or yellow seed color.
- Mendel crossed plants with each of the seven contrasting characteristics and then studied their offspring. The offspring of crosses between parents with different traits are called **hybrids.**

Genes and Alleles

- When doing genetic crosses, we call each original pair of plants the P, or parental, generation.

- Their offspring are called the F1, or first filial, generation.
- Individual′s characteristics are determined by factors that are passed from one parental generation to the next.
- Today scientists call the factors that are passed from parent to offspring **genes.**

Each of the traits Mendel studied was controlled by a **single gene** that occurred in **two contrasting** varieties. Different versions of the same gene are called **alleles.**

Because humans reproduce sexually, we receive **half** of our chromosomes from our **father** and the other half from our mother. And the two sets are very **similar.**

In our cells we have **46** chromosomes; **23 are paternal** in origin (came from our **father**) and **23 are maternal** in origin (came from **mother**).

And when they get together, they form pairs called **homologous pairs**.
→These homologous pairs have genes controlling the **same** features in the **same position** or **locus** on the **chromosome.** However, the **alleles may not be the same**.

Dominant and Recessive Alleles

The principle of dominance states that some alleles are dominant and others are recessive.

In Mendel's experiments, the allele for tall plants was dominant and the allele for short plants was recessive. Likewise, the allele for yellow seeds was dominant over the recessive allele for green seeds.

====Mendel explained these results in the following way:
1. Every trait is controlled by two' heritable factors' --these are what we call genes.

The factors (genes) may take different forms called alleles.

2. If the two alleles in an individual are different, one is dominant and the other is recessive, the dominant allele masks the appearance of the recessive allele.

3. The only physical link between the generations is the gametes or sex cells.
   - The gametes must pass the genes from one organism to the next.

4. The heritable factors (alleles) separate when the gamete (sex cells) are formed; each gamete therefore contains only one allele containing the trait. This is Mendel's **Law of Segregation.**

- Mendel also stated that the gametes (sex cells) fuse randomly at fertilization.
- After further studies and experiments, Mendel also formulated another law called the Law of Independent Assortment.
- This law states that the inheritance of one trait is independent of the inheritance of another.
- That is, the alleles of one pair segregate independently of the alleles of another pair controlling a different feature.
- Whilst, this was true for the traits that Mendel studied in pea plants and is true for many traits in many other organisms, we now know that it is NOT always the case, as we shall see when we look at the phenomena of **linkage.**
- The particular experiment to find out if an organism is homozygous or heterozygous for a dominant trait is called the test cross or the back cross.
- A cross between two contrasting trait is called a monohybrid cross (or a hybrid with one pair of heritable characters is called monohybrid).
- Mendel studied the simultaneous inheritance of **two pairs of characters.**
- Mendel did this by crossing plants that differed in two pairs of alternative characters. Such a cross is called **dihybrid cross.**
- A hybrid with two pairs of heritable characters is called **dihybrid.**
- In one of his dihybrid crosses, Mendel crossed a round-yellow seed with a wrinkled -green seed

Round(R)-yellow(Y) x Wrinkled(r)-green(y)	F_1 == RrYy (all round – yellow)
Parental genotypes---RRYY x rryy	F_1 x F_1 means RrYy x RrYy
Parental genotypes---RRYY x rryy	F_1 gametes==Paternal (RY, Ry, rY, ry) & Maternal (RY, Ry, rY, ry)

The traits of round and yellow were dominant to wrinkled and green which were recessive.

After using Punnett square we will have 16 offspring of which,

1) RRYY, RRYy, RrYY, RrYy, RRYy, RrYy, RrYY, RrYy, RrYy, are Round-yellow (9/16)
2) RRyy, Rryy, Rryy-------are round-green (3/16)
3) rrYY, rrYy, rrYy---------are wrinkled-yellow (3/16)
4) 4--rryy----------is wrinkled-green (1/16)

5. Phenotypic ration = 9:3:3:1------4 phenotypic classes

6. Genotypic ratio ==1:2:1:2:4:2:1:2:1

- **Mendel made two conclusions from this observation**

Two new combinations of characters had appeared in the F_2 generation:

These are: A) wrinkled and yellow B) round and green.

2. The ratios of each pair of characters appeared in the monohybrid ratio of 3:1, that is 3 round to 1 wrinkled, and 3 yellow to 1 green.

- **Dihybrids** are considered as **two monohybrids.**
- From the consideration of monohybrid inheritance, where **3/4** of the F_2 phenotypes show the dominant allele and **1/4** the recessive allele.

❖ The calculations indicate that the dihybrid cross is equivalent to two separate monohybrid crosses.
❖ This type (9:3:3:1) ratio in the Mendelian dihybrid inheritance only applies to characters controlled by genes that are located on **different chromosomes.**
❖ Genes situated in the **same chromosome may not** show this pattern of independent assortment.
❖ On the bases of these results, Mendel stated that the two characters (seed shape and color) while combining in F_1 generation, separate and behave independently from one another in subsequent generations.
❖ This principle became **Mendel's Second law**, and is known as the **Law** of **Independent Assortment.**
❖ This law states that any one of a pair of characters may combine with either one of another pair without affecting one another.
❖ This principle does also hold true for trihybrid crosses, cross involving three pairs of contrasting characters.

Types of Dominance

1. Complete dominance

❖ Heterozygous individuals at all of the F_1 offspring are phenotypically identical to the dominant homozygous individuals.
❖ In this case the a single allele of the dominant trait produces the same effect as two dominant alleles.
❖ In a complete dominance, the phenotypic ratio of Mendelian cross of a monohybrid F_2 and dihybrid F_2 are 3:1 and 9:3:3:1respectively.
❖ However, after Mendel, it was discovered that genes of a number of traits do not show complete dominance.

2. Incomplete dominance--is a situation whereby two genes are equally dominant thereby interacting to produce a new phenotype.

❖ Eg:- if red snapdragon (R) are crossed with white snapdragon(r), all of the F1 offspring would be pink. The pink color is produced by the interaction of red and white alleles. RR x rr=all are Rr== **all are pink**
❖ If F_1 were self-pollinated (F_1 xF_1) the resulting F2 generation produced a
❖ phenotypic ratio of 1:2:1 ==1 red:2 pink:1 white snapdragon flowered plants.

- In incomplete dominance, both phenotypic ratio and genotypic ratio are similar, **1: 2: 1**
- RR (red) with rr (white)== **Rr, Rr, Rr, Rr all are pink**
- F1 with F1 (Rr x Rr)=RR, Rr, Rr,rr that means **one red, two pink and one white** (1RR, 2Rr, 1rr).

3. Co-dominance---is a pattern of inheritance in which **both alleles of gene are expressed.**

In co-dominance the heterozygote does not show an intermediate phenotype between the two homozygous parents but shows both characteristics.

This is because both alleles contribute to the phenotype and both are fully expressed.

E.g. A red bull crossed with a white cow (or a white bull crossed with a red cow) produces a roan calf.

The **roan calf** has intermingled patches of white and red hair.

Neither the white nor the red are completely dominant or recessive both alleles are expressed in the offspring.

Another example of co-dominance is an ABO blood group system in humans.There are four blood types A, B, AB, and O. Blood type A and B are co-dominant alleles.

An individual with one A allele and one B allele expresses an intermediate blood type called AB.

In this co-dominance the heterozygote has the characteristics of **both parents.** But both allele A and allele B are dominant to allele O. Therefore an individual with one A allele and one O allele will express type A blood. An individual with one B allele and one O allele will express type B blood.

The four blood groups are determined by the presence and absence of two antigens (antigen A and antigen B) on the surface of Red blood cells.

There are three alleles involved in the inheritance of these blood groups:

I^A -- determines the production of the A antigen

I^B -- determines the production of the B antigen

I^O -- determines that neither antigen is produced

Genotype	Blood group
$\mathbf{I^AIA, I^AI^O}$	A
$\mathbf{I^BI^B, I^BI^O}$	B
$\mathbf{I^AI^B}$	AB
$\mathbf{I^OI^O}$	O

Allele A and allele B are co-dominant but allele O is recessive to both.

The possible genotypes and phenotypes (blood groups) are shown below:

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

These are: $\mathbf{I^AI^O \ x \ I^BI^O == I^AI^B, \ I^AI^O, \ I^BI^O, I^OI^O}$

Cell Division

There two kinds of cell divisions in organisms, namely m**itosis** and **meiosis.**

Mitosis:- is a type of cell division in which the daughter cells receive the same number of chromosomes as the parent cell. For example, the human body cells with 46 chromosomes divide by mitosis and produce **two identical daughter cells** each containing **46** chromosomes as the parent cells.

Meiosis: is the process by which sex cells (gametes) are formed.

Unlike mitosis, meiotic division produces sex cells that contain half as many chromosomes as the parent cell. Therefore, meiosis is termed as a reduction division. A human cell containing 46 chromosomes will undergo meiosis and produce sex cells that have 23 chromosomes.

When a cell divides in this manner, there are **three outcomes:**

1. It produces four daughter cells

2. These daughter cells have only half the number of chromosomes of the original cell; they have one chromosome from each homologous pair

3. The daughter cells show genetic variation.

- At the start of meiosis each chromosome is a double structure; it is made of two chromatids held together by a centromere.
- This is because the DNA in each chromosome replicated prior to meiosis commencing.
- Before any division takes place, chromatids from different chromosomes in the homologous pair undergo 'crossing over.'
- In this process (the crossing over), they exchange sections of DNA.
- After this has taken place, the two chromosomes that make up the pair are separated into different cells.
- In meiosis II, the two chromatids that make up each chromosome are separated into separate cells.
- Notice that, because of crossing over, none of these chromatids are the same.
- There is genetic variation in the daughter cells, which also has only half the original chromosome number ----they are said to have the haploid number of chromosomes, unlike the parent cell which had the diploid number of chromosomes.
- During meiosis the following things happen to the chromosome:

1. They duplicate; the DNA in each chromosome makes an exact copy of itself and histones associate with it to make another chromosome. The original and the copy remain attached by a centromere and are called NOT chromosomes but chromatids.

2. They **condense**; when chromosomes are not involved in cell division, they are very long and thin and all the genes can be active.

However, they cannot be moved around a cell in this form, so they become much shorter and fatter.

3. The chromosomes of a **homologous pair** (each one by now duplicated) find' each other, this is called **synapse** and form a **bivalent** (a pair of homologous chromosomes).

4. Whilst, associated in the bivalent, chromatids from different chromosomes undergo crossing over.
- These chromatids are called **non-sister chromatids;** the chromatids that make up one chromosome are called **sister chromatids.**
- In this process, the chromatids exchange equivalent sections of DNA, and all four chromatids in the homologous pair are genetically different.

5. The chromosomes (or chromatids) are moved around the cell by fibers that makeup a spindle.
- This is achieved by the spindle fibers contracting and pulling the chromosomes/or chromatids.

Meiosis—is a complex process.
It involves two successive nuclear divisions after the process of duplicating chromosomal material, thereby producing four haploid daughter cells.

The first meiotic division (meiosis l) involves the separation of diploid cells into haploid cells, hence called **reduction division.**

The **second meiotic division** (Meiosis ll), on the other hand, is marked by the separation of the two chromatids.

In the two divisions of meiosis, the chromosomes attach to the spindles differently so that:

In meiosis I, the whole chromosomes are moved and the chromosomes that makeup a homologous pair are separate.

In meiosis II, the chromatids that make up each chromosome are separated.

It is pure chance how bivalents arrange themselves at metaphase I.

With just two bivalents, there are two possible arrangements and two different sets of gametes.

Each bivalent aligns itself independent of the others.This is called independent assortment and is an important source of genetic variation in the gametes produced by meiosis. It explains why alleles of two different genes behave in the way they do in a dihybrid cross.

The main stages of meiosis

Meiosis I:-is divided into four phase: 1. Prophase 2. Metaphase 3. Anaphase 4. Telophase

1. Events during Prophase I
- Nuclear membrane begins to dissolve (disappear).
- Centriole splits and migrates toward opposite poles
- Spindle fiber formed

2. Events during Metaphase I:
- Homologous chromosomes line up at the equatorial plate of the cell.
- The centromere of each homologue is situated on either side of the equator.

3, Events during Anaphase I
- Homologous chromosomes migrate toward opposite poles.
- This process is known as segregation.
- At this point of meiosis, reduction division occurs.
- One member of each homologous pair will be found in each of the new cells.
- The centromeres do not split and each chromosome still consists of two chromatids.

4. Events during Telophase I
- Chromosomes congregate (come together) at the poles.
- A nuclear membrane begins to form around each group of chromosomes at the poles
- karyokinesis takes place.
- The cytoplasm divides (cytokinesis) resulting in two daughter cells.
- Each daughter cell contains one member of each homologous pair of chromosomes.
- The cells recognize the preparation for the second meiotic division (meiosis II)

1.prophase II ---spindles form and nuclear membrane disintegrate

2. Metaphase II---Each chromosome, made of two chromatids, aligns itself on the equator of the cell.
- The chromatids of each chromosome are held together by centromere.

3. Anaphase II---Centromere of each chromosome splits.
- Sister chromatids separate and move to the opposite poles.

4. Telophase II--- In Telophase II, the daughter chromosomes group at the poles.
- Nuclear membrane begins to form around the chromosomes and division of the cytoplasm, known as **cytokinesis**, commences. **Cytokinesis**: is the final step in the division of the cell.

Cell organelles such as mitochondria and chloroplast become evenly distributed between the double cells.

Cytokinesis in **animal cells** is brought about by the invagination of the cell membrane at the equator of the cells. During constriction, **microtubules** help to form a **furrow** in the cytoplasm thus dividing the cytoplasm into two.

In **plant cells:** a cell- plate forms at the equator of the cell.
This plate divides the cytoplasm and separates the daughter cells.When the cytoplasm divides, the DNA in the mitochondria and chloroplast also transmits certain characteristics of the cell to the new cells. The cell is divided into two daughter cells.
Note: The actual division into two cells is called **cytokinesis.**

- It is important to note that the cells formed at the end of meiosis I are **haploid** (two haploid cells are formed; **chromosomes are still double**):
- Each cell contains only one chromosome from each homologous pair.
- Even though each chromosome comprises two chromatids, it is still only one chromosome and so the cell has half the number of chromosomes of the parent cell===haploid cells==reductional division.
- Some important difference between mitosis and meiosis are

Mitosis:

- has one division per cycle:
- is an equational division which separates chromatids.
- chromosomes fail to synapse
- no chiasmata form.
- genetic exchange does not occur between homologous chromosomes.
- two daughter cells are produced per cycle (not 4)
- genetic contents of mitotic products are identical.
- chromosome number of daughter cells is the same as that of the mother cell.
- mitotic products are usually capable of undergoing additional mitotic divisions.
- normally occurs in all body parts for growth and repair.

Genetic Linkage

- Some genes are always inherited together with other genes---they exhibit linkage.
- This happens when the genes in question are on the same chromosome.
- A chromosome is a physical unit as are the genes on it, so when a particular chromosome is passed into a gamete, and none of them pass into another gamete.
- The genes are linked and inherited together because they are on the same chromosome.
- One of the earliest studies of linkage was carried out by two British geneticists, Bateson and Punnett (who also devised the Punnett square).
- They investigated the inheritance of flower color (purple or red) and seed shape (round or long) in sweet peas. The genes are:

  P---purple (dominant) **p---red (recessive)**
  L---long (dominant) **l---round (recessive)**

If we were to cross individuals heterozygous for two features, then we normally would expect the 9:3:3:1 ratio typical of dihybrid inheritance.

But these genes are linked genes, and, because they are linked, the two genes are inherited as a single unit. Starting from pure-breeding (homozygous) parents which were:-

- ❖ Purple-flowered-with long seeds(PL/PL)
- ❖ White flowered with round seeds (pl/pl).

We can predict what might happen over two generations using the standard genetic diagram parent phenotype:

PL/PL **x** pl/pl = The gametes-------->PL pl

- F1 generation PL/pl (selfed) ⟶ male X female

Male gametes	**Female gametes**			
	pL		**pl**	
PL	**offspring**	**PL/PL ---Purple, long**	**offspring**	**PL/pl---Purple, long**
Pl		**PL/pl ---Purple, long**		**Pl/pl ---red, round**

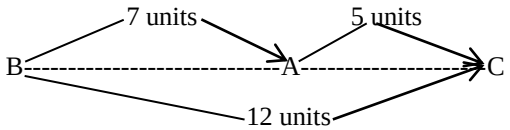
PL & pl (male gametes) PL & pl (female gametes)

- We now predict NOT a 9:3:3:1 ratio but 3:1 ratio of purple- flowered, long -seeded plant **to** red-flowered, round-seeded plants.
- Because the two genes are behaving as a single unit, it is like carrying out a **monohybrid** cross.
- Because the genes are inherited in this way, we would NOT predict any plant that had either purple flowers with round seeds or red flowers with long seeds.
- But the story does not end here.
- We must not forget that when these gametes are formed, they are formed by meiosis and that this involves crossing over at prophase l.
- The consequence of this is some gametes do contain the combination of Pl and others contain pL.
- So we do, in fact, get the four types of offspring from a cross between two plants both heterozygous for both features ---but NOT in a 9:3:3:1 ratio.
- The reason we do not get either is because the genes are linked, but there is some crossing over between them during prophase of meiosis l.
- This produces the types we would not expect from linked inheritance.
- These types are called recombinant types.
- Much of the early research on crossing over and recombination was carried out using fruit flies.
- Suppose three genes A, B and C have loci on the same chromosome.

From investigations, the crossover values are found to be:

1, A and B--------7% 2. A and C--------5% 3. B and C -------12%

This can only hold true if the genes are arranged as shown in page 120



- Gene mapping has been used to track down genes that cause disease (for example, cystic fibrosis and Huntington's disease) so that the DNA of the gene can be cloned for analysis and research.
- **Importance of cross-breeding and inbreeding crops and stock**
- Both cross-breeding and inbreeding are aspects of the same process.
- **Selective breeding**---where organisms are chosen to breed with a specific outcome in mind.
- **Cross-breeding** is an established breeding method used in sheep and beef cattle breeding to **increase overall productivity.**
- It has been used throughout the world and there is a lot of evidence to support the production gains possible from cross-breeding.
- **Commercial cattle farmers may cross-breed animals for two related reasons:**
- 1. to take advantage of hybrid vigor
- 2. to take advantage of the good qualities to improve market suitability
- Hybrid vigor occur when unrelated breeds or lines (of the same species) are cross-bred
- In many cases the offspring from these crosses are more productive (higher milk yields, more beef per carcass) than the average of their parent breeds.
- The extra performance observed through hybrid vigor is simply the recovery of production losses that occurred through inbreeding in the parental breeds.
- Hybrid vigour is reduced when animals produced by cross-breeding are mated together.
- When a new variety of a species is established, organisms of that type are often bred only with each other.
- This is called **inbreeding** and, whilst it helps to produce a **pure line** (remembers Mendel's pea plants).

- When two lines or varieties are cross-bred, the offspring (the F_1hybrid) results in an increase in the number of genes that are heterozygous.
- The 'pure lines' that were used would each be homozygous dominant for the genes which give them their particular characteristics.
- Crossing the two results in offspring with dominant alleles, albeit (even though) in the heterozygous form.
- However, since the dominant allele in a heterozygote often has the same effect as a dominant allele in a homozygote, this increases in the heterozygosity that causes the increased vigor of the hybrid.
- In addition to making use of hybrid vigor, cross-breeding can have the advantage of allowing breeds to be chosen for complementary characteristics.
- For example, cattle produced by cross-breeding dairy and beef breeds can **have high milk yields and the ability to produce many calves.**
- However, if mated with large bulls, the offspring of these cattle also grow to large sizes, making them **good beef cattle.**
- It would not be possible to achieve both these outcomes with either **pure-bred dairy cattle** or **pure-breed beef cattle.**
- It is important at the outset to choose the cattle carefully--to check that they are likely to produce the desired result.
- The same principles can apply in breeding crops
- **Cross-breeding**, naturally or planned, has been important in producing many of the **high-yielding crop plants** we now grow.

  Note: 1. Because it is the result of increased **heterozygosity**, the term hybrid vigor is sometimes replaced by **heterosis.**

  2. The cattle only produce milk after they have calved.
- So if we can produce a breed of cattle that produces potentially high beef calves at the same time as producing a lot of milk (intended for these calves) then the cross-breeding will have been successful.

Genes on the Sex chromosomes

Sex determination

- Males have one X chromosome and one Y chromosome, whereas females have two X chromosomes.
- Because males have two different sex chromosomes, they are called the **heterogametic sex**, whereas females are the **homogametic sex.**
- In addition, they both have 44 (22 pairs) autosomes--non-sex chromosomes.
- We also learned that in any family, or in any mating in mammals, the predicted ratio of males to females is 1:1.
- However, also it is Y chromosome that appears to determine a person's sex, it is, in fact, the action of one gene on this chromosome, the **SRY** gene that determines the formation of testes.
- In the early development of embryo, a region called the **urogenital ridge** develops into a 'bi-potential' gonad.
- This means that the same structure can develop into **either ovary** or **testis.**
- When the SRY is activated, the bi-potential gonad develops into a testis, and the embryo is male.
- If the SRY gene is absent (or inactivated for some reason), genes on the X-chromosome and on the autosomes cause the bi-potential gonad to develop into an ovary, and the embryo is female.
- Because it is the presence or absence of the SRY gene that determines sex, individuals with only X-chromosome and no Y-chromosome (written X-) develop into females, but with slightly masculinized features.
- Similarly, individuals with two X-chromosomes and one Y-chromosome (XXY) develop into males, but with feminized features.
- These individuals are also sterile.
- The abnormal number of chromosomes arises as a result of non-disjunction of the sex chromosomes during meiosis.
- This means that the chromosomes do not segregate properly into the gametes.
- When these abnormal gametes fuse with normal gametes, the abnormal chromosome numbers give rise to the condition described above.

Other Systems of Sex determination

- There are several systems of sex-determination.
- In birds it is females who are the heterogametic sex and males the homozygotic sex.
- But they don't have X and Y chromosomes--they have W and Z.
- Females are ZW and males ZZ.
- There are also other chromosomal systems as shown in figure 3.30 page 123.
- In some reptiles, such as alligators, sex is determined by the temperature at which the egg is incubated.
- Some snails start out male, then become female
- In tropical clown fish, the dominant individual in a group becomes female while the other ones are male, and in blue wrasse fish the reverse.
- Some species have no sex-determination system—they are hermaphrodite (have both male and female sex organs)
- Hermaphrodites include the common earthworm and some species of snails.

The Gene on the Sex Chromosome

- Genes that are found only on the X- chromosomes or on the Y-chromosome are said to be Sex-linked.
- Genes found on the Y-chromosome include those that determine:

1. One form of the degenerative condition Retinitis pigmentosa (in which eye sight becomes progressively weaker and may lead to blindness).

2. One form of deafness.

- These particular conditions can only be inherited by males, as only male have the Y-chromosome.
- *Genes found only on the X-chromosome include those that determine:

1. Red-green colour blindness
2. One form of hemophilia

- These conditions can be inherited by females and males as both possess at least one X-chromosome.
- Many of these conditions are determined by recessive alleles, including both red-green color-blindness and haemophilia.
- If we think about this carefully, we will see why it is that these conditions are more common in men than in women:

1. men have only one X-chromosome

2. if this chromosome carries the recessive allele for haemophilia, there is no corresponding dominant allele on the Y-chromosome to mask its effect.

- women have two X-chromosome

4. both these need to carry the recessive allele for haemophilia for a woman to suffer from a conditions as, if only one of them did, the dominant allele on the other X-chromosome would mask its effects.

5. a man needs to inherit only one X- chromosome with a recessive haemophilia allele to suffer from the condition, where as a woman must inherit two; this is less likely to happen.

- **Sex-linked features determined by recessive alleles on the X-chromosomes have the following characteristics:**

1. They are much more common among males **(because females must inherit two chromosomes** carrying the recessive allele, whereas males must inherit **only one.**

2. Affected males inherit the allele from their mother

3. Affected females inherit one allele from each parent (so the father will be affected)

4. Females who are heterozygous for the condition are called carriers.

5. They may 'skip' a generation and then appear in the males only.

Genes on both X and Y chromosome

- Even though the X and Y chromosomes are very different, they have regions that are
- The genes in this region follow the same pattern of inheritance as genes on the autosomes.
- Therefore, they have three regions:

1. Differential region of X chromosome

2. Differential region of Y chromosome

3. Homologous region of X and Y chromosomes.

- Most of these genes are concerned with control of metabolic activities in cells.
- Genotypes of sex-linked features include the appropriate sex chromosomes as well as the alleles.
- For example, for red-green color blindness, 'B' represents the allele for normal vision and 'b' represents the allele for red-green color blindness.

The possible genotypes and phenotypes are:

1) $X^B Y$-------normal male
2) $X^b Y$-------color-blind (affected) male
4) $X^B X^b$ ------carrier (is not color blind) female

3) $X^B X^B$ ------normal female 5) $X^b X^b$ ------color-blind (affected) female.

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

1. it clearly skips a generation
2. it is more common in males
3. the only affected female has an affected father.

Sex-influenced and Sex-limited Traits

- **Sex-influenced** and **sex-limited traits**:-are examples of traits that are expressed differently in the two sexes.
- However, the genes that determine these traits are not carried on the sex chromosomes, so they cannot be said to be sex-linked.

Pattern baldness (often called male pattern baldness) is an example of a sex-influenced trait.

- It is the high concentration of the male sex hormone testosterone that makes the allele dominant in males.
- Because of this, males need only one pattern baldness allele and they will go bald (because the allele is dominant in males). It does not matter whether the second allele is a baldness allele or a non-baldness allele.
- Females must inherit **two** before they go bald (because the allele is recessive in females).Even then the level of baldness in females is minimized by the low level of action of the alleles.

Sex-limited traits----are only expressed in one sex.

- Both males and females have genes that stimulate lactation, but these are only expressed in females.
- The condition of cryptorchidism (undescended testicles) is genetically determined, but clearly can only ever be expressed in males.

Molecular Genetics

What is a chromosome really like?

- Chromosomes are made from two chemicals:
  1. **DNA** (deoxyribonucleic acid)
  2. **Histones** (a set of globular protein)

- DNA molecule wraps itself around the histone molecules to form a fiber of chromatin.
- When the cell is not dividing, the chromatin is loosely organized throughout the nucleus as loops of chromatin fibers.
- Individual chromosomes cannot be distinguished.
- The loose organization allows the genes to be **active.**
- As a cell prepares to divide, the chromatin loops (which by now will have duplicated themselves) become compacted or "condensed" to form a chromosome that is visible (when stained) under a light microscope.
- The compact state of the chromatin in such a chromosome means that the genes are too tightly packed to be active.

Genes: are short sections of DNA within the chromosome.

We shall learn more about the structure and action of genes in section 3.3 (page 142).

What is a molecule of DNA put together?

DNA (Deoxyribo-Nucleic-Acid)--is one of the two types of nucleic acids (DNA & RNA).

- **DNA** is made of two strands joined together and wound into a double helix.
- The strands of DNA are 'anti-parallel'--the 'start' of one strand is paired with the 'end' of the other strand (see figure 3.34 page 129).
- The basic unit of a DNA strand is a **nucleotide.**

There are four types of nucleotides. These are:

1. Adenine (A)--containing nucleotide
2. Guanine (G)--containing nucleotide
3. Cytosine (C)--containing nucleotide
4. Thymine (T)--containing nucleotide (the Thymine in DNA is replaced by Uracil (U) in RNA).

All nucleotides have the same three components:

1. phosphate group
2. a pentose sugar (deoxyriibose in DNA nucleotides and ribose in RNA nucleotides)
3. One of four nitrogenous bases (Adenine, Guanine, Cytosine, & ether Thymine (in DNA) or Uracil (in RNA).
   - ❖ The structure of a nucleotide is shown in fig.3.35 page130.

❖ **DNA is a huge molecule made from two anti-parallel polynucleotide strands.**

♥ The nucleotides are held together by bonds between the sugar in one nucleotide and the phosphate group in the next.

♥ The base does not take in this linking of the nucleotides in a strand.

- ♥ For this reason, we sometimes say that there is a 'sugar-phosphate back bone' holding each DNA strand together.
- ♥ The nucleotides in one strand are paired with nucleotides in the other.

According to the base-pairing rule:

1. Adenine (A)--containing nucleotide will always be opposite to Thymine (T) --containing nucleotide
2. Guanine (G)--containing nucleotide will always be opposite to Cytosine(C)--containing nucleotide

- ♥ Because of this base-pairing rule, all the bases on one strand of a DNA molecule are base-paired to those on the other strand.
- ♥ We say that the sequence of bases on the two strands is complementary.
- ♥ DNA is a very stable molecule at normal temperatures.
- ♥ The individual hydrogen bonds that hold the two strands together are quite weak, but the sheer number of them in the whole molecule ensures that the strands stay in position.
- ♥ The bonds that hold the nucleotides in each strand are much stronger than the hydrogen bonds.
- ♥ The stability of the DNA molecule is important in ensuring that the genetic code-held in the DNA molecule-does not become corrupted in any way.

How does the DNA molecule replicate itself?

- ❖ The ability of the DNA molecule to make an exact copy of itself is the basis of all methods of reproduction and the basis of passing on genetic information from one generation to the next.
- ❖ When cells divide, it is important that the daughter cells formed (unless sex cells are being formed) contain the same genetic information as the parent cell that produced them.
- ❖ To achieve this, DNA must be able to replicate itself exactly.
- ❖ DNA molecules exist within chromosomes in the nucleus and are surrounded by a soup of free DNA nucleotides--the 'building blocks' with which to build new DNA molecules.
- ❖ Even though they did not know the details, in 1953, Watson and Crick (discovered the structure of DNA) proposed that DNA must replicate semi-conservatively.

This means that the DNA molecule replicates in such a way that:

- ✓ each new DNA molecule formed contains one strand from the original DNA
- ✓ both new DNA molecules formed are identical to each other and to the original molecule.
- ✓ The process involves several enzymes and proteins, but the key stages are as follows:

1. Molecules of the enzyme DNA helicase break hydrogen bonds and 'unwind' part of the helix of the DNA molecule, revealing two single-stranded regions.
2. Molecules of DNA polymerase follow the DNA helicase along each single-stranded region, which acts as a template for a synthesis of a new strand.
3, The DNA polymerase assembles free DNA nucleotides into a new strand alongside each of the template strands.
The base sequence in each of these new strands is complementary to its template strand because of the base pairing rule, A-T, G-C.
4. The processes of unwinding followed by complementary strand syntheses progresses along the whole length of the DNA molecule.
5. The result is two DNA molecules that are identical to each other (and to the original molecule); each contains one strand from the original DNA and one newly synthesized strand that is complementary to this.

Note:

1, DNA helicase--is the enzyme that initiates the separation of the polynucleotide strands during DNA replication.
2. DNA polymerase--is the enzyme that initiates the building of a new complementary polynucleotide strand of DNA following separation of the original two strands.
3. The molecules of DNA in prokaryotic cells are different in a number of ways:

- ✓ they are much smaller
- ✓ they are circular, not linear as in eukaryotic cells
- ✓ they are not associated with histones to form chromosome

4, Histone--is the core of a chromosome around which the chromosome's DNA is wrapped.
5, Chromatin--is the loose form taken by a chromosome when the cell is not dividing.
6. RNA (ribonucleic acid)--is another molecule that stores genetic information.

- ❖ Genetic information stored as DNA is transcribed into RNA as part of the process for making proteins.

7. Double helix--describes the structure of a DNA molecule.
It consists of two anti-parallel polynucleotide strands
8. Nucleotide--is a component of a nucleic acid molecule. It consists of—
1. Phosphate group, 2. Sugar called a deoxyribose (or ribose) and 3. Nitrogenous base.

How are organisms cloned?

- ❖ The term clone is often applied to whole organisms as well as to genes.
- ❖ A **clone** of organisms is a group of organisms produced asexually from one parent.
- ❖ The members of the clone are genetically identical to each other and to the parent organism.

- Plant cuttings are clones and the thousands of plants produced from one parent by micro-propagation also represent a clone.
- Typically, a small section of the growing point of a shoot is taken and sub-divided.
- These small groups of a few hundred cells are placed in test tubes containing a special medium with hormones that induce root growth.
- They are then transferred to another medium containing hormones to Induce shoot growth.
- When they are grown sufficiently, the small plantlets are transferred to compost and grown on. In this way thousands of identical plants can be produced.
- Most of the **world's bananas** are now produced by **micro-propagation.**
- The reason why it is relatively easy to clone plants is that many more plant cells retain the ability to divide than is the case in animals.
- We cannot just cut off a piece of animal and place it in a special medium and watch it grow.
- However, animals can be cloned. The first mammal to be cloned, and still the most famous, was Dolly the sheep see p.134 fig. 3.38).
- **Dolly's genetic mother** was a type of sheep called **'Finn-Dorset'.**
- **Dolly** was produced by transferring a diploid nucleus to an egg cell that had been enucleated (had been nucleus removed).
- Once the nucleus has been successfully transferred, the egg cell was stimulated to divide by a small electric current.
- When development had reached a stage called a blastocyst, the embryo was implanted into a surrogate (substitute) 'mother' ewe.
- Seven months later, Dolly was born.
- She was identical to the Finn-Dorset ewe (female sheep) from whom the genetic material had been obtained (see figure 3.38 page 134).

Invivo cloning: The gene is introduced into a cell and is copied as the cell divides.

Invitro cloning: this does not take place in living cells but the DNA is copied many times over using the Polymerase Chain Reaction (PCR).

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

What is Genetic Engineering?

Genetic Engineering--is a process in which the genome of an organism is altered, usually by having an extra gene from a different organism added.

- The organism is then genetically modified or transgenic organism.
- Much of the early work on genetic engineering was done to genetically modify bacteria.
- This was often done with the aim of altering the bacteria so that they would make a useful product.
- One of the first of these products to be produced by transgenic bacteria was human insulin.
- The gene that controls the production of human insulin was extracted from human pancreas cells and transferred to the bacteria.
- Once modified, the bacteria were then cultured in massive scale in a fermenter and the insulin harvested and purified before distribution.
- Transgenic organism-is a genetically modified organism that contains a gene or genes transferred from another organism belonging to a different species.

The Main Steps in Genetic Engineering

1. Identifying insulin producing cell and the bacterium (E. coli) to be injected.
2. Strand of DNA from insulin producing cell is identified.
3. Plasmid (a ring of DNA from a bacterium) is identified.
4. Insulin gene is cut out of DNA
5. Plasmid is cut open
6. Insulin gene is spliced into plasmid
7. Hybrid plasmid is put back into bacterium
8. Bacterium makes human insulin.

Genetically modified bacterium produces a range of products including:

1. Enzyme for the food industry
2. Thermo-stable (unchanged by heat) enzymes for washing powders
3. Human insulin
4. vaccines (e.g. for prevention of hepatitis B)
5. Bovine somatotrophin (to increase milk yield and muscle development in cattle).

Plants have also been genetically modified so that they:

1. are disease resistant
2. have an improved yield
3. produce a specific product (e.g. golden rice is genetically modified rice that produces beta-carotene, important in the formation of vitamin A which prevents night blindness).

Fewer animals have been genetically modified, but genetically modified salmon and tilapia fish grow bigger and faster than the non-modified fish and could prove to be an important source of protein in some regions of Africa.

- Other animals have also been genetically modified to produce specific products; this is sometimes called 'pharming'.
- Most of the genetic modifications that have been carried out have been with the aim of improving yield of a crop plant or a stock animal, or changing organisms so that they will produce a useful product like-insulin.
- But some do not fall into this category.
- The glow fish in figure 3.41 page 136.literally glow in the dark because they have had a gene added from a bioluminescent jelly fish.
- It was originally produced as a warning against water pollution --it would only glow in polluted water.
- Now they are produced to glow in various colours for the pet market.

Genetic engineering has many potential benefits.

Some of these are described below

1. Disease could be prevented by detecting people /plants/animas/that are genetically prone to certain hereditary diseases, and preparing for a inevitable.
2, It may be possible to treat infectious disease by implanting genes that code for antiviral proteins specific to each antigen.
3, Genetically engineered plants and animals can be produced to give increased growth rates and reduced susceptibility to disease.
   - This would reduce the use of fertilizers and pesticides and the Chemical pollution that results from their use.
4. Animals and plants can be tailor made to show desirable characteristics.
   - Genes could also be manipulated in trees, for example, to absorb More CO_2 and reduce the threat of global warming.
5, Genetic engineering could increase genetic diversity, and produce more variant alleles which could also be crossed over and implanted into other species.
   - It is possible to alter the genetics of wheat plants to grow insulin, for example.
6, Genetic engineering is a much quicker process than traditional selective breeding.
   - This often took many generations to bring about the desired improvement.
   - A single gene transfer may achieve the same result.

How can Gene Technology be used in forensic Science?

Genetic fingerprint--is a technique for comparing a DNA of different people.

- It is a forensic technique that is used to try to solve crimes by matching DNA found at crime scenes with the DNA of suspects.
- Much of the DNA in the cells of the body is what is known as non-coding DNA.
- The non-coding DNA is found between genes and contains base sequences that are repeated, sometimes many times over.
- These repeating sequences of non-coding DNA are called mini-satellites and it is these that form the basis of a genetic finger print.
- The mini-satellites are inherited along with the coding DNA from one or other parent.
- The DNA used for analysis can be obtained from a sample of blood (white blood cells could supply the DNA),skin or semen-in fact, from any type of cell that has nucleus.
- If the sample does not contain sufficient DNA for analysis, the amount can be amplified using a polymerase chain reaction (PCR).

The main stages in preparing a genetic finger prints are as follows

1. DNA is isolated from the cells
2. The DNA is cut into fragments using one or more restriction enzymes.
   The fragments that are obtained are treated with alkali to separate the strands of each DNA molecule.
3. The fragments are separated by gel electrophoresis. Similar fragment (with a lower molecular mass)move further than larger fragments.
4. The (invisible) pattern of separated DNA fragments is transferred from gel to a nylon membrane.
   - The membrane is placed over the gel in a tray of 'flow buffer´ and is held in place by paper towels and a weight.
   - The buffer soaks up through the gel, carrying the fragments of DNA with it.
   - The buffer can pass through the membrane (to be absorbed by the paper towels), but the DNA cannot.
   - It remains in the nylon membrane in the same relative position as it was in the gel.
5. A radioactive gel probe is applied to the membrane.
   - This is made of single-stranded DNA (called c-DNA) and binds with base sequences in the mini-satellite regions.
   - The membrane is placed over a piece of X -ray film to reveal the positions of those fragments that have bound to the probe.

Preparing a genetic fingerprint

1. Preparation of fragments
2. Gel electrophoresis
3. Blotting DNA to membrane
4. Hybridization with radioactive probe
5. Autoradiography

Gel Electrophoresis:is the technique that uses a thick block of gel (gelly-like material) to act as a 'molecular sieve'.

- ✓ Fragments of DNA (or protein molecules) are separated by applying an electrical field across the gel. Because the DNA fragments are negatively charged, they move to the positive electrode.
- ✓ The smaller fragments move more quickly than the large ones and so move further in the same time.
- ✓ The size of DNA molecules is usually measured in kilobase pairs (thousands of pairs of bases).
- ✓ The fragments used in a genetic fingerprint are single-stranded, so there are no base pairs.

Their size is measured in kilobases.

- ✓ The chance of two people having the same fingerprint (unless they are identical twins) is about 1 in 1,000,000 .
- ✓ This means that the genetic fingerprint can be used to provide strong evidence of involvement in or innocence of a crime.
- ✓ Look at the fingerprints in figure 3.44 page 138 of a person accused of attacking a person, together with the victim's genetic fingerprint.
- ✓ Clearly the blood on the defendant's clothes has the same DNA as the victim's blood--it must be the victim's blood.
- ✓ So this is strong evidence that the defendant was at least present at the time.

What are the Moral and Ethical Considerations of using Gene technology?

Is genetic engineering right or wrong?

- ❖ A debate about right and wrong involves the principles of ethics and morality.
- ❖ **Morality** is our personal sense of what is right, or acceptable, and what is wrong.
- ❖ **Morality** is not necessarily linked to legality.
- ❖ **Ethics** also involves a sense of right or wrong.
- ❖ However, ethics are not individual opinions.
- ❖ They represent the code adopted by a particular group to govern its way of life.
- ❖ Many people have passionate views about genetic engineering.
- ❖ Some hold an unshakeable belief in the technology, which they see as something will bring great benefits to human kind.
- ❖ Other people hold the strong belief that genetic engineering is tampering with nature and its likely to cause serious ecological and physiological problems.
- ❖ Some of the issues people are concerned about are discussed below.

1, A species is sacrosanct (not to be or tampered with) criticized should not be altered genetically in any way.

- ❖ This personal, moral viewpoint. People who take this moral stance usually do so, on the basis that the genes from one species would not normally find their way into another species.
- ❖ However, genes have been 'jumping´ from one species to another (albeit a very low frequency) for millions of years.

2. Not enough is known about the long- term ecological effects of introducing genetically modified organisms into the field.
---They may outcompete wild plants and take over an area. This is also a moral viewpoint.

- ❖ The effects of any crop cannot be determined without field trials.
- ❖ Ten thousand years ago, the early farmers who cross-bred wild wheat plants to produce the forerunner of today's strains could not have known what impact these would have. Does this make it wrong?

3. If plants are genetically engineered to be resistant to herbicides, th gene could 'jump' into population of weeds and other wild plants.

- ❖ This is perfectly true -it could. However, non-genetically modified herbicide-resistant strains of plants already exist.
- ❖ The gene could just as easily jump from these.

4. Gene technology might give doctors the ability to create designer babies.

- ❖ It could become possible to obtain a newly fertilized human egg, determine its genotype and ask the parents which genes they would like to be modified.
- ❖ Initially, only genes that cause disease might be replaced.
- ❖ Subsequently, the technology might be used to replace other genes.
- ❖ Most doctors would find this morally and ethically unacceptable.
- ❖ They might consider replacing genes that cause disease but not replacing genes merely to improve a child's image in the eyes of its parents.

5. Using genetic fingerprint to combat crime will only be useful if there is **genetic data base** --a file of the genetic fingerprints of everyone in the country, so that a genetic fingerprint found at the scene of a crime could instantly implicate that person.

Note: Although the human genome project has identified all the base sequences in the human genome, much of this is junk (non-coding) DNA and the exact start and end points of many genes are NOT yet known.

- ♥ In 1922, **Alexander Fleming** discovered **penicillin** in the blue mould penicillium.

Protein Synthesis

How does a cell know to make a protein?

- ♥ The code for a protein is specified by **DNA** and has to be carried out to the ribosomes so that they can assemble the amino acids in the correct sequence to form the protein.
- ♥ However, DNA is a huge molecule and remains in the nucleus all the times.

The following events occur:-

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

The Genetic Code

xThe genetic code is held in the DNA molecule.

- ❖ It is the sequence of bases in the nucleotides of the DNA that makes a gene that codes for the protein and that each amino acid in the protein is coded for by a **triplet** (sequence of three) of bases.

This gives us a useful definition of a gene.

- ❖ A **gene** is a sequence of **base triplets** in the DNA molecule that carries the code for a protein.
- ❖ With four different bases to work (Adenine, Thymine, Guanine and Cytosine), there are 64 possible triplet codes, but only **20 amino acids** are used to make all the different proteins.
- ❖ What is the purpose of other **44 codes**? In fact none of these is spare or redundant(not needed).
- ❖ However, only one of the strands of the DNA molecule carries the code for proteins. This is called the coding strand or the **sense strand**. The other strand is the **non-coding** or **antisense** strand. Most amino acids have more than one code. Only methionine and tryptophan have just **one** triplet that codes for them; arginine has six.
- ♥ Three of the triplets (**TAA,TAG** and **TGA**) do not code for amino acids at all.
- ❖ They are ´**stop**' codes that signify the end of a coding sequence.
- ❖ Because there is this extra capacity in the genetic code, over and above what is essential, it is said to be a degenerate code.
- ❖ Besides being a triplet and degenerate code, the DNA code is a **non-overlapping code.**
- ♥ This means that each triplet is distinct from all other triplets.
- ♥ The last base in one triplet cannot also be the first base (or second base) in another triplet.
- ♥ The genetic code is also a universal code.
- ♥ This means that the triplet **TAT** is the DNA code for the amino acid tyrosine in a human, a giant redwood tree, a bacterium or in any other living organisms.

One way of representing the genetic code

	T	C	A	G	
T	Phenylalanine	Serine	Tyrosine	Cysteine	T
					C
	Leucinnnnne		Stop	Stop	A
			Stop	Tryptophan	G
C	Leucine	Proline	Histidine	Arginine	T
					C
			Glutamine		A
					G
A	Isoleucine	Threonine	Aspargine	Serine	T
					C
	Methionine		Lysine	Arginine	A
					G
G	Valine	Alanine	Aspartic acid	Glycine	T
					C
			Glutamic acid		A
					G

- ♥ Notice the '**stop**´ code. In this method of representing the genetic code, start with one of the 'biggest' letters in the center.
- ♥ This represents the first base in the triplet. One of the four medium-sized letters in the next layer out represents the second base and the smallest letters represent the third base in the triplet.
- ♥ Outside that is the name of the amino acid for which the amino acid codes. So, ACC codes for threonine. GGG codes for glycine. See page 143 figure 3.43A

Note:-It is not just the actual bases in a triplet that matter, but also the sequence of bases within that triplet. So, the sequence **ATT** codes for a different amino acid to **TTA**.

How does transcription take place in eukaryotic cells?

- ❖ During this process, the coded information in the DNA of one gene is used to synthesize a molecule of mRNA that will carry the code to the ribosomes.
- ❖ mRNA is similar to DNA in that it is built from nucleotides; however, it is different from DNA in a number of ways:

1. it is much smaller molecule
2. the base thymine (T) is replaced by uracil (U)

3. the sugar in the nucleotides is ribose, not deoxyribose.

- The triplets of bases in mRNA that code for amino acids are called **codons.**
- The mRNA codons are identical to the DNA triplets that code for specific amino acids, except that U (uracil) is substituted for T (thymine).
- To form the single-stranded mRNA when transcription takes place, only the **anti-sense strand of DNA** is transcribed.
- This is because the sense strand of this section contains the gene that codes for a protein.
- However, transcribing this would produce a **complementary sequence** of bases, similar to those in the antisense strand, which would not code for anything.
- In eukaryotic cells, transcription takes place in the following way:-

1. The enzyme DNA-dependent **RNA polymerase** binds with a section of DNA next to the gene to be transcribed.
2. Transcription factors activate the enzyme
3. The enzyme begins to unwind a section of DNA.
4. RNA-polymerase moves along the antisense strand, using it as a template for synthesizing the mRNA.
5, The polymerase assembles free RNA nucleotides into a chain in which the base sequence is complementary to the base sequence on the antisense strand of the DNA. This, therefore, carries the same triplet code as the sense strand (except that Uracil replaces Thymine).
6, The completed molecule leaves the DNA; the strand of DNA rejoins and recoil.

The mRNA molecule now contains the code for the protein that was held in the DNA of the gene.

How does Translation take place?

Translation of the mRNA code into a protein depends on the interaction within a ribosome between mRNA and tRNA.

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

The following events take place:

1. The first two codons of the mRNA enter the ribosome
2. tRNA molecules (with amino acids attached) that have complementary anticodons to the first two codons of the mRNA bind to those codons.
3. A peptide bond forms between the amino acids carried by these two tRNA molecules and the dipeptide is transferred to the tRNA in the A site.
4. The ribosome moves along the mRNA by one codon, bringing the third codon into the ribosome; at the same time the 'free' tRNA exits the ribosome and the tRNA with the dipeptide moves into the P site.
5. tRNA with a complementary anticodon binds with the third codon, bringing its amino acid into position next to the second amino acids.
6. A peptide bond forms between the second and the third amino acids.
7. The ribosome moves along the mRNA by one codon, bringing the fourth mRNA codon into the ribosome, and the whole process is repeated until a stop codon is in position and translation ceases.

Note: The translation of the mRNA code into a protein molecule requires energy.
However, this **does not** come from the hydrolysis of **ATP** as is usual in a cell, but from the hydrolysis of a similar molecule, GTP (Guanosine) Triphosphate).
GTP is hydrolyzed to GDP and P_i in the same way as ATP, with the release of a small amount of energy.
Some important points to remember:-

1. mRNA is a nucleic acid that transmits the genetic code from DNA to ribosome
2. Transcription:-is the process that converts genetic information from a DNA code into mRNA code
3. tRNA:-transfers individual amino acids during translation
4. Ribosome:-is an organelle in the cell cytoplasm that makes protein
5. Translation:-is a process in which the mRNA code is converted into sequence of amino acids.

How is Protein Synthesis Different in Prokaryotic cell?

- The process is essentially similar in both types of cells, with DNA being transcribed to mRNA, which is then translated to a polypeptide chain.
- However, there are some differences and theses are linked to the fact that:

1. Prokaryotic cells do not have nucleus
2. Prokaryotic mRNA does not need post-transcriptional processing
   - In prokaryotes:-transcription and translation are coupled; mRNA can be translated by ribosomes at one end of its molecule while it is still being transcribed from DNA at the other end.
4. Eukaryotes:-transcription and translation are separated.
5. Transcription occurs in the nucleus, translation occurs in the cytoplasm.
6. Eukaryotic mRNAs are modified before leaving the nucleus.

What becomes of the proteins that are synthesized?

- ♥ All our proteins are synthesized in the way just described, but all our cells do not synthesize all our proteins as we shall see in the next section.
- ♥ However, we synthesize a vast array of different proteins that we can categorize, broadly, into the types shown in table 3.2 page 147.
- ♥ To synthesize these proteins continually, our body requires a constant supply of amino acids.
- ❖ These we can obtain from the protein in the foods we eat.
  The average adult protein requirement per day is about 50 grams.
- ❖ The proteins are hydrolyzed to amino acids in our gut and absorbed into the blood plasma by active transport.
- ❖ They are then transported to the cells where they are used to synthesize our proteins.
- ❖ As mentioned earlier, just 20 amino acids are used to make all the different proteins.
- ❖ Some of these can be made in our bodies by a process called transamination.
- ❖ In this process, the amino group of an amino acid is removed and transferred to a keto acid.
- ❖ The **keto acid** then becomes a different amino acid and what was the amino acid becomes a keto acid.
- ❖ Not all amino acids can be made by transamination.
- ❖ There are some that we just have to obtain from our food.
- ❖ These amino acids are called essential amino acids.

Some of the proteins our body synthesizes

Type protein	Example	Function of example
Structural	Collagen Keratin	Building fibers of cartilage Building nails and feathers
Enzyme	ATP synthase DNA helicase	Producing ATP from ADP & P Unwinding the double helix
Peptide hormone	Insulin Adrenalin (epinephrine)	Control of plasma glucose concentration Fight or flight response
Antigen	Antigen on RBC CD4	Determine blood group Allows binding of HIV to T-lymphocytes
Antibody	Anti-A antibodies HIV antibodies	Causes clotting of RBC with A-antigen Destroy some HIV antigens

What Controls Gene Expression?

- ❖ The fact that some genes are sex-limited tells us that all genes are not active all the time.
- ❖ There are more examples of this ---the genes that control the color of our iris are present in all our cells, but all our other cells are not this color--just the iris. Somehow, we can control which genes are active where.

How are genes switched on?

- ❖ Very often genes are switched on by 'transcription factors' that are present in the cells.
- ❖ These transcription factors are usually proteins that bind to a regulatory sequence of DNA near to the gene they influence.

They operate in the following way:

1. The transcription factors bind to a promoter sequence of DNA near to the gene to be activated
2, RNA polymerase binds to the to the DNA/ transcription factor complex.
1. The RNA polymerase is ´activated' and moves away from the DNA/transcription factor complex along the gene
2. The RNA polymerase transcribes the anti-sense strand of the DNA as it moves along; the gene is now being expressed.

Note: Think about it---where do transcription factors come from?

- ❖ If the transcription factors are proteins themselves, then they must be synthesized as a result of gene expression, and some other genes must regulate the expression of these genes.

Biologists think that this goes all the way back to the egg cell itself, which is able to synthesize a certain number of **transcription factors.**

- ❖ These are made once the egg is fertilized to become a zygote and are passed on to the cells formed when the zygote divides.
- ❖ They influence the cells formed and these cells produce other transcription factors, which are, in turn, passed onto the next generation of cells and so on.
- ❖ This' cascade' or 'hierarchy ‘of transcription factors results in each cell having only certain transcription factors that can activate certain genes.

How are genes switched off?

Besides transcription factors that promote the expression of genes, other factors can act to repress gene action.

- One group of substances that does this is known as Short interfering RNA (siRNA).
- These RNA molecules are unusual because they are very short-
- only about 21 to 23 nucleotides long --and are double stranded.
- The Short interfering RNAs (siRNA) do not act on the gene itself, but they ´interfere with' or ´silence' the mRNA once it has been transcribed from the DNA. This is called post-transcriptional interference.
- If the mRNA is prevented from translating its codons into amino acids, then the protein for which the gene codes cannot be built.
- The gene has effectively been silenced.
- Biologists think that the action of siRNA is as follows:

1. Double-stranded RNA (dsRNA) produced in the nucleus from a range of genes.
2. It is then split into the very short lengths that characterize siRNAby an enzyme called 'Dicer'
3. The anti-sense strand of the siRNA then binds with a complex of molecules called **RISC**.
4. The siRNA binds with mRNA and allows RISC to degrade(cleave the mRNA into small fragments).

Note: Some cancers are caused by hormones acting as transcription factors.

Oestrogen -- is a steroid hormone that can diffuse through the plasma membrane of a cell. It binds with a receptor in the cytoplasm.

- The oestrogen-receptor complex moves into the nucleus and binds with and activates specific genes.
- In the breasts, and lining of the uterus, the activated genes cause cell division.
- Many breast cancers are said to be oestrogen-receptor positive.
- This means that the cancer cells have oestrogen receptors to which the hormone can bind, causing the same increase in cell division as is does in normal breast tissue.
- The anti-cancer drug tamoxifen can bind with the oestrogen receptors and the tamoxifen/receptor complex binds with the DNA.
- However, tamoxifen does not allow transcription factors to bind and so expression of the genes is prevented, and cell division in the cancer is slowed.
- Biologists think that siRNA holds a great deal of promise to treat AIDS and some cancers.
- Researchers have already shown that they can use siRNA to prevent the replication of HIV in cultures by silencing either some of the genes of the virus or some of the human genes on which it depends.
- Other researchers have shown that they can silence genes associated With cancer.
- If oncogenes (cancer-causing genes) could be silenced effectively, then a treatment for many cancers is possible.

Mutations

Mutation-- is any spontaneous change in the genetic material of organism.

There can be large structural changes involving whole chromosomes or parts of chromosomes, or changes that involve only a single base.

- The changes involving only a single base are called **point mutations**, and it is these that we are mainly concerned with.
- There are several types of point mutation, in which one of the bases in the DNA sequence of a gene is altered, usually by being copied wrongly when the DNA replicates.

The different point mutations are: 1. Substitution 2. Addition 3. Deletion

- These mutations occur quite randomly when DNA is replicating and 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.
- 1. **Substitution**:- in substitution, one base is replaced by a different base, as shown in figure 3.56 page 152.

Original sequence:

GAC	GGG	**ATT**	GAG	GAG
Aspartic acid	glycine	isoleucine	glutamic acid	glutamic acid

Mutated sequence: Guanine replaces thymine in this substitution.

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

On the above case, the triplet ATT has been changed to ATG (no other triplet is affected).

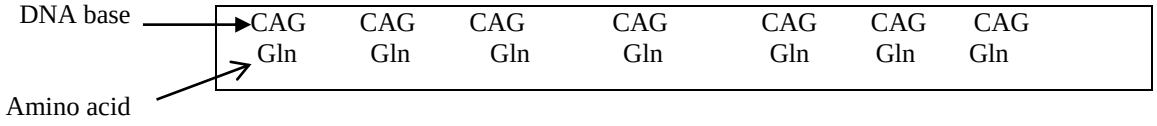
- The original triplet, **ATT**, codes for the amino acid **isoleucine.**
- However, the new triplet, ATG, codes for methionine.
- As a result, a different protein will be synthesized, which may or may not be significantly different from the original.
- One different amino acid in a protein does not always make a functional change.

- If the substitution had been by any base rather than guanine, because the DNA code is degenerate, (see figure 3.47A and B) the triplet still have coded for isoleucine and the same protein would have been synthesized.
- Effectively, it would still have been the same gene.

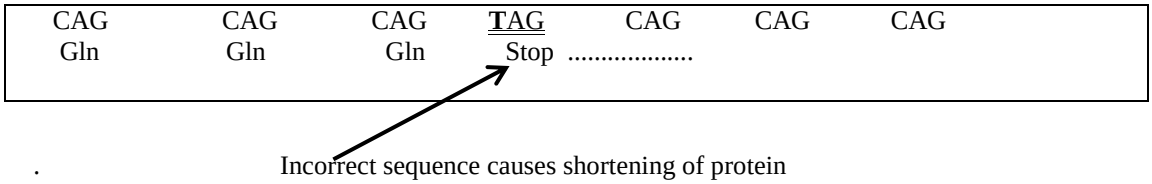
Other substitutions can result in a stop triplet, as shown in fig. 3.57 p.153.

- In this case transcription ceases when it reaches the stop code and a non-functional mRNA results.

Original DNA code for an amino acid sequence: fig. 3.57 A nonsense substitution



Replacement of a single nucleotide (C is replaced by T and then CAG becomes TAG



Example of substitution:

GTG	CAC	CTC	ACT	CCA	GAG	GAG
valine	histidine	leucine	threonine	proline	glutamic acid	glutamic acid

====Normal haemoglobin

GTG	CAC	CTC	ACT	CCA	**GTG**	GAG
valine	histidine	leucine	threonine	proline	valine	glutamic acid

The substitution that caused sickle-cell anaemia = (sickle-cell haemoglobin)

***Note**: A substitution of just one base in the sixth triplet of the gene coding for one of the four polypeptides in the haemoglobin molecule alters the triplet from GAG to GTG.*

This results in the amino acid valine replacing glutamate in the polypeptide chain.

*The different haemoglobin molecule formed results in the condition known as **Sickle-cell anaemia.***

***Sickle-cell anaemia**:-is a condition caused by a mutation that affects the structure of the haemoglobin molecule in RBCs causing the red blood cells to sickle under low oxygen tension.*

Addition and Deletion: In a deletion mutation a base is missed out during replication, whilst in addition, an extra base is added. Both of these are significant mutations than substitutions.

- Substitutions affect just one triplet and, because the DNA code is degenerate, may well have no overall effect--the same protein may still be produced.
- This can never be the case with additions and deletions.
- The reason for this is that they do not just alter the triplet in which the mutation occurs.
- Because there is one fewer or one extra base, the whole sequence after the point of the mutation is altered.

Deletion mutation: is a mutation caused by one DNA nucleotide being omitted from the sequence.

- We say that there has been a frameshift and these are frameshift mutstions.
- A totally different mRNA is produced (if one is produced at all) and a non-functional protein or no protein at all.
- Sometimes, a whole triplet is missed out or inserted.
- This will result 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.

Another way of thinking about frameshifts

Look at the sequence of letters below:

THEMANWASHOTANDRANFORHISHAT

If we give this a ´reading frame' of three letters, it becomes:

THE MAN WAS HOT AND RAN FOR HIS HAT and it makes sense.

But 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

In other words it no longer makes sense. In genetic term it is mis-sense coding.

What causes Point Mutation?

Mutations: occur spontaneously and randomly--they are accidents that occur when DNA is replicating. Mistakes happen.

Mutations: are rare events, which is quite surprising when we consider that each cell contains 6 x 109 (six billion) base pairs that might mutate.

- Biologists estimate that mutations arise at the rate of 1 in 5 x 106 (one in fifty million) base pairs.
- This means that each new cell will have, on average, 120 mutations.

This sounds rather worrying, but we should remember two things:
1. Most of these mistakes (mutations) are detected and repaired, and
2. Because 95% of our DNA is non-coding, most mutations are unlikely to affect coding genes.

The rate of mutation can be increased by a number of factors including:
1. Carcinogenic chemicals---e.g. those in tobacco smoke,
2. Ultraviolet radiation, X-rays etc.

What are the Consequence of Gene Mutations?

There are a number of factors that influence the answer for this, but, really, two important ones**:**
1. Which cell, and **2. Which genes?**
Mutations that occur in a normal body cell (a non-sex cell) will have one of **four possible consequences:**
1. It will be completely harmless
2. It will kill the cell
3. It will damage the cell
4. It will make the cell cancerous, which might kill the person.

- ✓ Which of these is the case, the mutation will affect no other person; it will not be passed on to the next generation.
- ✓ However, if the mutation occurs in a sex cell, or a cell that will divide to give rise to a sex cell, then it may be passed on to the next generation.
- ✓ Mutations in different genes will obviously produce different effects, but **two types of genes are really important:**
  1. Proto-oncogenes 2. Tumour suppressor genes
- ✓ When proto-oncogenes mutate, they often become active oncogenes, which stimulate the cell to divide in an uncontrolled manner. Ordinarily, some growth factor would be necessary to make the cell divide.

Tumour suppressor genes: recognize uncontrolled cell division and act to suppress cell division.
- ✓ If these genes mutate, and become inactive, a tumour will form as uncontrolled cell division continues.

Tumour:-is a mass of cells created when cell replication gets out of control
Tumour ---causes the disease cancer.

Can Mutation Benefit an Organism?

Mutations are the raw materials for evolution.
- ✓ Mutation is the only process that creates new species.
- ✓ Crossing over, segregation and random assortment in meiosis together with random fusion in fertilization reshuffle existing genetic material, but only mutation produced new genetic material.

If a mutated material gives an organism an advantage, then Natural Section will act so that frequency of that allele increases with successive generations.
- ✓ As it does the number of the organism with the mutated allele will also increase, at the expense of those without it.
- ✓ Mutation in the DNA of the bacteria can give them resistance to a specific antibiotic, such as penicillin or ampicillin.
- ✓ These mutations arise spontaneously, as do all mutations.
- ✓ They only give the bacterium an advantage if the particular antibiotic is actually being used. Being resistant to streptomycin is no advantage if penicillin is being used.
- ✓ But being resistant to penicillin in an environment where penicillin is widely used confers a considerable advantage to the organisms.

In 1947, just four years after penicillin was used widely in USA, the first penicillin-resistant bacterium was found--it was a bacterium called ***Staphylococcus aureus*** are caused by penicillin--resistant types.
- ❖ Bacteria can also ´swap´ antibiotic resistance genes with each other.
- ❖ Most of the mutant genes that confer (favour) resistance are found in the plasmids--the 'extra' small circular pieces of DNA that are separate from the main bacterial DNA .

They can transfer these plasmids to other bacteria by:
1. Conjugation--the plasmid passes through a special conjugation tube from one to another.
2. Transduction--a virus carries the plasmid from one to another
3. Trasformation---the plasmid is absorbed from a dead bacterium.

Chromosomal Mutations

Chromosomal mutations occur when there is any change in the arrangement or structure of the chromosomes.
- ❖ They occur most often during meiosis at crossing over in prophase I
- ❖ There are several different mutation types that result in a change in the structure of a chromosome.
- ❖ They 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 foetus may be aborted.

Six types of Chromosomal Mutations

1. Inversion
2. Deletion
3. Insertion
4. Duplication
5. Chromosome non-disjunction
6. Translocation

Inversion: occurs when an area of DNA on the chromosome reverses its orientation on the chromosome.
- ♣ Just one inversion on chromosome 16 can cause leukemia.

- ♣ An inversion that leads to an embryo having too few or too many copies of genes , can cause the embryo to miscarry, fail to grow, or to be born with substantial medical problems.

Deletion: a decrease in the number of genes occurs due to the deletion of the large section of a chromosome.
Deletion can result in a variety of genetic disorders such as Prader-Willi syndrome.

Prader-Willi syndrome:- is developmental disorder**,** a genetic disorder caused by a small chromosomal deletion that results in behavioral problems, underdeveloped genitals, and delayed puberty

This results from a malfunction of the hypothalamus which plays a crucial role in many bodily functions, including:

1. hunger and satiety
2. emotions
3. puberty
4. fluid balance
5. temperature and pain regulation
6. fertility

Insertion: describes an increase in the number of genes caused when an **unequal crossover** happens during meiosis.
---The chromosome may become abnormally long or short and stop functioning as a result.
Duplication: When genes are duplicated it results in them being displayed twice on a single chromosome.
---This is usually harmless as the chromosome still has all its genes.
---However, duplication of the whole chromosome is more serious.
Having three copies of chromosome 16 known as trisomy 16, leads to babies being born with a range of medical issues, such as:

1. poor fetal growth
2. muscular and skeletal anomalies
3. congenital heart defects
4. under developed lungs

Chromosome non-disjunction: When homologous chromosomes do not separate successfully to opposite poles during meiosis, the result is one of the gametes lacking chromosome and another having an **extra** chromosome.

- ❖ If this happens with **chromosome 21, Down's syndrome** results.
- ❖ Those with the condition will have **47 chromosomes in every cell** (because they have three copies of chromosome 21) as opposed to 46 like normal.

Down's syndrome is characterized by mental retardation, heart defects and stunted growth.
Translocation: A piece of one chromosome is transferred to another non-homologous chromosome.
This type of chromosomal mutation is often responsible for **chronic myelogenous leukemia.** These chromosomal mutations are illustrated in fig.3.64 page 158.

Review Questions (Unit 3)

1. In order for the cell to divide successfully, the cell must first
   A. Duplicate its genetic information C. Increase its number of chromosomes
   B. Decrease its volume D. decrease its number of organelles
2. Sister chromatids are attached to each other at an area called
   A. A. Centriole B. Spindle C. Centromere D. Chromosome
3. If a cell has 12 chromosomes, how many chromosomes will each of its daughter cells have after mitosis and cytokinesis?
   A. 4 B. 6 C. 12 D. 24
4. Different forms of a gene are called
   A. Hybrids B. dominant factors C. Alleles D. Recessive factors
5. Organisms that have two identical alleles for a particular trait are said to be
   A. Hybrid B. Heterozygous C. Homozygous D. Dominant
6. A Punnett square is used to determine the
   A. Probable outcome of a cross C. Actual outcomes of a cross
   B. Result of incomplete dominance D. Result of meiosis
7. The physical characteristics of an organism are called
   A. genetics B. heredity C. phenotype D. genotype
8. The probability of flipping a coin twice and getting two heads is
   A. 1 B.1/2 C. 1/4 D. ¾
9. A situation in which a gene has more than two alleles is known as
   A. Complete dominance C. Codominance
   B. Polygenic dominance D. Multiple alleles
10. A pink-flowered *Mirabilis* plant (RW) is crossed with a white-flowered Mirabilis (WW). What is the chance that a seed from this cross will produce a red-flowered plant?
    A. 0 B. 1/4 C. 1/2 D. 1
11. A gene map shows: A. The number of possible alleles for a gene
    B. The relative locations of genes on a chromosome
    C, Where chromosomes are in a cell D. How crossing-over occurs

12. Unlike mitosis, meiosis in male mammals results in the formation of
    A. One haploid gamete C. Three diploid gametes
    B. Four diploid gametes D. Four haploid gametes
13. What happens to the chromosome number during meiosis?
    A. It doubles B. It stays the same C. It halves D. It becomes diploid
14. Which ratio did Mendel find in his F_2 generation? A. 3:1 B. 1:3:1 C. 1:2 D. 3:4
15. During which phase of meiosis is chromosome number reduced?
    A. Anaphase I B. Metaphase I C. Telophase I D. Telophase II
16. Two pink-flowering plants are crossed. The offspring flower as follows: 25% red, 25% white, and 50% pink. What pattern of inheritance does flower color in these flowers follow?
    A. Dominance B. Multiple alleles C. Incomplete dominance D. polygenic trait
17. Which of the following is used to construct a gene map?
    A. Chromosome number C. Mutation rate
    B. Rate of meiosis D. Recombination rate
18. Alleles for the same trait are separated from each other during the process of
    A. Cytokinesis B. Meiosis I C. Meiosis II D. Metaphase II
19. Which of the following is NOT one of Gregor Mendel's principles?
    A. The alleles for different genes usually segregate independently
    B. Some form of a gene may be dominant
    C. The inheritance of characteristics is determined by factors (gene)
    D. Crossing-over occurs during meiosis
20. The process by which one strain of bacterium is apparently changed into another strain is called
    A. Transcription B. transformation C. Duplication D. Replication
21. Which of the following researchers used radioactive markers in experiments to show the DNA was the genetic material in cells?
    A, Frederick Griffith C. Alfred Hershey and Martha Chase
    B, Oswald Avery D. James Watson and Francis Crick
22. Before DNA could definitely be shown to be genetic material in cells, scientists had to show that it could:
    A. tolerate high temperature
    B, carry and make copies of information
    C. be taken down into small sub units
    D. be modified in response to environmental conditions
23. A nucleotide does not contain: A. a 5-carbon sugar C. an amino acid
    B. a nitrogen base D. a phosphate group
24. According to Chargaff's rule of base pairing, which of the following is true about DNA?
    A. A=T, and C=G B. A=C, and T=G C. A=G, and T=C D. A=T=C=G
25. The bonds that hold the two strands of DNA together come from
    A. The attraction of phosphate groups for each other
    B. Strong bonds between nitrogenous bases and the sugar-phosphate backbone
    C. Weak hydrogen bonds between nitrogen bases
    D. Carbon-to-carbon bonds in the portion of the nucleotides.
26. In prokaryotes, DNA molecules are located in the
    A. Nucleus B. Ribosomes C. Cytoplasm D. Histones
27. The main enzyme involved in linking individual nucleotides into DNA molecules is
    A. DNA protease B. Ribosome C. Carbohydrase D. DNA polymerase
28. During replication, which sequence of nucleotides would bond with the DNA sequence TATGA?
    A. TATGA B. ATACT C. CACTA D. AGTAT
29. The scientist(s) responsible for the discovery of bacterial transformation is (are)
    A. Watson and Crick B. Avery C. Griffith D. Franklin
30. Which of the following does NOT describe the structure of DNA?
    A. Double helix C. Contain adenine-guanine pair
    B. Nucleotide polymer D. Bacteria contain DNA but not protein
31. What did Hershey and Chase's work show?
    A. Genes are probably made up of DNA C. Viruses contain DNA but not protein
    B. Genes are probably made up of protein D. Bacteria contain DNA but not protein
32. The two backbones of the DNA molecule consist of
    A. Adenine and sugars C. Phosphates and sugars
    B. Adenine and thymines D. Thymines and sugars
33. In eukaryotic chromosomes, DNA is tightly coiled around proteins called
    A. DNA polymerase B. Chromatin C. Histones D. Nucleotides

34. When prokaryotic cells copy their DNA, replication begins at
    A. One point on the DNA molecule
    B. Two points on opposite ends of the DNA molecule
    C. Dozens of hundreds of points along the molecule
    D. Opposite ends of the molecule
35. Compared to eukaryotic cells, prokaryotic cells contain
    A. About 1000 times more DNA C. Twice as much DNA
    B. About one thousandth as much DNA D. The same amount of DNA
36. The process by which the genetic code of DNA is copied into a strand of RNA is called-386
    A. Translation B. Transcription C. Transformation D. Replication
37. Which of the following describes RNA?
    A. RNA is usually double-stranded and contains the base thymine
    B. RNA is usually single-stranded and contains the base uracil
    C. RNA is longer than DNA and uses fives bases to encode information
    D. RNA is made in the nucleus of eukaryotic cells and stays there to carry out its function
38. In messenger RNA, each codon specifies a particular
    A. Nucleotide B. Enzyme C. Amino acid D. Promoter
39. In eukaryotes, nearly all the DNA is found in the
    A. Nucleus B. Ribosomes C. Cytoplasm D. Histones
40. Which of the following statements about the genetic code is true?
    A. A codon can specify more than one amino acid
    B. Every codon specifies a different amino acid
    C. Some codon specifies the same amino acid
    D. Some codons have no function at all
41. The process of making proteins on the ribosome based on instructions from messenger RNA is called:
    A. Transcription B. Transformation C. Translation D. Molecular biology
42. Changes in DNA sequences that affect genetic information are known as
    A. Replication B. Mutation C. Transformation C. Translation
43. A single-base mutation in a messenger RNA molecule could transcribe the DNA sequence CAGTAT into:
    A. GTCATA B. GUCAUA C. GTCUTU D. GUAAUA
44. A substance that can cause a change to the DNA code of an organism is called a
    A. Toxin B. Mutagen C. Nitrogenous base D. Nucleotide
45. Blocking gene expression in eukaryotes with microRNA strands is called RNA
    A. Transcription B. Translation C. Interference D. Digestion
46. How does RNA differ from DNA?
    A. RNA contains uracil and deoxyribose C. RNA contains uracil and ribose
    B. RNA contains ribose and thymine D. RNA contains adenine and ribose
47. How would the DNA sequence GCTATA be transcribed to mRNA?
    A. GCUAUA B. CGATAT C. CGAUAU D. GCUTUT

Questions 48 and 49: Use the chart below to answer the questions

First base in Code Word	Second base in Code Word: A	G	U	C	Third Base in Code Word
A	Lys	Arg	Ile	Thr	A
	Lys	Arg	Met	Thr	G
	Asn	Ser	Ile	Thr	U
	Asn	Ser	Ile	Thr	C
G	Glu	Gly	Val	Ala	A
	Glu	Gly	Val	Ala	G
	Asp	Gly	Val	Ala	U
	Asp	Gly	Val	Ala	C
U	“Stop”	‘Stop’	Leu	Ser	A
	“Stop”	Trp	Leu	Ser	G
	Tyr	Cys	Phe	Ser	U
	Tyr	Cys	Phe	SEr	C
C	Gln	Arg	Leu	Pro	A
	Gln	Arg	Leu	Pro	G
	His	Arg	Leu	Pro	U
	His	Arg	Leu	Pro	C

48. Which of the following codons signifies the end of translation?
    A. CAA B. UGA C. AUC D. CCA

49. Which of the chains of amino acids corresponds to the nucleotide sequence UCAAGCGUA?
    A. Glu-Cys-Pro B. Glu-Asp-"Stop" C. Thr-Arg-Met D. Ser-Ser-Val

Questions 50-51: Use the table below to answer the questions

Normal chromosome

M	N	O	P	Q	R	S

Mutant 1

M	P	O	N	Q	R	S

Mutant 2

M	N	N	O	P	Q	R	S

50. 50. Mutant 1 is a (an): A. Deletion B. Translocation C. Inversion D. duplication
51. 51. Mutant 2 is a (an): A. Deletion B. Translocation C. Inversion D. duplication
52. A normal diploid human zygote contains
    A. 23 chromosomes B. 46 chromosomes C. 44 chromosomes D. XXY chromosomes
53. A chart that traces the inheritance of a trait in a family is called a (an)
    A. Pedigree B. Karyotype C. Genome D. Autosome
54. An example of a trait that is determined by multiple alleles is
    A. Cystic fibrosis B. ABO blood groups C. Down syndrome D. Colorblindness
55. A mutation involving a change in a single DNA base pair
    A. Will definitely result in a genetic disease
    B. Will have no effect on the organism`s phenotype
    C. Will produce a positive change
    D. May have an effect on the organisms phenotype
56. Cystic fibrosis is caused by
    A. Nondisjunction of an autosome C. Nondisjunction of a sex chromosome
    B. A change of three base pairs in DNA D. Deletion of an entire gene from a chromosome
57. Malaria is a disease caused by a
    A. Gene mutation C. Bacterium found in water
    B. Defect in red blood cells D. Parasite carried by mosquitoes
58. The human genome consists of approximately how many DNA base pairs?
    A. 30,000 B. 3,000,000 C. 3000,000,000 D. 3,000,000,000
59. The fraction of the human genome that actually codes for proteins is about
    A. 2% B. 20% C. 98% D. 100%
60. Cutting DNA into small pieces that can be sequenced is accomplished by
    A. Restriction enzymes B. DNA polymerase
    B. Gel electrophoresis D. RNA polymerase
61. Which of the following disorders can be observed in a human karyotype?
    A. Colorblindness B. Trisomy 21 C. Cystic fibrosis D. Sickle cell disease
62. A woman is homozygous for A^{--} blood type. A man has AB^{--} blood type. What is the probability that the couple's child will have type B^{--} blood? A. 0% B. 50% C. 75% D. 100%
63. Which of the following disorders is a direct result of nondisjunction?
    A. Sickle cell disease C. Turners syndrome
    B. Huntington's disease D. Cystic fibrosis
64. A cystic fibrosis is a genetic disease caused by
    A. Single base substitution in the gene for hemoglobin
    B. Deletion of an amino acid from a chloride channel protein
    C. Defective gene found on the X chromosome
    D. Trisomy of chromosome 21

Huntington's disease is caused by a dominant allele for a protein found in brain cells.
The symptoms of the Huntington's disease, namely mental deterioration and uncontrollable movements usually do not appear until middle age.
The greater the number of codon repeats, the earlier the disease appears, and the more severe are its symptoms.
The allele for this disease contains a long string of bases in which the codon—CAG coding for the amino acid glutamine—repeats over and over again, more than 40 times.
Cystic fibrosis known as **CF** for short, cystic fibrosis is most common among people of European ancestry.
CF is caused by a genetic damage almost as small as the ear wax allele. Most cases result from the deletion of just three bases in the gene for a protein called cystic fibrosis trans membrane conductance regulator (**CFTR**).

CFTR normally allows chloride ions (**Cl^-**) to pass across cell membranes. The loss of these bases removes a single amino acid—phenylalanine –from **CFTR**, causing the protein to fold improperly. The misfolded protein is then destroyed. With cell membranes unable to transport chlorine ions, tissues throughout the body malfunction.

65. The technique used to separate DNA strands of different lengths is
    A. Gel electrophoresis C. Shotgun sequencing
    B. Restriction enzyme digestion D. Bioinformatics
66. The study of whole genomes, including genes and their functions, is called
    A. Bioinformatics C. Information science
    B. Life science D. Genomics
67. DNA can be cut into shorter sequences known as
    A. Haplotypes C. Polymerases
    B. Restriction enzymes D. Restriction fragments
68. Crossing dissimilar individuals to bring together their best characteristics is called
    A. Domestication B. Inbreeding C. Hybridization D. Polyploidy
69. Crossing individuals with similar characteristics so that these characteristics will appear in their offspring is called:
    A. polyploidy B. inbreeding C. hybridization D. recombination
70. Taking advantages of naturally occurring variations in organisms to pass wanted traits on to future generations is called:
    A. selective breeding B. in breeding C. hybridization D. mutation
71. Organisms that contain genes from other organisms are called:
    A. Transgenic B. mutagenic C. donors D. clones
72. When cell transformation is successful, the recombinant DNA
    A. Undergoes mutation C. becomes a nucleus
    B. Is treated with antibiotics D. becomes part of the transformed cell's genome
73. Bacteria often contain small circular molecules of DNA known as
    A. Clone B. Chromosomes C. Plasmids D. Hybrids
74. A member of a population a genetically identical cells produced from a single cell is a
    A. Clone B. Plasmid C. Mutant D. Sequence
75. Which of the following characteristics is often genetically engineered into crop plants?
    A. Improved flavor C. resistance to herbicide
    B. Shorten ripening time D. Thicker stems
76. A substance that have been engineered into transgenic rice has the potential to treat
    A. Cancer B. High blood pressure C. Vitamin A deficiency D. malaria
77. Physicians can screen for a genetic disorder using
    A. DNA microarray B. PCR C. restriction enzyme analysis D. DNA sequencing
78. Which of the following is most likely to be used in a court case to determine who the father of a particular child is?
    A. Microarray B. DNA fingerprinting C. Gene therapy D. Genetic engineering
79. Polyploidy may instantly produce new type of organisms that are larger and stronger than their diploid relatives in:
    A. Animals B. Plants C. Bacteria D. Fungi
80. Which of the following characteristics does NOT apply to a plasmid?
    A. Made in DNA C. Found in bacterial cells
    B. Has circular loops D. found in animal cells
81. To separate DNA fragments from one another, scientists use:
    A. Polymerase Chain Reaction C. DNA microarrays
    B. Gel electrophoresis D. Restriction enzymes
82. Restriction enzymes cut DNA molecules
    A. into individual nucleotides C. at random locations
    B. at short sequences specific to each type of enzyme D. into equal-sized pieces
83. The expression of thousand types of genes at one time can be followed using:
    A. polymerase chain reaction C. plasmid transformation
    B. restriction enzymes D. DNA microarrays
84. Genetically engineered crop plants can benefit farmers by
    A. reducing the amount of land that is required to grow them
    B. introducing chemicals into the environment
    C. increasing animal's resistance to antibiotics
    D. changing the genome of other crop plants
85. genetic markers allow scientists to:
    A. clone animals C. Separate strands of DNA
    B. Synthesize antibiotics D. Identify transformed cells

86. A cross between two contrasting traits or a hybrid with one pair of heritable characters is called
A. the test cross B. the back cross C. monohybrid cross D. dihybrid cross
87. Mendel studied the simultaneous inheritance of two pairs of characters. He did this by crossing plants that differed in two pairs of alternative characters. Such a cross is called
A. the test cross B. the back cross C. monohybrid cross D. dihybrid cross
88. Two parents of genotype Aa are cross-bred. The alleles show complete dominance.
What proportion of the offspring will genotypically look like their parents?
A. 1/2 B. 3/4 C. 1/4 D. 2/3
89. A mating between two heterozygous individuals such as Bb could produce offspring of genotype.
A. homozygous dominant C. homozygous recessive
B. heterozygous D. All of the above are produced
90. As was shown by Gregor Mendel in garden pea, what percentage of the F_2 generation of a monohybrid cross has the recessive phenotype? A. 25% B. 50% C. 75% D. 80%
91. Which of the following are not contrasting pairs in Mendel's breeding experiment
A. Yellow versus round seeds C. round versus wrinkled seeds
B. Inflated versus constricted pods D. Tall versus short plants
92. From which of the following generations did Mendel formulate his principle of dominance?
A. F_1 generation B. F_2 generation C. P_1 generation D. F_3 generation
93. A cross between two individuals that differ with respect to the alleles that carry for a single locus is known as
A. Monohybrid cross B. Dihybrid cross C. Genotypic cross D. Genotypic cross
94.A plant has a genotype AaBb. If there is no linkage of genes, the gametes it produces are
A. AB and ab B. Aa and Bb C. AA, aa, BB, and Bb D. AB, Ab, aB, and ab
95. Mendel formulated his law of independent assortment from the results of
A. his monohybrid cross C. his test cross
B. his dihybrid cross D. incomplete dominance
96. Which concept of genetics came to be known after the death of Gregore Mendel?
A. The concept of incomplete dominance C. The concept of cytological nature of chromosome
B. The concept of multiple alleles D. All of the above
97. Why did Mendel opened all his experimental flowers at their bud stage and cut their stamens?
A. To promote the flowers to self-pollinate C. To prevent the flowers from self-pollinating
B. To enable him artificially cross pollinate the plants D. B and C E. A and B
98. If two phenotypically tall plants are crossed, the first generation of plants will always be
A. All phenotypically and genotypically tall
B. All phenotypically tall C. One fourth will be short D. half will be short
99. In a certain fly species gray body (B) is dominant over black body (b). Two gray flies were mated and produce 21 gray and 7 black. The parents were probably
A. Bb and Bb B. Bb and bb C. BB and bb D. BB and BB
100. If an organism produces a certain trait consistently generation after generation, the organism is said to be: A. True breeding B. Pure breeding C. Hybrid D. A and B E. All
101. The forms of a gene such as those controlling tallness and shortness in a pea plant (T and t) are referred to as: A. Homologous chromosome C. sister chromatids
B. Alleles D. Polymorphs E. a and B
102. The geenotypes of homozygous tall and heterozygous tall plants are
A. TT or Tt B. Tall C. Short D. tt E. A and B
103. Suppose 1000 pea plants are produced from Tt and tt crosses, how many of them are expected to be tall? A. 750 B. 500 C. 50 D. 0 E. 250
104. If a cross between two tall plants gave you only tall plants, which of the following conclusions you arrive at? (Assume tallness is dominant).
A. The two parents are pure for tallness
B. Shortness is dominant over tallness
C. One of the parents were pure tall and the other is hybrid tall
D. Both parents were hybrid tall E. A and C
105. Which of the following is true statement?
A. The Y chromosome carries more genes than the X chromosome
B. In order to be viable, humans must have at least one functional X-Chromosome
C. Genes in the Y chromosome direct female development
D. Human males are homogametic E. None of the above
106. Suppose a cell with 14 chromosomes divides meiotically and one of the four new cells has 6 chromatids and the other 8 chromatids. At what stage in meiosis do you conclude a mistake occurred?
A. Prophase I B. Prophase II C. Anaphase I D. Telophase I

107. Mesfin is left handed. His parents are both right handed. If right handedness (R) dominates over left handedness (r), what was the genotype of the parents?
A. RR and Rr B. Rr and Rr C. Rr and rr D. RR E. rr

108. In humans blue eye color is due to a recessive gene (b) and brown eye color is due to a dominant gene (B). If the mother is BB and the father is Bb, what proportion of their children would be expected to be the blue eyed?
A. $1/4^{th}$ B. $1/2^{th}$ C. $3/4^{th}$ D. $1/8^{th}$ E. 0

109. W/o Chaltu said her baby is exchanged with W/o Almaz's. W/o Chaltu's baby was blood type O and W/o Almaz and her husband are both AB. The baby could belong to W/o Chaltu if
A. W/o Chaltu is heterozygous B, and her husband is heterozygous A
B. W/o Chaltu is homozygous A, and her husband is homozygous O
C. W/o Chaltu is AB and her husband O
D. W/o Chaltu is O and her husband is homozygous B E. B and D.

110. A woman is married for the second time. Her first husband was blood type A, and her child by that marriage was blood type O. Her new husband is blood type B and their child is type AB. What is the woman's genotype and blood type?
A. Homozygous A C. Homozygous B
B. Heterozygous A D. Heterozygous B E. B and D

111. In a certain family, the father is blood type B, his wife's blood group is unknown. They have blood group AB child. What would be the possible blood group of the wife?
A. A B. O C. AB D. B E. A and C

112. Codominance differs from complete dominance in that in codominance
A. The phenotype of the heterozygotes is different from either of the homozygote parents
B. the phenotypic ratio in a cross between the two heterozygotes is 1:2:1
C. the phenotypic ratio in a cross between the two heterozygotes is 3:1 D. A and B E. B and D

113. Upon crossing two green podded pea plants Mendel obtained 428 green and 152 yellow podded plants. What are the most likely genotypes of the two green plants that he crossed?
A. Gg and Gg B. gg and GG C. Gg and gg D. GG and Gg E. A and B

114. Which of the following statements concerning multiple allele inheritance is NOT true?
A. a gene has more than two alleles
B. An individual will have more than two alleles of the gene
C. There are more than two alleles in the population
D. The alleles may be dominant, recessive, or codominant

115. Synthesis of new DNA occurs during:
A. Prophase B. Interphase C. Mitosis D. Cytokinesis

116. Mitosis differs from meiosis in that mitosis
A. has one division per cycle C. forms no chiasmata
B. is an equational division D. occurs in body cells E. all of the above

117. For haploid cells to be formed from diploid cells, a special type of cell division that reduces the chromosome number is required. This process is known as
A. Meiosis B. Mitosis C. Reduction division D. A and C E. All

118. Meiosis differs from mitosis in that
A. In meiosis, there are two successive nuclear and cell division
B. Although in meiosis there are two cell divisions, the DNA and other chromosomal components are duplicated once
C. In meiosis each of the four daughter cells contain only one representative of each homologous pair
D. B and C E. All of the above

119. Which of the following is a correct match between the phase in meiosis and the event happening?
A. Prophase I—synapsis completed and crossing over occurs
B. Anaphase I –sister chromatids separate
C. Anaphase II –homologous chromosomes move to opposite poles
D, After Telophase II and cytokinesis—two haploid cells formed E. A and D

120. The process of breakage and rejoining of chromosomes so that genetic material may be exchanged between homologous (non-sister) chromatids is referred to as:
A. Crossing over B. Chiasmata C. Kinetochore D. Linkage

121. The basic activities occurring in meiosis are:
A. The reduction of chromosome number
B. The production of genetic variation in offspring
C. The reshuffling of genes by crossing over D. All of the above

122. When two organisms heterozygous for two individual traits are mated, the offspring demonstrate a phenotypic ratio of 9: 3: 3: 1. This is due to
A. Independent assortment during meiosis C. Dependent assortment during meiosis
B. Crossing over D. B and C E. None of the above

123. The chance of crossing over occurring between two genes depends how far apart they are on the chromosome. If they are very close together, then
A. it is unlikely that crossing over will occur between the genes
B. it is more likely that crossing over will occur between them
C. it is likely that there will be greater chance to form tetrads
D. A and C are correct

124. Eye color in the fruit fly is said to be sex-linked. This simply means that the gene for eye color is
A. On the Y chromosome C. On the X and Y chromosomes
B. On an autosome D. On the x chromosome E. B and D

125. Identify the correct statement from the following
A. For an X-linked trait to be expressed in a female, two recessive X-linked alleles must be present
B, X-linked traits are generally much more common in males than in females
C, A color-blind female must have a color-blind father and a mother who is at least heterozygous for color–blindness.
D. All of the above

126. Crossing-over
A. Occurs between non-sister chromatids
B. Results in genetic recombination
C. Occurs when chromosomes pair and undergo synapsis during meiosis
D. All are correct

127. Which of the following statements is correct?
A. Gametogenesis is the process by which sex cells are formed
B, Human males are heterozygotic
C. Human females are homogametic D. A and B E. All of the above

128. Which of the following statements is NOT correct?
A. Genes present on the same chromosome can assort independently of one another
B, Assortment can be independent only when genes are on separate chromosomes
C, The number of genotypes and phenotypes during dependent assortment is less than that produced during independent
D, Crossing over increases the formation of different number of gametes E. C and D

129. Genes that are inherited together on the same chromosome are called
A. Equal B. Linked C. Synaptic D. Linear E. Non-linked

130. The frequency of crossing over depends on
A. The relative distance between genes on chromosome
B. The type of cell C. Whether the gene is dominant or not D. A and B

131. Mendel did not deal with:
A. Segregation B. Incomplete dominance C. Linkage D. B and C E. A and C

132. The alternative forms of a gene known as
A. Isomers B. Alleles C. Loci D. Cross over E. Factors

133. Assuming complete dominance which is greater in a hybrid cross?
A. The number of genotypes
B. Both the number of genotypes and phenotypes are equal
C. The number of phenotypes D. B and C

134. In meiosis chromosomes replicate
A. During prophase and metaphase C. During interphase
B. Only once during the entire process D. A and B E. B and C

135. In humans the number of tetrads formed during meiosis is: A. 23 B. 46 C. 4 D. 36

136. Which of the following phenomena makes meiosis to differ from mitosis?
A. The occurrence of synapsis during meiosis
B. The occurrence of crossing over during meiosis
C. The process of tetrad formation in meiosis D. All of the above

137. Identify the correct statement from the following
A. In DNA molecules, the sequence of bases in the two chains are complementary, but not identical
B, In DNA molecules, the sequence of nucleotides in one chain dictates the complementary sequence of nucleotides in the other.
C, The information on a DNA molecule is precisely copied by a semi-conservative mechanism
D. All of the above

138. The enzyme that catalyzes the linking together of nucleotides subunits is termed as
A. DNA polymerase B, DNA helicase C, DNA ligase D. DNA synthase

DNA polymerase: is an enzyme that synthesizes DNA molecules from deoxirebonucleotides (the building blocks of DNA) These enzymes are essential for DNA replication and usually work in pairs to create two identical DNA strands from a single original DNA molecule.

DNA polymerase plays the central role in the processes of life. It carries the weighty responsibility of duplicating our genetic information.

Synthase and **synthetase** enzymes: Both help in forming chemical bonds to synthesize a new molecule in a biological system.
By definition, **synthetases** must cleave (hydrolyze) an ATP molecule to function, while synthases, do not require energy input provided by ATP hydrolysis. Both enzymes are the class of ligases. When ATP is used by a synthase enzyme it is better called **synthetase**.
Medical definition of synthetase: an enzyme that catalyzes the linking together of two molecules especially by using the **energy** derived from the concurrent splitting off of a pyrophosphate group from a triphosphate (as ATP)—called also ligase.
The main difference between synthase and synthetase is that **Synthase is an enzyme** and Synthetase is a **class of enzymes** which can form bonds between molecules. In biochemistry, a synthase is an enzyme that catalyzes a synthesis process.
e.g. ATP synthase, Citrate synthase, Fatty acid synthase, etc.

139. Which of the following can be considered as a manager molecule in protein synthesis?
A. DNA B. RNA C. Amino acid D. All of the above
140. Which of the following holds true about genetic code?
A. Ability to represent more than one amino acid C. Most amino acids have more than one code
C, The genetic code is universal D. B and C
141. Which of the following is correct regarding the number of adenine (A), guanine (G), thymine (T), and cytosine (C) in a DNA molecule? A. G=A B. A+C = G+T C. C=T D. A+T = G+C
142. For a DNA molecule that has 100 cytosine and 50 thymine base the correct number of base pairs are
A. 100 thymine – Cytosine and 50 Adenine – Guanine
B. 100 Guanine – Cytosine and 50 Adenine – Thymine
C. 50 Guanine – Cytosine and 100 Adenine – Thymine D. A and B
143. What property of DNA molecules make them easily separated and replicated?
A. Their double helical structure
B. The presence of a weak hydrogen bond between the bases
C. The fact that they are made of pentose sugar
D. The fact that the deoxyribose sugar is attached to phosphate
144. When a DNA replicates the two daughters DNA contains
A. One molecule each C. One old and one new molecule each
B. Two old nucleotides each D. Two nucleotides that are new
145. The clover leaf configuration of the tRNA has at one end a triplet of base called
A. an anticodon B. a codon C. a code D. antisense
146. RNA differs from DNA in that
A. Its sugar is ribose C. It is single strand
B. It contains the base uracil instead of thymine D. All of the above
147. If the sequence of bases in one of the strands of a DNA molecule is 5^1-ATTGCGGA-3^1, the complementary strand would read
A, 5^1-TAACGCCT-3^1 C. 1^1-ATTGCGGA-3^1
B, 3^1-TAACGCCT-5^1 D. 3^1-TAAGGCCT-5^1
148. Which of the following stages is not involved in the process of protein synthesis?
A, Addition of amino acids to the forming polypeptide
B, Initiation C. Elongation D. Termination E. All are involved
149. The process of precisely copying the information in a DNA is termed as
A. DNA replication B, DNA translation C. DNA termination D, DNA transcription
150. A group of three bases in the mRNA that specifies an amino acid is termed as
A. codon B. anticodon C. decoder D. code
151. In DNA
A. The strands must unbound during replication C. Synthesis always proceeds in 5^1 ------->3^1 direction
B. Replication is semi conservative D. All of the above
152. The genetic code is
A. a triplet code, degenerate and overlapping C. a double code, degenerate and universal
B. a double code, degenerate and non-overlapping D. a triplet code, degenerate and universal
153. When compared protein synthesis in prokaryotic cells and eukaryotic cells it is correct to say that transcription and translation are:
A. separate in both C. separate in prokaryotes and coupled in eukaryotes
B. coupled in both D. separate in eukaryotes and coupled in prokaryotes
154. DNA is considered to be the genetic material because
A. The coded instructions it contains normally remain intact from one generation to the next

B. Its ability to replicate
C. It is able to control cell's activities by directing the synthesis of proteins D. All of the above

155. Which of the following codons do not specify the synthesis of any polypeptide chain?
A. UAA, UGA, UAG B. ACC, AGC, UAG C. UCC, UAC, CCG D. CCC, UUU, UGA

156. The DNA triplet AAT would code for an amino acid carried by tRNA with the anticodon:
A. AAU B. TTA C. AAT D. UUA

157. Which of the following statement is NOT true?
A. In DNA the relative amounts of adenine, thymine, cytosine and guanine vary for a given species
B, In DNA the amount of purines equals the amount of pyrimidine
B. In DNA the amount of adenine equals the amount of thymine
C. In DNA the uprights are made up of the sugars and phosphates

158. Which of the following is NOT true?
A. There are five types of nitrogenous bases
B. Adenine and Guanine are double ringed and are called purines
C. Cytosine, Thymine and Uracil are single ringed and are called Pyrimidines
D, The number or percentage of adenine is equals to that of thymine in RNA molecule

Purines and pyrimidenes are the nitrogen-containig bases found in the nucleotides that make up DNA and RNA.
Purines have two rings in their structure, while pyrimidines have just one.
The two-carbon nitrogen ring bases (adenine and guanine) are purines, while the one-carbon-nitrogen ring bases (thymine and cytosine) are pyrimidines.
Purines are larger than pyrimidines because they have a two-ring structure while pyrimidines only have a single ring.

159. Which of the following statements about transcription factor is wrong?
A. They promotes the expression of genes
B. They are necessary to activate genes
C. They allow the RNA polymerase to transcribe the gene
D. They deactivate the gene expression pairing E. None of the above.

160. In the Watson—Crick model of a double helix, the "rugs" of the "twisted ladder" are composed of
A. sugars B. a purine and a pyrimidine C. two purines D. two pyrimidines

161. Of the following codons which one is a terminator codon?
A. UAA B. UAG C. UGA D. AUG E. All except D

162. Which of the following is NOT true about RNA?
A. is a single stranded C. is much smaller molecule than DNA molecule
B. The thymine is replaced by uracil D. The sugar in the nucleotides is deoxyribose, not ribose

163. a special form of codon that signals the RNA transcription should begin is termed as
A. Initiation codon C. an anticodon
B, a terminator codon D. polymerase E. elongation

164. The mRNA codon for the amino acid methionine is 5^1-AUG-3^1.
The DNA base sequence from where it is transcribed is------and the tRNA anticodon is ----- respectively.
A. 3^1-TAC--5^1, 3^1-UAC-5^1 C. 3^1—UAC--5^1, 3^1--TAC-5^1
B. 5^1-TAC--3^1, 3^1--UAC--5^1 D. 5^1—UAC--3^1, 3^1--TAC-5^1

165. As transcription occurs in the nucleus, translation takes place
A. inside ribosome B. on mRNA C. on endoplasmic reticulum D. On nuclear envelope

166. Which of the following summarizes the "flow" of information in cells?
A. DNA→ RNA→Protein C. Protein→RNA→DNA
B. RNA→DNA→Protein D, DNA→Protein→RNA

167, Transcription of part of a DNA molecule with a nucleotide sequence AAACAACTT results in an mRNA molecule with the complementary sequence of: A/, GGG AGA ACC C/. TTT GAA GCC
B/. UUU GUU GAA D/. CCC ACC CTCC

168. ----------are the monomeric units of nucleic acids
A. Nucleotides B. Purines C. Polymers D. Pyrimidines

169. Which of the following is NOT the property of a tRNA molecule?
A. It must be recognized by ribosomes
B. It must have a specific complementary binding sequence for the correct mRNA codon
C, It must have a region that serves as the attachment site for the charged amino acid
D. All the above are its properties

170. During protein synthesis, where in the cell does transcription take place?
A. Ribosome B, Nucleus C. Endoplasmic reticulum D. Golgi apparatus

171. In protein synthesis, what is produced during transcription?
A. Protein B. mRNA C. DNA D. Polypeptide

172. The sequence of bases in the two chains of a DNA molecule is
A. Complementary and identical C. Complementary but not identical
B. Non-complementary but identical D. Non complementary and not identical
173. Those bacterial enzymes which are able to cut DNA molecules only at specific base sequences are termed as:
A. Restriction enzymes C. Cloning enzymes
B. Vector enzymes D. Plasmids E. DNA ligase
174. The first genetically engineered protein to be commercially produced was: A. Human insulin produced by E. coli
C. Human growth hormone
B. Human blood clotting factor D. Human females menstrual cycle controlling hormone
175. Clones are: A. Genetically identical cells
B. Produced from a single parent asexually
C. Results of mitotic cell division D. All of the above
176. The organism that is utilized now in recombinant DNA technology is
A, *Escherichia coli* B. Yeast C. Human being D. *Entamoeba histolytica*
177. Recombinant DNA technique makes use of
A. Restriction and ligase enzymes C. Bacteriophages and plasmids
B. Viruses that can serve as vectors D. All of the above
178. Inbreeding may be disadvantageous in that
A. It may cause loss of vigour, size and fertility
B. It may produce some harmful traits because the recessive alleles are no longer masked
C, It promotes homozygosity, which in turn decreases diversity or genotypes D. All of the above
179. A type of gene mutation that causes the whole gene to be misread is termed as
A. Frame shift mutation C. Missense mutation
B. Nonsense mutation D. Chromosomal mutation
180. Which of the following could cause point mutation?
A. Deletion C. Inversion
B. Duplication D. Insertion E. All of the above
181. When we say that mutations occur spontaneously, we mean that any gene can mutate.
A. Any time for no obvious reason C. In any part of the world
B. Directed by a known mutagen D. That any gene can mutate randomly and rarely
182. Which of the following statements is NOT true?
A. Mutations can be either spontaneous or induced
B. Thomas Hunt Morgan was the first person to perform artificial chromosome mutation by radiation
C, Somatic mutations contribute toward the malfunctioning of the body and can pass onto the next generation
D, Germ cell mutations are localized to the ovaries, testes, anthers or embryo sac
183. Which of the following is a frame shift mutation
A. A. Point replacement B. Deletion C. Inversion D. Substitution
184. The increase in bacterial resistance to penicillin is due to:
A. mutation C. the increased use of penicillin
B. natural selection D. a combination of all the above
185. During gamete formation sometimes one or more pairs of homologous chromosomes fail to separate so that some gametes contain extra while others contain too few.
A. Epistasis B. Translocation C. Non-disjunction D. Duplication
186. One of the following is different from the rest
A. Insertion B. Translocation C. Duplication D. Point mutation
187. Which of the following statement is NOT true?
A. Point mutation involves a change in only one pair of nucleotide
B. In frame shift mutations nucleotide pairs are inserted into or deleted from the molecule
C. Translocation is a type of chromosomal mutation in which a piece of one chromosome is transferred to another non-homologous chromosome
D. Deletion mutation and addition mutation are less significant than substitution mutation
188. Mutations are important when: A. adaptive B, spontaneous C. heritable D. dominant
189. Mutations result from a change in
A. The nucleotide base pairs of the gene C. The chromosome
B. The rearrangement of genes within chromosomes D. All of the above
190. If a base pair (or pairs) is omitted from a sequence of a DNA molecule, the change is called
A. Deletion B. Insertion C. Substitution D. Translocation E. Duplication
191. Which of the following factors can make gene mutations to occur frequently?
A. X-rays, UV light B, Cyanide C. Formaldehyde, colchicines D. all of the above

192. Non-disjunctions:
A. produce an offspring with an extra chromosome (n+1), (2n+1)
B. produce an offspring with a chromosome missing (n-1), (2n-1)
C. occurs when pairs of homologous chromosomes fail to separate during anaphase I of meiosis
D. is a type of chromosomal mutation E, All of the above

193. In plant hybridization experiment, which one of the following is the best way to prevent self-pollination?
A. To remove the stamens C. To cross-pollinate flowers
B. To cover flowers with bags D. To make reciprocal crosses

194. Which of the following is a right vector to transfer alien genes to bacteria through genetic engineering?
A. Plasmid B. Mosquitoes C. Snails D. Yeasts

195. Suppose in a monohybrid cross of 80 F_2 plants were produced, what is the number of the plants that are expected to have the dominant and the recessive phenotypes?
A. 70 dominant + 10 recessive C. 60 dominant + 20 recessive
B. 50 dominant + 30 recessive D. 40 dominant + 40 recessive

196. Which one of the following is the correct direction of transferring genetic information in most living things?
A. Protein–-->DNA–---->mRNA C. Protein–-->RNA-–>DNA
B. DNA –---->Protein–-->tRNA D. DNA–-->RNA–-->Protein

197. If, due to incomplete dominance, the F_1 plants from a cross of red flowered with white flowered parents are pink, which of the following ratios are expected in F_2 generation?
A. 2 red: 1 pink: 1white B. 1 red: 1 pink: 1white C. 1 red: 2 pink: 1white D. 3 red: 1 pink: 1white

198. Which statement is true regarding a cell's surface area –to-volume ratio?
A. as the size of a cell increases, its volume decreases.
B. as the size of a cell increases, its volume increases.
C. larger cells ill have a greater surface area- to- volume ratio.
D. a smaller cells will have a greater surface area-to-volume ratio.

199. Which one of the following refers to a change in a gene?
A. Replication B. Transcription C. Mutation D. Protein synthesis

200. Among the following traits of the garden pea studied by Gregor Mendel, identify the one that did not express itself in the F_1 generation? A. Green pod color C. Round seed shape
B. Purple flower color D. Constricted pod shape

201. Regarding seed characteristics, suppose a heterozygous round yellow pea plant of RrYy genotype is self-pollinated and produced 160 seeds, how many of the seeds are expected to be round yellow?
A. 30 B. 60 C. 90 D. 105 E. 120

202. The particular experiment to find out if an organism is homozygous or heterozygous for a dominant trait is called: A. crossing over B. monohybrid cross C. the test cross D. dihybrid cross.

203. Which of the following mechanisms can separate linked genes?
A. Crossing over B. Test cross C. Segregation D. Independent assortment

204. Suppose a lost and found baby is claimed by the four families whose blood genotypes are shown below. If a baby has blood type o, which of the families is the possible parent?
A. AO and BB B. AA X OO C. AO X BO D. AB X OO E. AB X BO

205. Which of the following types of gene mutations results in a replacement of just one amino acid by another amino acid in a protein
A. Addition of a base pair C. substitution of a base pair
B. deletion of a base pair D. duplication of a base pair

206. Color blindness is due to an X-linked recessive gene. Suppose a woman heterozygous for color blindness marries a normal visioned man what proportion of their children will be color blind?
A. All the daughters B. Half the daughters C. All the sons D. Half the sons

207. Choose the alternative that illustrates the application of genetics in forensic medicine.
A. Recombinant DNA technology C. DNA finger printing technology
B. Tissue culture D. A and C

208. Short interfering RNA (SiRNA) switch off genes by
A. interfering with mRNA C. translating codons of mRNA into amino acids
B. binding with tRNA and cleave RISC D. acting on the gene itself E. All of the above

209. Two parents of genotype Aa are cross bred. The alleles do not show codominance. What proportion of the offspring will? look like their parents? A. none B. 3/4 C. 1/4 D. 1/2

210. A woman with blood group A and a man with blood group B could potentially have offspring with which of the following blood group? A. A B. B C. O D. all blood groups

211. In an organism of genotype Aa, half the gametes carry the 'A' allele and half carry the 'a' allele. This is due to:
A. dominance B. independent assortment C. recessiveness D. segregation

212. The genotype of a homozygote could be: A. AA B. aa C. Aa D. A and B

213. A plant has a genotype AaBb. There is no linkage of the genes. The gametes it will produce are
A. AB and ab B. Aa and Bb C. AA, aa, BB and Bb D. AB, Ab and ab
214. A tall pea plant with purple flowers (both determined by dominant alleles) is crossed with a short plant with white flowers. There is no linkage of the genes. If the tall, purple-flowered plant is heterozygous for both traits, the offspring will be:
A. 1 purple tall: 1 white short
B. 3 purple tall: 1 white short
C. 9 purple tall: 3 purple short: 3 white tall: 1 white short
D. 1 purple tall: 1 purple short: 1 white tall: 1 white short
215. Cross- breeding results in:
A. an increase in heterozygocity C. hybrid vigor
B. an increase in the number of dominant alleles D. all of the above
216. Which of the following is true of sex-limited traits?
A. They are determined by genes on the autosomes
B. They are expressed in only one sex (male or female)
C. They are carried on the X-chromosome
D. They often result in sexual dimorphism (very different physical appearance in male and female animals)
217. Ligase is an enzyme that:
A. cuts DNA molecules, leaving sticky ends C. Copies DNA fragments
B. joins sticky ends of DNA fragments D. separates DNA fragments
218. The number of different types of genotypes formed when monohybrid is selfed is
A. 1 B. 2 C. 3 D, 4
219. Which of the following is the recessive character on Mendel's experiment in pea plant?

A. Green pod B. Inflated pod C.Tall stems D. Terminal flower
220, A cross between two tall pea plants gave both tall and short plants. The genotypes of the two tall plants could be:
A. TT x TT B. Tt x Tt C. Tt x TT D. tt x tt
221, The person who discovered the laws of heredity and laid the foundation of the science of genetics is
A. Gregor Mendel B. Aristotle C. Carlos Linnaeus D. William Harvey
222. Some F1 (Tt) pea plants were self-pollinated and produced 1000 seeds. If these seeds are sown how many of them are expected to produce tall plants? A. 500 B. 300 C. 750 D. 250
223. The genotype of the organism showing the dominant trait can be determined by carrying out a:
A. Dihybrid cross B. Monohybrid cross C, Trihybrid cross D. Back cross
224. When the F1 hybrid of a monohybrid cross is backcrossed with homozygous recessive parent, what percentage of the offspring would be homozygous recessive? A. 50% B. 25% C. 0% C. 75%
225. In a cross between round green pea of RRyy genotype and wrinkled yellow pea of rrYY genotype, which of the following is the expected of F_1? A. RRyy B. rrYY C. RrYy D. RRYY
226. The number of different types of phenotypes (phenotypic classes) formed when a dihybrid is selfed is:
A. 2 B. 4 C. 9 D. 3
227. Which of the following processes represents a test cross? A) Tt x tt B) TT x Tt C) Tt x Tt D) tt x tt
227. If the genotype of an organism is DdRr, the possible gametes that can be produced are:
A. DR, Dr, dR and dr C. DD, Dd, DR, and Dr
B. RR, RD, Rr and Rd D. Dd, DR, dd, and Dr
228. Which type of dominance is/are involved in the human ABO blood system?
A. Incomplete dominance only C. Complete dominance and codominance
B. Codominance only D. Complete dominance only
229. A gene is a portion of: A, a protein molecule C. an RNA molecule
B, a histone molecule D. a DNA molecule
230. When individuals of genotype AaBb were crossed with individuals of genotype AaBb, 3200 offspring are produced. How many of the offspring would be expected to have aabb genotype?
A. 800 B. 600 C. 200 D. 400
231. The stage of meiosis in which crossing over occurs is:
A. First prophase B. Second prophase C, First anaphase D. Second metaphase.
232. The stage of meiosis where pairs of homologous chromosomes separate is:
A. Prophase l B. Anaphase I C. Metaphase ll D. Anaphase II
233. If a cell having 40 chromosomes enters meiosis, it will produce four daughter cells each with chromosome number of:
A. 10 B. 20 C. 15 D. 40
234. Which of the following is NOT true about meiosis
A. Meiosis is used for gamete formation
B. Four gametes are produced at the end of meiosis
C. Meiosis reduces the chromosome number by half
D. Meiosis produces genetically identical daughter cells

235. Which of the following is referred to as the Mendel's first Law?
   A. The occurrence of alleles in pairs
   B. The dominance of one allele over the other
   C. The equal contribution of alleles by both parents
   D. The separation (segregation) of alleles during gamete formation
236. Which one of the following is best expressed if two plants with flower color cross breed and produce flower color "Z" which is an intermediate of the two?
   A. Incomplete dominance B. Full dominance C. Complete dominance D. Over dominance
237. The DNA of certain organism has guanine as 30 percent of its bases. What percentage of its bases would be accounted for by adenine? A. 10% B. 15% C. 30% D. 20%
238. RNA differs from DNA in that it is
   A. Much larger B. Stable C. single stranded D. Replicates itself
239. What percentage of short plants result from a cross between hybrid tall and pure shot pea plants?
   A. 50% B. 25% C. 75% D. 100%
240. The hereditary phenomenon which was not discovered by Mendel is:
   A. Independent assortment of genes C. Linkage of genes
   B. Dominance of genes D. Segregation of genes
241. Which of the following parts of the DNA ladder make up the cross bars?
   A. Sugars B. Acids C. phosphates D. Bases
242. Which of the following ratios are expected in the F2 generation when F1 plants are self-pollinated due to dominance in flower color of a Snapdragon plant?
   A. 2 red: 1 pink :1 white C. 1 red: 1 pink: 1 white
   B. 1 red: 2 pink : 1 white D. 3 red: 1 pink: 1 white
243. Which of the following is NOT correct about crossing over? It:
   A. Occurs between sister chromatids
   B. Results in genetic recombination
   C. Occurs when chromosomes pair and undergo synapsis during meiosis
244. Which of the following is a CORRECT much between the phase in meiosis and the event happening?
   A. Anaphase l ---sister chromatids separate
   B. Anaphase ll-- Homologous chromosomes move to opposite poles
   C. Prophase l—synapsis completed and crossing over occurs
   D. After Telophase ll and cytokinesis—two haploid cells formed
245. Which of the following is correctly matched?
   A. Baldness –sex linked trait C. Lactation—sex-influenced
   B. Hemophilia—sex-influenced D. Red-green color blindness---sex linked
246. A haemophliac man marries a normal homozygous woman. What is the possibility that their son will be haemophiliac? A. 50% B. 0% C. 75% D. 100%
247. On chromosomes the point at which crossing over occurs is known as
   A. Chiasmata B. centromere C. centriole D. spindle fiber
248. For red-green color blindness, B represents the allele for normal vision and b represents the allele for red-green color blindness. Which of the following does not match the correct possible genotypes and phenotypes
   A. X^bY –carrier male C. X^BX^b--- carrier female
   B, X^BY—normal male D. X^bX^b----affected female
249. Which of the following is the correct constitution of the sex chromosome of a normal woman?
   A. XY B. XXY C. XO D. XX
250. Which of the following terms refers to the failure of sister chromatids to separate from one another during anaphase?
   A. Crossing over B. Non-disjunction C. Synapsis D. Replication
251. What percentage of the F_2 progeny of a monohybrid cross is expected to have the recessive phenotype?
   A. 25% B. 50% C. 75% D. 100%
252. How many chromosomes do humans inherit from each of their parents?
   A. 23 pairs of chromosomes C. 46 chromosomes
   B. 23 chromosomes D. 46 pairs of chromosomes
253. The phenomena by which the progeny produces better yield than the parents is known as
   A. Dominance B. Homozygosity C. Heterozygosity D. Hybrid vigour
254. Which of the following processes restores the chromosomes number from haploid state to diploid state? A. Meiosis B. Fertilization C. Chromosome replication D. Mitosis
255. What is the probability of getting the gamete Ab from the genotype AaBb?
   A. 25% B. 50% C. &5% D. 100%
256. The enzyme that assembles free DNA nucleotides into a new strand of DNA is
   A, DNA helicase B. DNA ligase C. DNA polymerase D. DNA transferase

257. What can be concluded about the parents if a couple produced one normal visioned and one colorblind son?
   A. The mother is color blind but the father is normal
   B. The mother is color blind but the father is carrier
   C. Color blindness cannot be inherited
   D. The mother is carrier but the father may be either normal or color blind
258. The components of a nucleotide are
   A. Phosphate, protein and nitrogenous base C. Deoxyribose sugar and nitrogenous base
   B. Phosphate, ribose sugar and nitrogenous base D. Ribose sugar and nitrogenous base
259. The machine used to clone DNA outside a cell is
   A. Golden gun B. Paper blot C. X-ray machine D. PCR machine
260. If one side a DNA molecule contains the sequence AGTCCG, the complementary sequence on the other side would be: A. CTGAAT B. TCAGGC C. AGTCCG D. GCCTGA
261. Which of the following can be considered as a manager molecule in protein synthesis?
A. DNA B. RNA C. Amino acid D. Glucose
262. Which of the following holds true about the genetic code?
   A. Ability to represent more than one amino acid C. Usability by all living things
   B. Having more than one meaning D. Ability to be none universal.
263. If the sequence of bases on one of the strands of a DNA molecule is 5^1-ATTGCGGA-3^1, the complementary strand would read.
   A. 5^1-TAACGCCT-3^1 C. 1^1-ATTGCGGA-3^1
   B. 5^1- TACCGCCT-3^1 D. 3^1-TAACGCCT-5^1
264. Which of the following stages is not involved in the process of protein synthesis?
   A. Initiation and elongation C. Termination
   B. Addition of amino acids to the forming polypeptide D. All of the above are involved
265. The process of precisely copying the information in a DNA molecule is termed as:
   A. DNA replication B. DNA translation C. DNA termination D. DNA transcription
266. A group of three bases in the mRNA that specifies an amino acid is termed as:
   A. a codon B. an anticodon C. a decoder D. a code
267. The conversion of genetic information into protein requires the linking together of amino acids in the correct order by peptide bonds. This is accomplished by
   A. Ribosomes B. mRNA C. DNA D. tRNA
268. The molecules of DNA in prokaryotes are different from eukaryotes because they are:
   A. much smaller C. not associated with histones to form chromosomes
   B. circular, not linear as in eukaryotes D. All of the above
269. The combination of a 5-carbon sugar and an organic base with no attached phosphate group is called
   A. nucleoside B. nucleotide C. polypeptide D. nucleosome
270. Which of the following codons do NOT specify the synthesis of any polypeptide chain?
   A. UAA, UGA, UAG C. UCC, UAC, CCG
   B. ACC, AGC, UAG D. CCC, UUU, UGA
271. If the mRNA codon for the amino acid methionine is 5^1-AUG-3^1, then which statement is true?
   A. The codon is transcribed from the DNA base sequence is 3^1-TAC-5^1
   B. The tRNA anticodon is 3^1-UAC-5^1 C. The tRNA anticodon is 5^1-UAC-3^1 D. A and B
272. From the following codons which one is not a terminator codon?
   A. UAA B. UAG C. UGA D. AUG
273. A special form of codon that signals that RNA transcription should begin is termed as
   A. Initiation codon B. Terminator codon C. Anticodon D. Elongation
274. As transcription occurs in the nucleus, translation takes place in
   A. inside the ribosome B. endoplasmic reticulum C. on mRNA D. on nuclear membrane
275. The first genetically engineered proteins to be commercially produced was
   A. Human insulin produced by Escherichia coli (E. coli.)
   B. Human growth hormone
   C. Human blood clotting factor
   D. Human female's menstrual cycle controlling hormone
276. Inbreeding may be disadvantageous in that:
   A. It may cause loss of vigor, size and fertility
   B. It may produce some harmful traits because the recessive alleles are no longer masked
   C. It promotes homozygosity, which in turn decreases diversity or genotypes
   D. All of the above
277. The organism that is utilized now in recombinant DNA technology is
   A. *Escherichia coli* B. *Endameba histolytica* C. Human being D. Yeast

278. In DNA: A. The strands must unwound during replication C. Replication is semiconservative
B. Synthesis always proceeds in a $5^1 \rightarrow 3^1$ direction D. all of the above
279. Which of the following is an example of a chromosomal mutation?
A. a base duplication B. a base insertion C. a translocation D. a base addition
280. Which of the following is a frame shift mutation?
A. Point replacement B. Inversion C. Insertion D. Substitution
281. The only source of new genetic material during evolution is
A. Mutation B. Segregation C. Crossing over D. Random assortment
282. The increase in bacterial resistance to penicillin is due to:
A. mutation C. The increased use of penicillin
B. Natural selection D. A combination of all the above
283. Which one is the correct direction of transfer of genetic information in most living things (2003 E.C.)?
A. Protein------DNA----------mRNA C. Protein --------RNA-------DNA
B. DNA--------Protein---------tRNA D. DNA-------RNA-------Protein
284. Which of the following is true about both DNA and RNA (2003 E.C)?
A. Both are single stranded C. Both have a five carbon sugar
B. Both are polymers of amino acids D. Both contain the same four nitrogenous bases
285. If it is known that the total amount of DNA in a cell contains 300 nucleotides and adenine constitutes to 80 of these, how many nucleotides go to guanine (2003 E.C.)? A. 35 B. 70 C. 80 D. 140
286. What proportion of the number of chromosomes found in a normal cell an angiosperm plant is expected in its endosperm tissue (2003 E.C.)? A. Half B. Some C. Two times D. Three times
287. Which of the following phases of mitosis if blocked would produce a cell with twice as many chromosomes as the mother cell (2003 E.C.)? A. Interphase B. Prophase C. Anaphase D. Telophase
288. Which one of the following types of mutations is responsible for sickle cell anaemia (2003 E.C.)?
A. Addition of a base pair C. Deletion of a base pair
B. Substitution of a base pair D. Shift in the reading frame of the genetic code
289. If, due to incomplete dominance, the F1 plants from a cross of red flowered x white flowered parents are pink, which of the following ratios are expected in F2 generation (2003 E.C.)?
A. 1 red : 2 pink : 1 white C. 1 red : 1 pink : 1 white
B. 2 red : 1 pink : 1 white D. 3 red : 1 pink : 1 white
290. Why is it that the typical diploid chromosome number of many organisms including human beings is an even number (2003 E.C.)?
A. Chromosomes duplicate before cell division C. Meiosis reduces chromosome number
B. Both parents contribute equal number of chromosomes D. It is only a coincidence
291. If it is known that the total number of the purine bases account for 50% of a DNA molecule and if each of the remaining bases is known to have the same proportion, what proportion is accounted for by thymine alone in the same molecule (2003 E.C.)? A. 25% B. 50% C. 75% 100%
292. As was shown by Gregor Mendel in garden pea, what percentage of F2 generation of a monohybrid cross has the recessive phenotype (2004 E.C)? A. 75% B. 50% C. 25% D. 12.5%
293. Which of the following parts of a flower did Mendel remove from young flowers to prevent self-pollination (2009 E.C.)? A. Stamens B. Sepals C. Petals D. Ovaries
294. Which of the following is the sex hormone constitution of human males (2009 E.C.)?
A. XX B. XY C. ZZ D.ZW
295. Which of the following bases is NOT found in RNA (2009 E.C.)?
A. Adenine B. Guanine C. Cytosine D. Thymine
296. What type of cross performed to determine whether the father was homozygous or heterozygous (2009 E.C.)?
A. Monohybrid cross B. Dihybrid cross C. Back cross D. Double cross
297. If a heterozygous tall pea plant (Tt) is crossed with a short pea plant (tt), what percentage of the progeny is expected to be short (2009 E.C A. 100% B. 75% C.50% D. 25%
298. When Mendel crossed a tall pea plant with a short plant, the F1 progeny were all tall. What F1 did he obtain when he made the reciprocal cross (2009 E.C.)?
A. Short plants B. Extra-tall plants C. Tall plants D. Plants of average height
299. Among the following ABO blood group genotypes, which one produces two types of antigens (2009 E.C.)?
A. I^AI^O B. I^BI^O C. I^AI^B DI^BI^B
300. Which of the following methods do animal breeders use to produce domestic animals with hybrid vigor (2009 E.C.)?
A. Feeding with nutritive food C. Mating together related animals
B, Giving proper veterinary care D. Cross breeding their animals
301. At which of the following generations of crosses between dominant and recessive homozygote parents are all the progeny heterozygous (2009 E.C.)?
A. P_1 generation B. F_1 generation C. F_2 generation D. F_3 generation

302. Which of the following is publicly an UNDESIRED research activity (2009 E.C.)?
   A. Breeding a new crop variety
   B. Synthesis of a new vaccine
   C. Breeding a new pathogenic micro-organism
   D. Manufacture of a new effective medicine
303. Which of the following nitrogenous bases of nucleic acids is a purine base (2009 E.C.)?
   A. Adenine B. Cytosine C. Thymine D. Uracil
304. Which of the plants with the following genotypes is heterozygous (2009 E.C.)?
   A. BBYY B. BbYy C. bbyy D. YYBB
305. If in a DNA molecule consisting of 1000 base pairs, there are 300 adenine bases, how many guanine bases will be present (2009 E.C.)? A. 200 B. 400 C. 600 D.700
306. Which one of the following is NOT a mutation (2004 E.C)?
   A. DNA replication to form two daughter cells
   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
307. Mutation may be described as (2009 E.C.):
   A. Phenotypic change
   B. Change in gene structure
   C. Continuous variation
   D. Change due to hybridization
308. What do geneticists call the genotype in which the two alleles of a pair are identical (2004 E. C.)?
   A. Dominant B. Recessive C. Homozygous D. Heterozygous
309. Which form of mutation is responsible for the disease known as leukemia (2009 E.C.)?
   A. Duplication B. Insertion C. Inversion D. Deletion
310. Which groups of organisms has a system of protein synthesis in which transcription and translation take place at separate times (2004 E.C.)?
   A. In all eukaryotic organisms
   B. Only in prokaryotic organisms
   C. In multicellular animals only
   D. In both eukaryotic and prokaryotic organisms
311. Which one of the following is referred to as the First Law of Mendel (2004 E.C)?
   A. The occurrence of alleles in pairs
   B. The dominance of one allele over the other
   C. The equal contribution of alleles by both parents
   D. The separation of alleles during gamete formation
312. Which of the following is the best way to check whether an individual having a dominant phenotype is homozygous or heterozygous for the trait (2004 E.C.)
   A. To self the individual
   B. To cross it to a homozygous dominant individual
   C. To cross it to homozygous recessive individual
   D. To cross it to a homozygous dominant individual
313. Which of the following ideas is NOT a part of Darwin's theory of evolution (2004 E.C)?
   A. Over reproduction
   B. Use-and-disuse of body parts
   C. Existence of heritable variation
   D. Competitive for scarce resources
314. In the process of amino acid condensation, which one of the following happens (2004E.C)?
   A. Oxygen is used up
   B. Carbon dioxide is released
   C. Water is released as a byproduct
   D. Protein is broken down into amino acids
315. A genetic cross between two F1 hybrid pea plants having a yellow seeds (dominant) will yield what percent green-seeded (recessive) plants in the F2 generation (2004 E.C.)?
   A. 0% B.25% C. 50% D. &5%
316. Among the following couples whose ABO blood genotypes are shown, which one can produce children, A,B,AB and O blood types (2004 E.C)?
   A. OO and AB B. BO and AA C. BO and AO D. BB and AO
317. Which of the following pairs of molecules can give information about how much two species are evolutionary related to one another (2004)?
   A. DNA and proteins
   B. Starch and cellulose
   C. Lipids and carbohydrates
   D. Carbohydrates and proteins
318. What would most likely result if mitosis fails to be accomplished by cytoplasmic division (2004 E.C.)?
   A. Two cells without nuclei
   B. One cell without a nucleus
   C. Two cells each with one nucleus
   D. One cell with two identical nuclei
319. Which part of the angiosperm flower, are both essential for the success of hybridization experiments (2004 E.C)?
   A. Sepal and petal
   B, stamen
   C. Gynoecium and androecium
   D. Pollen and filament
320. In which of its contents RNA differs from DNA (2005)?
   A. Deoxyribose and guanine
   B. Ribose and uracil
   C. Ribose and thymine
   D. Phosphate and adenine
321. Before making crosses which part of the flower did Mendel remove to avoid self- pollination (2005 E.C)?
   A. Stigma B. Ovule C. Ovary D. Stamens

322. Which of the following is correct F2 phenotypic ratio of a monohybrid cross (2005 E.C)?
A. 1:2 B. 1:1 C. 3:1 C. 2:2
323. Which of the following crops is considered to be the best choice for a better of essential amino acids in a human diet (2005E.C)? A. Maize B. Quinoa C. Rice D. Wheat
324. How many chromosomes do humans inherit from each of their parents (2005 E.C)?
A. 23 chromosomes C. 46 chromosomes
B. 23 pairs of chromosomes D. 46 Pairs of chromosomes
325. Which of the following is true about the gene called sex (2005 E.C.)
A. It is found on the Y chromosome C. It determines maleness
B. Testes develop in its presence D. Females have two copies of these gene
326. The four nucleotides that are used as building blocks of DNA differ from each other in their
A. Organic base molecules C. Sugar molecules
B. Phosphate molecules D. Fatty acids and glycerol
327. The sheep "dolly" is an example of which biotechnological manipulation of animals by human (2005 E,C)?
A. Transgenic animal B. Genetically engineered animal C. Cloned animal D. Hybrid animal
328. Choose the one that is different from all the others (2005E.C)/
A. Genetically modified organisms C. Pathogenic organisms
B. Genetically engineered organisms D. Transgenic organisms
329. In a cross between heterozygotes what proportion is expected to be homozygote recessive (2005E.C)?
A. 25% B. 50% C. 75% D. 100%
330. Gene silencing is the function of the following molecules (2005 E.C.)?
A. dsRNA B. mRNA C. SiRNA D. tRNA
331. Which process is held responsible for chronic myelogenous leukemia (2005E.C)?
A. Translocation B. Translation C. Transcription D. Duplication
332. Two parents of genotype Aa are cross bred. The alleles show complete dominance what proportion of the offspring will phenotypically look like their parents (2005 E.C)? A. 0 B. 1/4 C. 1/2 D. 3/4
333. Among the following mating, the ABO blood genotypes of the parents are shown, identifying the mating in which all the children will have the same blood type (2005 E. C)?
A. AO x BO B. AA x OO C. AB x BO D. BB x AO
334. 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 (2005 E.C)?
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 population
335. Suppose the amino acid coding region in a mRNA is 1200 nucleotides long, how long is the protein in terms of amino acid number (2005 E.C)? A. 1200 amino acids C. 400 amino acids
B. 600 amino acids D. 300 amino acids
336. Which one of the following choices shows the end products of a mitotic cell division (2005 E.C)?
A. Gametes and ordinary cells C. Two genetically different cells
B, Four genetically different cells D. Two genetically identical cells
337. What exactly happens during a substitution mutation (2005E.C)?
A. One base is replaced by 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 of structure of a chromosome
338. In some human cells there are 92 chromosomes per cell what is the progeny level of such cells (2005E. C)?
A. Haploid B. Tetraploid C. Diploid D. Hexaploid
339. In a DNA molecule the "up-rights" of the ladder are made of
A. Sugar and phosphate C. Organic bases
B. Sugar and organic bases D. Phosphate group and bases
340. Which molecule in the cell is the constituent of the gene (2006E.C)?
A. Nucleic acid B. Protein C. Lipid D. Carbohydrate
341. Which of the following is the distinguishing feature of amino acids that is not found in carbohydrates (2005E.C)?
A. Carbon B. Oxygen C. Hydrogen D. Nitrogen
342. In which of their structural parts do different molecules of amino acids differ from one another?
A. In their alpha-carbon chain B. In their amino group C. In their R-group D. In their carboxyl group
343. In a cross between round green pea of RRyy genotype and wrinkled yellow pea of rrYY genotype, what is the expected genotype of the F1 (2005 E.C)? A. RRyy B. rrYY C. Rryy D. RyYy
344. Which of the following groups of animals have males with zz and females with zw sex chromosome constitution (2005E.C)? A. Grass hopper B. Mammals C. Birds D. Honey bees

345. Which one of the following is the mechanism by which two genes located on the same chromosome are separated (2005E.C)? A. Independent assortment B, Segregation C. Linkage D. Crossing over
346. During protein synthesis, where in the cell does transcription take place (2005 E.C)?
A. Ribosome B. Nucleus C. Endoplasmic reticulum D. Golgi apparatus
347. In some crosses of maize, the progeny produces better yield than the parents. What is this phenomenon known as (2006 E.C)? A. Hybrid vigour B. Heterozygosity C. Dominance D. Codominance
348. Which molecules carry the instructions for protein synthesis (2006E,C)?
A. Carbohydrates and lipids B. amino acids C. DNA and RNA D, Enzymes
349. In protein synthesis what is produced during transcription (2006E.C)?
A. Protein B. DNA C. mRNA D. Polypeptide
350. What is a perfect flower (2006 E.C)?
A. A flower with petal C. A flower with stamen and sepal
B. A flower with stamen and pistil D. A flower with sepal and petal
351. Which of the following type of chromosome mutations gives rise to an extra chromosome (2006 E.C)?
A. Inversion B. Translocation C. Duplication D. Deletion
352. Which of the following pairs of individuals have identical DNA finger prints (2006E.C)?
A. Father and son B. Brother and sister C. Mother and daughter D. Monozygotic twins
353. Which of the following mating process children all having the same ABO blood phenotypes (2006 E.C)?
A. AO x AB B. BB x OO C. AO x BO D. AA x BO
354. If a DNA contains, 10% thymine what is the percentage of cytosine in the DNA (2006E.C)?
A. 10% B. 30% C.40% D.90%
355. Which one of the following are the two major constituents of eukaryotic chromosomes (2007E.C)?
A. DNA and RNA B. RNA and lipid C. DNA and protein D. DNA and carbohydrate
356. Which of the following is true about mutations that occur in normal body cells (2007E.C)?
A. They never lead to cancerous cells C. They never pass to the next generation
B. They never damage the affected cells D. There is no way that they kill the affected cells
357. In which of the following ways do retroviruses differ from other RNA viruses (2007 E.C)?
A. Their genetic material is DNA C. Their genetic material is RNA
B. They copy RNA to DNA molecule D. They copy RNA from DNA molecule
358. To what purpose molecular biologists use the technology known as a polymerase chain reaction or PCR (2007 E.C)?
A. To insert DNA into plasmid C. To insert plasmid into bacteria
B, To multiply copies of DNA molecules D. To produce DNA from RNA
359. Which element is found in nucleic acids (2007 E.C)?
A. Calcium B. Iron C. Magnesium D. Phosphorus
360. What do you call a group of genetically identical plants produced by vegetative reproduction (2007 E.C)?
A. Hybrid B. Family C. Clone D. Genus
361. What is the base found in RNA in place of thymine of DNA (2007E.C)?
A. Cytosine B. Guanine C. Thymine D. Uracil
362. What does a restriction enzyme do (2007E.C)?
A. Restricts transcription C. Prevents the DNA from replicating
B. Cuts DNA at specific sites D. Hydrolyses the DNA molecule
363. A cow was found to yield much higher milk than any of the breeds of the parental cattle. What could be the most probable reason for this (2007 E. C)?
A. Dominant genes B. Hybrid vigor C. Recessive genes D. Co-dominant genes
364. Which of the following expression is more related to the phrase "survival of the fittest" (2007 E.C)?
A. Natural selection C. Gene mutation
B. Mendelian inheritance D. Inheritance of acquired characteristics
365. Which two nitrogenous bases belong to purines (2007E.C)?
A. Adenine and thymine C. Guanine and cytosine C. Adenine and guanine D. Thymine and uracil
366. Which one of the following is true (2007 E.C)?
A. Recessive alleles are only expressed in the homozygote
B. Dominant alleles are expressed only in the heterozygote
C. Recessive alleles are expressed in the heterozygote
D. Genetically modified organisms are never used to manufacture vaccine
367. Which hormone promotes human sleepfulness in darkness and controls the sleep-wake cycle (2007 E,C)?
A. Insulin B. Melatonin C. Adrenalin D. Thyroxin
368. Which process produces mRNA during protein synthesis (2007 E.C)?
A. Translation B. Replication C. Mutation D. Transcription
369. Which of the following is true about gene mutation (2007 E.C)?
A. Altering the DNA sequence of the gene C. Change in the position a block of genes
B. Addition of genes to a chromosome D. Loss of genes from a chromosome

370. Suppose in a monohybrid cross 80 F2 plants were produced, what is the number of the plants that are expected to have the dominant and the recessive phenotypes?
   A. 60 dominant: 20 recessive C. 70 dominant:10 recessive
   B. 40 dominant: 40 recessive D. 50 dominant: 30 recessive
371. In cell division, what is the phase that comes following the metaphase called (2007 E.C)?
   A. Prophase B. Interphase C. Anaphase D. Telophase
372. What is the use of enzymes circumstance that causes the health condition known as sickle cell anemia (2007 E. C.)?
   A. DNA denaturation C. RNA mutation and decay
   B, Haemoglobin mutation D. Phosphate mutagenesis
373. Which of the following is the correct constitution of the sex chromosome of a normal woman (2008 E.C)?
   A. XY B. XX C. XO D. XXY
374. Which of the following sequences represents the correct change in number of chromosomes during fertilization (2007 E.C)? A. $n + n \longrightarrow 2n$ B. $2n \longrightarrow 2n$ C. $n \longrightarrow n$ D. $2n \longrightarrow n+n$
375. Why is it that the typical diploid chromosome number of many organisms including human beings is an even number?
   A. Both parents contribute equal number of chromosomes
   B. Chromosomes duplicate before cell division
   C. Meiosis deduces chromosome number D. It is only coincidence
376. Which of the following is made up of globular proteins (2007 E.C)?
   A. Enzymes B. Keratin C. Collagen D. Glycogen
377. Which of the following is true about sex determination in birds (2008E.C)?
   A. They have the heterozygotic X and Y chromosomes
   B. Males have heterozygotic W and Z chromosomes
   C. Females have the homozygotic WW chromosomes
   D. They have the heterozygotic W and Z chromosomes
378. How many amino acids are there in all known proteins (2008 E.C)?
   A. About 10 B.About 20 C. About 35 D. About 46
379. Which of the following is the mechanism by which two genes located on the same chromosome are separated:
   A. Crossing over B. Linkage C, Independent assortment D. Segregation
380. Which of the following crosses will produce progeny with phenotypic ratio of 3:1 (2008 E.C)?
   A. Crossing the F1 to the dominant parent C. Crossing two homozygote individuals
   B. Crossing the F1 to the recessive parent D. Crossing two heterozygote individuals
381. Which of the following molecule is capable of mutation?
   A. Proteins B. Nucleic acids C. Carbohydrates D. Lipids
382. What percentage of F2 progeny of a monohybrid cross is expected to have the recessive phenotype (2008 E.C)?
   A. 100% B. 75% C. 25% D. 50%
383. Deficiency of which of the following nutrients in human diet is likely to result in a deficiency of some co-enzymes like FAD (2008 E. C.)?
   A. Essential amino acids B. Carbohydrates C. Vitamins D. Saturated fatty acids
384. Which of these could be a gamete? A. GgRr B. GRr C. Gr D. Gg
385. In a codon on the mRNA is UUU, what is the complementary anticodon on the tRNA (2008E.C)?
   A. UUU B. GGG C. CCC D. AAA
386. If a clone is produced by transferring a nucleus of animal A to an enucleated egg of animal B and the egg then implanted in the uterus of animal C, which animal would the clone resemble most (2008 E.C)?
   A. Animal C B. Anima B C. Animal A D. Other animals
387. How many years have passed since Darwins book on the theory of evolution was published (2008E. C)?
   A. About 50 years B. About 120 years C. About 160 years D. About 100 Years
388. Which of the following techniques is used to separate DNA fragments according to their size on a gel?
   A. Radioactive labeling C. Southern blotting
   B. Electrophoresis D. Digestion by restriction enzyme
389. Which of the following can be understood about living things from the study of how breeders improved domesticated plants and animals (2008 E. C.)?
   A. Living things tend to over-reproduce C. Natural resources are of limited supply
   B. Living things can be improved through selection D. Individuals compete for resources
390. Linked genes do not assort
   A. when dominant B. if crossed over C. when recessive D. independently
391. Suppose two heterozygous round yellow (RrYy x RrYy) pea plants were crossed and seeds were produced, how many of the seeds are expected to the heterozygous round yellow (2008 E.C.)?
   A. 4 B. 16 C. 9 D. 3
392. Why is that mutations are considered as one of the raw materials of evolution (2007 E.C)?
   A. They contribute to new variations in organisms
   B. They are usually related to environment in which they appear

C. They are mostly beneficial to the environment in which they appear
D. They usually become the causes for species extinction

Answer for Review Questions (unit 3)

1	A	34	A	67	D	100	D	133	C	166	A	199	C	232	B	265	D	298	A	331	D	364	A
2	C	35	B	68	C	101	B	134	E	167	B	200	D	233	B	266	A	299	C	332	C	365	C
3	C	36	B	69	B	102	A	135	C	168	A	201	C	234	D	267	A	300	D	333	A	366	A
4	C	37	B	70	A	103	B	136	D	169	D	202	C	235	D	268	D	301	B	334	A	367	B
5	C	38	C	71	A	104	E	137	D	170	A	203	A	236	A	269	A	302	C	335	C	368	D
6	A	39	A	72	D	105	B	138	C	171	B	204	C	237	D	270	A	303	A	336	D	369	D
7	C	40	C	73	C	106	C	139	A	172	C	205	C	238	C	271	D	304	B	337	A	370	A
8	C	41	C	74	A	107	B	140	D	173	A	206	D	239	A	272	D	305	A	338	B	371	C
9	D	42	B	75	C	108	E	141	B	174	A	207	C	240	C	273	A	306	A	339	A	372	B
10	A	43	D	76	C	109	A	142	B	175	D	208	A	241	D	274	A	307	B	340	A	373	B
11	B	44	B	77	A	110	B	143	B	176	A	209	D	242	B	275	A	308	C	341	D	374	A
12	D	45	C	78	B	111	E	144	C	177	D	210	D	243	A	276	D	309	A	342	C	375	A
13	C	46	C	79	B	112	D	145	A	178	D	211	D	244	C	277	A	310	A	343	D	376	A
14	A	47	C	80	D	113	A	146	B	179	A	212	D	245	D	278	D	311	D	344	C	377	D
15	D	48	B	81	B	114	C	147	B	180	E	213	D	246	B	279	C	312	C	345	D	378	B
16	C	49	D	82	B	115	B	148	E	181	A	214	C	247	A	280	C	313	B	346	A	379	A
17	D	50	C	83	A	116	E	149	D	182	C	215	D	248	A	281	A	314	C	347	A	380	D
18	A	51	D	84	A	117	D	150	A	183	B	216	B	249	D	282	D	315	B	348	C	381	B
19	D	52	B	85	D	118	E	151	D	184	D	217	B	250	B	283	D	316	C	349	C	382	C
20	B	53	A	86	C	119	A	152	D	185	C	218	D	251	A	284	C	317	A	350	B	383	C
21	C	54	B	87	D	120	A	153	D	186	B	219	D	252	B	285	B	318	D	351	C	384	C
22	B	55	D	88	A	121	D	154	D	187	D	220	B	253	D	286	D	319	C	352	D	385	D
23	C	56	B	89	D	122	A	155	A	188	A	221	A	254	B	287	C	320	B	353	B	386	C
24	A	57	D	90	A	123	A	156	A	189	D	222	C	255	A	288	B	321	D	354	C	387	A
25	C	58	D	91	A	124	D	157	A	190	A	223	D	256	C	289	A	322	C	355	C	388	B
26	C	59		92	B	125	D	158	D	191	D	224	A	257	D	290	B	323	C	356	C	389	B
27	D	60	A	93	A	126	D	159	D	192	E	225	C	258	B	291	A	324	A	357	B	390	D
28	B	61	B	94	D	127	D	160	B	193	A	226	B	259	D	292	C	325	D	358	B	391	A
29	B	62	A	95	B	128	A	161	E	194	A	227	A	260	B	293	A	326	A	359	D	392	A
30	C	63	C	96	D	129	B	162	D	195	C	228	C	261	A	294	B	327	C	360	C	---	---
31	A	64	B	97	D	130	A	163	A	196	D	229	D	262	C	295	D	328	C	361	D	---	---
32	C	65	A	98	C	131	C	164	C	197	C	230	C	263	D	296	C	329	A	362	B	---	---
33	C	66	D	99	A	132	B	165	A	198	D	231	A	264	D	297	C	330	C	363	B	---	---

UNIT 4

EVOLUTION

Evolution: is the process by which all living things have developed from primitive organisms through changes taking place over billions of years.

- It is now a scientific fact that evolution does occur.
- The theory of evolution describes how the various forms of life on earth (including humans) emerged and developed.
- We have something like the summary shown in figure 4.1 page 172 in mind.
- Scientists agree that all living things arose through a long history of changes brought about by physical and chemical processes.
- Changes occur in living organisms that serve to increase their adaptability or potential for survival and reproduction in a changing environment.
- For new species to appear, groups of organisms (the population) have to change, not just single organisms.

- For them to change, their genes must change, as the genes define what they will be by controlling protein synthesis.

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

- How did the first form of life come about?

The Origin of Life

Evolution is a process of gradual development from simple forms through a series of gradual changes.

- **Evolution of life** may be defined as the development of differentiated organisms from pre-existing, less differentiated organisms over the course of time.
- There are two theories that try to explain this process of gradual change.
  These are: 1. **Chemical evolution** 2. **Organic evolution**

1. **Chemical evolution**: Proponents of chemical evolution believe that complex organic compounds were formed from simple chemical elements or compounds.
   - These complex organic compounds, such as DNA molecules were able to reproduce themselves and became the originators of life on earth.
   - It can be assumed that the first form of life was very simple. May be a single cell that could grow, reproduce and mutate.
   - Since it was very first living thing; it had to come from non-living chemicals.
   - Simple gases from the atmosphere and water probably combined to form simple substances.
   - The simple substances collected together in groups to form larger substances.
   - A membrane surrounded the larger groups of substances with a control center inside.
   - Thus a cell is formed which eventually could divide to form groups of cells.
   - From these groups of cells developed the larger organisms through successive generations.

There are several theories and views regarding the origin of life on the earth.

The five main theories are:

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

1. Special creation theory:

- The special creation theory says that life on earth was created by a supernatural power or divine entity. We call this divine entity God.
- Special creation is nearly always linked to religion, where as an acceptance of evolution is linked to scientific thinking.
- It is unlikely that the difference between the scientific theory of evolution and special creation will ever be resolved.
- Science describes the natural world around us using a means of observation and empirical testing using instruments.
- ☞ These observations then result in the development of scientific theories. There is no attempt on the part of science to give opinions about morality or purpose.
- ☞ Religion mainly focuses on spiritual matters that, by their very nature, cannot be seen, touched or measured effectively. Religion deals with philosophical matter that relates to morality and concerns between humans and their **God**.
- ☞ Religion is less concerned with empirical observable facts and testable hypothesis but rather with faith, the belief in things that cannot be proven.
- ☞ Science relies on provable events; religion relies on believing in that which cannot be proven. The two views are very, very different from each other even though each is a valid worldview in in its own context.
- ☞ Special creation states that at some stage, some supreme being created life on Earth. There are many different versions of special creation, linked with different religions.
- ☞ Often, there is considerable variation as to how rapidly the special creation theory is interpreted within a religion (Read page 173-174).

- These are: 1. Young Earth Creationism 4. Progressive creationism
  2. Old Earth Creationism 5. Theistic evolution (Evolutionary Creationism)
  3. Day-age and gap creationism 6. Intelligent design

Young Earth Creationism

- This form of creationism today suggests that the Earth is only a few thousand years old.
- Young Earth creationists often 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 the Noah's flood.

Old Earth Creationism

- There are several types of creationism that are considered Old Earth.
- They vary in different aspects f how they explain the age of the Earth while still holding to the story found in Genesis.
- Those who believe in Old Earth creationism accept the evidence that the Earth is very old but still maintain that all life was created by God.

Day-age and gap creation

- These are similar in that each interprets the beginnings of the creation story as actually having taken much longer than six Earth days:

Gap creation : discusses a large gap between the formation of the Earth and creation of all the animals and humans.

- The gap could be millions or billions of years.
- This gets around the scientific evidence that the Earth is several billion years old without having to believe in the process of evolution itself.
- Day-age creationism is similar in the length of time but talks about each of six 'days' as really meaning a billion years or so of geologic time; the 'days' are just symbolic.

Progressive creationism: This type of creationism accepts the Big Bang as the origin of the Universe.

- It accepts the fossil record of a series of creations for all of the organisms catalogued.
- However, it does not accept these as part of a continuing process; 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. It also involves the role of God in areas not discussed by science, like the creation of the human soul.
- Theistic evolution is promoted by the Pope for the Catholic Church and is also espoused by most mainline Protestants.

Intelligent design: This is the newest version of creationism and maintains that God's handwork can be seen in all creation if one knows to look.

- Advocates of intelligent design offer sophisticated arguments, often based on cell biology and mathematics, to give the impression of complex scientific arguments and to create equal stature with mainstream scientific thought.
- These arguments attack different parts of evolutionary theory, with the idea that if one part of evolutionary theory found to be incorrect then it follows that all of the evolution must be incorrect.
- The term intelligent design is used to mask the fact that it is a form of creationism cloaked in scientific sounding ideas.

2. Theory of spontaneous generation or abiogenesis:

- States that life has originated from non-living organic matter spontaneously or abiogenetically, i.e., without the intervention of living things.
- It was only a few hundred years ago that people still believed this to be true.
- For example, people believed that rotting meat turned into flies and that wine produced bacteria as it went sour.
- A supporter of spontaneous generation, Van Helmont, suggested that mice could spontaneously generate from non-living objects like dirty shirt and grains.
- This theory was later disproved by a series of experiments conducted by Francesco Redi, Lazzaro Spallanzani and Louis Pasteur.
- It took the work of Francisco Redi to disprove the idea of rotting meat producing flies and the work of Louis Pasteur to finally show not even micro-organisms could be produced by spontaneous generation.
- In Red's experiment, illustrated in figure 4.2 page 174, flies only appeared in the jars where flies had access in the first place.
- If flies are excluded, as he did with some jars, the meat does not produce either maggots or flies.
- 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) micro-organisms (Pasteur) can only arise from pre-existing organisms, disproving the theory of spontaneous generation.

3. The theory of Eternity of life

- This theory assumes that life is as eternal as matter itself.
- This theory maintains that life only changes its form but is not created from dead or non-living substances.

- ⇨ Proponents of this theory believe that life has no origin and has always existed.

4. The Cosmozoan theory

- ⇨ According to this theory life had an extra-terrestrial origin.
- ⇨ This theory proposed that life must have come from some other planet, carried by a space ship or it could have come in a comet or meteorites, in the form of some sort of spore.
- ⇨ Support for this idea comes from analysis of meteorites, which were found to contain amino acids, the building blocks of proteins.

5. Biochemical evolution

- ⇨ This theory states that the first form of life evolved from a set of chemicals.
- ⇨ This theory is more scientific, stating that life came from non-life.
- ⇨ That through the course of millions of years, life came about from the elements that were in the primitive atmosphere, as stated by Alexander Oparin's heterotrophic hypothesis.

Oparin's heterotrophic hypothesis

Alexander Oparin was a Russian scientist. In 1923 he presented a hypothesis on the origin of the first forms life.

- He called these first forms of life protobionts.
- Oparin considered that the origin of life was a natural step in the constant transformation of matter.
- The **basis of Oparin's** theory is that the conditions in the primitive earth were different from the ones we know today.

Oparin assumed that oxygen was totally absent from the primeval (primitive) atmosphere of the earth.

- This primitive atmosphere was thought to have contained mainly nitrogen gas.
- Other gases present in these atmosphere were co_2 and water vapour that was thrown up from volcanoes.
- Since the elements sulphur, nitrogen and carbon were present, it is possible that the compounds, ammonia, methane and hydrogen sulphide were also part of the atmosphere.
- Slowly the atmosphere began to cool.
- Cooling of the atmosphere led to the formation of various saturated and unsaturated hydrocarbons.
- Through the process of **condensation, polymerization** and **oxidation-reduction**, these hydrocarbons formed a specialized mixture of water almost like a hot dilute soup.
- This soup contained alcohols, aldehydes, acids and various amines and amino acids.
- We must remember that at this time there was immense organic activity and fierce lighting storms.
- The energy from organic eruptions and lighting allowed gases to form simple organic molecules.
- This was the next step in the evolution of life.
- The **amino acids** probably combined to form polypeptides.
- This was the first stage of protein synthesis.
- **Proteins** form the major part of a living cell. So, the synthesis of proteins were the starting point of the origin of life.

The energy requirement for protein synthesis was provided by:

1.Radioactivity of the cooling of the earth,
2.Ultraviolet light
3. Radiation
4. Heat and
5. Lighting

Protein synthesis in primitive earth was taking place in the ocean over thousands of years.

- ➢ The compounds of hot dilute soup were colloidal, hydrophilic complexes surrounded by water coverings.
- ➢ The word hydrophilic means water loving. So the colloidal complexes attracted water onto their surface.
- ➢ Some of these complexes joined together to form various combinations of higher proteins.
- ➢ Through polymerization and condensation in the ocean water, a process of coacervation (an aggregate of colloidal droplets bound together by electrostatic forces) took place.
- ➢ The mixing of two different colloid solutions resulted in some microscopic droplets getting separated from them.
- ➢ Oparin called these coacervate **droplets** or **coacervates**.
- ➢ This word is derived from the Latin word acervus, which means **pile**.
- ➢ These droplets were capable of absorbing water onto their surface.
- ➢ This then provided the basis for the development of the cellular membrane.
- ➢ **Oparin** considered the coacervates to be the sole living molecules, which give rise to life.
- ➢ A scientist by the name of **B. S. Haldane** also proposed a similar theory. Both **Oparin** and **Hldane** hypothesized that life originated in the early seas from a primeval soup made up of gases present at the time in the earth's atmosphere.
- ➢ **Oparin's hypothesis** was supported by an experiment conducted by **Stanley Miller** and **Harold Urey in 1953**.
- ➢ **Miller** and **Urey** designed an apparatus to simulate the primitive atmosphere and hypothesized life-forming processes.

Gases were admitted into the apparatus at the point where it says boiling water. This represented the **ocean**.

- ♥ The gases are then circulated past an energy source.
- ♥ This energy is provided by electrodes in the form of spark discharges.
- ♥ The gases are **cooled** in a condenser and then collected in water in a trap. The liquid from the trap can be withdrawn for analysis.

The main steps of the experiment and the reasons for each step:

1. **Assemble an atmosphere** similar to the one thought to exist on the primitive earth. Some of these gases were methane, ammonia, hydrogen and water vapour.
2. **Place the atmosphere on liquid water**, which was present on the cooling earth.
3. **Exclude gaseous oxygen** from the atmosphere since none was present in the atmosphere of the primeval earth.
   Note that this atmosphere was a reducing atmosphere, unlike the oxidizing atmosphere of today.
4. **Maintain the mixture at a temperature** a little below 100 degrees centigrade.
   - ♥ At that time the temperature on earth was extremely high because of the volcanic activity, meteorites and fierce lighting storms.
   - ♥ Also the absence of oxygen from the atmosphere meant that there was no ozone layer.
   - ♥ This led to very high temperatures through radiation.

5. Subject the gases to energy in the form of electrical sparks

- ❖ The electrical sparks simulated or represented lighting.
- ❖ The experiment was run for a week. Samples of water were removed from the tap and its composition analyzed.
- ❖ From this experiment Miller and Urey were able to synthesize the 20 amino acids and other biochemicals such as sugars, lipids, short lengths of polypeptides and ATP.
- ❖ These experiments indicate that the primitive gases could have and probably did react with one another to produce simple organic compounds that accumulated in the ancient seas for millions of years.
- ❖ These compounds could have been the chemical building blocks of life. Miller's experiment did not produce life.
- ❖ But it certainly provided strong evidence that the basic ingredients and the conditions for life were present.

Origin of Autotrophs

Paleontological evidence suggests that the first forms of life were heterotrophic prokaryotes which were also anaerobic (respiring without oxygen) and dependent on the organic molecules which had accumulated in the seas.

- ❖ Later, the organic molecules were depleted. In such an environment organisms which could survive were those able to synthesize organic substances from simple inorganic substances and these are autotrophs (either chemosynthetic or photosynthetic).
- ❖ The earliest autotrophs lacked the biochemical pathways to produce oxygen while utilizing solar energy.
- ❖ However, at later stage, oxygen-producing autotrophs are believed to have evolved which must have made it possible for the accumulation of oxygen in the atmosphere.
- ❖ The evolution of aerobic organisms is linked with this process.
- ❖ Despite tremendous advances in biochemistry and other relevant disciplines, the question of the origin of life has not been fully explained.
- ❖ Future research in the field is expected to provide adequate evidence for the origin of trophic forms.

Theories of evolution

- ❖ In section one we arrived at a definition of evolution as:
- ❖ *The change in genetic composition of a population over successive generations, which may be caused by meiosis, hybridization, natural selection or mutation.*
- ❖ *This leads to a sequence of events by which the population diverges from other populations of the same species and may lead to the origin of a new species.*
- ❖ But how does it happen? What derives the population to become a new species?
- ❖ Over time there have been many theories that have attempted to explain this.
- ❖ We owe much of our current thinking on natural selection to the ideas of Charles Darwin, who put forward the idea to the Royal Society in 1858.
- ❖ His paper suggested that those organisms that were best adapted to their environment would have an advantage and be able to reproduce in greater numbers than other types, and pass on the advantageous adaptations.
- ❖ Because he knew nothing of genetics, he was unable to suggest how this might take place.
- ❖ For many years in Europe, the Christian belief had been that the earth and all species had been created about 6000 years ago.
- ❖ In the mid-1700s, George Buffon challenged this idea, suggesting that:
- ❖ The earth was much older than this, and that organisms changed over time in response to environmental pressures and random events.
- ❖ Whilst we now accept these ideas almost without a second thought, at the time Buffon had no evidence to back them up and, as a result could not convince people.
- ❖ At the start of 19^{th} century, Lamarck, having read Buffon's ideas, made what is now considered to be the first major advance towards modern evolutionary thinking because he proposed a mechanism by which the gradual change in species might take place.
- ❖ In 1809 he published a paper entitled **'Philosophie Zoologique'**, in which he described a two-part mechanism by which change was gradually introduced into the species and passed down through generations.
- ❖ His theory is called the theory of transformation or, more usually, simply **'Lamarckism'**. The two parts of this theory are: 1, Use and disuse 2, In heritance of acquired traits

Use and disuse

In this part of his theory, Lamarck suggests that by continually using a structure or process, that structure or process will become enlarged or more developed.

- Conversely, any structure or process that is not used or little used will become reduced in size or less developed.
- The classic example he used to explain the concept of use and disuse is the elongated neck of the giraffe.
- According to Lamarck, a given giraffe could, over a lifetime of straining to reach high branches, develop an elongated neck.
- However, Lamarck could not explain how this might happen.
- He talks about a **'natural tendency towards perfection'—**but this is not really an explanation.
- Another example Lamarck used to illustrate his idea was the toes of water birds.
- He suggested that from years of straining their toes to swim through water, these birds gained elongated, webbed toes to improve their swimming.
- These two examples demonstrate how use could change a trait.
- He used the wings of penguins as an example to illustrate what might happen to a structure with disuse. Their wings would have become smaller than those of other birds because penguins do not use them to fly.

Inheritance of acquired traits

Lamarck believed that traits changed or acquired during an individual's lifetime could be passed on to offspring.

- Giraffes that had acquired long necks would have offspring with long necks rather than the short necks their parents born with.
- This type of inheritance, sometimes called **Lamarckian inheritance**, has since been disproved by the discoveries of genetics.
- However, Lamarck did believe that evolutionary change takes place gradually and constantly.
- He studied ancient seashells and noticed that the older they were, the simpler they appeared.
- From his, he concluded that species started out simple and consistently moved towards complexity, or, as he termed it, closer to perfection.
- These ideas we still retain today.
- Just 50 years later, in 1858, Charles Darwin published his famous paper on **Natural Selection.**
- He had developed the idea some twenty years earlier, but was afraid of the ridicule the idea might receive.
- In 1858, another biologist, Alfred Russell Wallace, had come to similar conclusions and they jointly published the scientific paper to the Linnaean Society of London that would change our thinking on the origin of species forever.
- Some of Darwin's evidence came from a visit to the Galapagos Islands.
- These are small group of islands in the Pacific Ocean about 600 miles off the coast of Ecuador in South America.
- Darwin visited five of the Galapagos Islands and made drawings and collected specimens.
- In particular, Darwin studied the finches found on the different islands and noted that there were many similarities between them, as well as the obvious differences.
- He concluded that the simplest explanation was that an ancestral finch' had colonized the islands from the mainland and, in the absence of predators, been able to adapt to the different conditions on the islands and, eventually, evolve into different species.
- Some of the finches had, he suggested, evolved into insect eaters, with pointed beaks.
- Others had evolved into seed eaters with beaks capable of crushing the seeds.
- 150 years later on and geneticists have been able to confirm Darwin's ideas and even produced a **'family tree'** based on the similarity of their DNA. Figure 4.16 page 185 shows this family tree.
- Biologists wanted to test how well the finches were adapted to their 'niche'.
- They analyzed the sizes of the seeds eaten by three different ground finches.
- Figure 4.17 page 186 shows what proportion of each species are the different sized seeds.

- As we can see, although there is a little overlap, each finch eats seeds of a different size and their beaks are adapted to obtain and crush theses different sized seeds.
- At the time, Darwin called this descent with modification and believed it to be key evidence in support of his theory of natural selection. We now call this '**adaptive radiation**'.
- Darwin summarized his observations in two main ideas.

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

From these observations he deduced that:

- There will be a 'struggle for existence' between members of a species (because they over-reproduce, and resources are limited).
- Some members of a species will be better adapted than others to their environment (because there is variation in the offspring)
- Combining these two deductions, Darwin proposed:
- Those members of a species which are best adapted to their environment will survive and reproduce in greater numbers than others less well adapted.
- This is his now—famous theory of natural selection, and can be summarized in the flow chart below (p186)

➲ Living things tend to over reproduce
➲ Resources are limited
➲ There is a struggle for existence between members of a species
➲ Members of a species show variation
➲ Some features of the environment give some types an advantage
➲ Those best adapted to the environment survive to reproduce in greater numbers

Table 4.1 Comparison of Lamarck's theory of use and disuse with Darwin's theory of natural selection

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

What is Neo-Darwinism?

- Charles Darwin new very little of genetics. Mendel had not carried out his ground breaking work on inheritance at the time Darwin published his book *On the Origin of Species.*
- However, we can now incorporate our knowledge of genes and gene action into the theory of natural selection to give a better understanding of what drives evolution.

Neo-Darwinism—is a revised version of Darwin's theory of evolution by means of natural selection.

This theory, which is now accepted by most biologists, combines:

1. Darwin's original theory 2. genetic theory and 3. theories about animal behavior.

- Genes or, more accurately, alleles of genes determine features.

- ❖ But when we think about how a population might evolve into a new species, we think not just in terms of the alleles each individual might carry, but also in terms of all the alleles (of all the genes) present in the population.
- ❖ We call this the **gene pool** of the population.
- ❖ Suppose an allele determines a feature that gives an organism an advantage in its environment.

The following will happen:

- Those individuals with the advantageous allele of the gene will survive to reproduce in greater numbers than other types.
- They will pass on their advantageous allele in greater numbers than the other types pass on their alleles of the same gene..
- The frequency of the advantageous allele in the gene pool of the population will be higher in the next generation .
- This process repeats over many generations and the frequency of the advantageous allele in the gene pool will increases with each generation that passes.

- ✓ Mutations are important in introducing variation into populations,
- ✓ Any mutation could produce an allele which:

- Confer a selective advantage; the frequency of the allele will increase over time
- .neutral in its overall effect; the frequency may increase slowly, remain stable or decrease (the change the change in frequency will depend on what other genes / alleles are associated with the mutant

But **Neo-Darwinism** does not just take into account our knowledge of genetics.

It also encompasses our understanding of animal behavior—sometimes referred to as **ethology.**

- ⌗ Many ethologists and also and also evolutionary psychologists believe that it is not just physical features that can confer an advantage, but that behavior patterns can also be advantageous—or not.
- ⌗ As such, a behavior pattern that confers a survival advantage will be selected for, whilst those that do not will be selected against.
- ⌗ An example of an advantageous behavior is imprinting in geese.
- ⌗ Young geese (goslings) ‘imprint' up on the first moving object that they see after hatching, and follow it everywhere.
- ⌗ Since this will almost certainly be ‘ mother goose' there is a very obvious survival advantage in following her; the young goslings will be fed and protected.
- ⌗ Any goslings that do not show this behavior pattern are <u>much less</u> likely to survive.

Evidence of Evolution

1. Evidence from **paleontology**
2. Evidence from **body structure**
3. Evidence from **comparative embryology**
4. Evidence from **comparative biochemistry**
5. Evidence from **plant and animal breeding**

1. Evidence from paleontology (fossil records)

The word ‘paleontology' refers to the study of ancient life and comes from the Greek words *palaios* (ancient) and *logos* (study).

Fossils--are any form of preserved remains derived from a living organism.

Fossils form the basis of this science as they are the main direct evidence about past life.

Fossils (this word is derived from the Latin word *fossus,* meaning ‘having been dug up') are tge remains or traces of animals, plants and other organisms from the remote past.

We can group fossils into two categories:

Category 1 : the remains of dead animal or plant or the imprint left from the remains, including:

1. The hardened shell of an ancient invertebrate such as a trilobite or an ammonite
2. An impression of an animal or plant, even if the actual parts are missing
3. Bones 4. Teeth 5. Skin impressions 6. Hair

Category 2: something that was made by the animal while it was living tha has since hardened into stone; these are called trace fossils and include: 1. Foot prints 2. Burrows 3. Coprolite (animal faeces)

Type 1 fossils can be the actual organism or part of an organism, like a

piece of bone or hair or feather as it actually was.

- ✓ **Amber** is fossilized resin from trees. Figure 4.18 (page 191) shows that the spider has been trapped, completely unchanged, inside the amber for millions of years.
- ✓ Amber is fossilized resin from trees.
- ✓ This spider probably became stuck inside the sticky resin and could not escape.
- ❖ As the amber become fossilized, the spider was protected from microorganisms and air which would have led to its decomposition.
- ❖ In many fossils like this, the soft parts of the body have been lost, but the exoskeleton is perfectly preserved.
- ❖ In some cases, however, the entire body remains. In some cases, however , the entire body remains.

Fossils are the remains of organisms that lived long ago.

Fossils include-- 1. entire organisms 2. Impressions 3. Hard skeletal materials, etc.

Types of fossils and their formation

1. An **entire organism** may have become fossilized.
   - ❖ This would have happened if the organism were frozen into ice during glaciations or it would have been encased in hardened resin, also known as **amber**, of **coniferous trees.**
   - ❖ Examples of these organisms are the **woolly mammoths** found in the Siberian forest.
   - ❖ The whole skeletons of the woolly mammoth have been found. It was mainly small organisms, such as **insects** that have trapped in resins.
   - ❖ Their **exoskeletons** have been found in Oligocene rocks on the Baltic coast.
2. **Hard skeletal muscles**---have also fossilized.
   - ❖ In this case the Dinosaur became trapped by sedimentary sand and clay, which then formed sedimentary rocks. Examples of these are bones, shells and teeth.
3. **Moulds and Casts**---This type of fossil is formed when the skeleton slowly dissolves leaving its impression as a mould of an organism.
   - ❖ Examples of these are mollusk shells showing muscle attachment points.
   - ❖ This type of fossil formed depends to some extent on the nature of the environment at time.
4. **Petrifaction fossils**--were formed by gradual replacement of body tissues by water-carried mineral deposits.
   - ❖ These deposits are silica, pyrites and calcium carbonate or carbon.
   - ❖ The minerals slowly filled into the decomposing organism.
   - ❖ One such organism was **echinoderms**. Their body was replaced by **silica.**
   - ❖ Many plants were also **fossilized**. Today, fossils of plants are being discovered as petrified or mineralized wood.
5. **Impressions of the remains of the organisms** occurred in fine grained sediments on which they died.
   - ☞ The fern leaf is an example of an impression fossil.
   - ☞ Most plant fossils are in the form of impressions.

- **Paleontologists** can tell the size of an organism or whether it was a mammal or reptile by studying imprints of **foot prints, tails, tracks and tunnels** of various organisms made in **mud.**
- These imprints are rapidly baked and filled in with sand and covered by further sediments. Numerous foot prints and tail scrapings of dinosaurs have been found.

6. **Coprolites**---are faecal pellets that did not decompose and were later compressed in sedimentary rock.

- Examples are some mammalian faeces.
- Most of the fossils that were discovered were formed by **chance.**
- Usually when an organism dies, scavengers either consume it or it undergoes rapid decay by micro-organisms.
- The remains could also be dispersed by wind or rain.
- The hardest parts of organisms like t**eeth, shells, wood, bones** and **pollen** can resist the action of weathering for a long period in dry environments.
- In a few instances, even soft tissues of extinct organisms, imprints of organisms, tracks made in soft mud and faecal matter of animals have been discovered.
- Occasionally depending on where the organism dies, **it is buried quickly and in such a way that decomposition is never completed or is completed** so slowly that the organism may leave an imprint or cast, which clearly indicates its external feature.

7. Preserved fossils---are most often found in sedimentary rocks.

- Weathering produces sediments that are carried by streams and rivers into the oceans and other large bodies of water.
- There they settle and are converted into sedimentary rock. Later through upheavals the rocks form new land.
- Researchers look for fossil remains trapped in these rocks.

In general there are four main stages of fossil formation:

1, Death without decomposition 2. Sedimentation 3. Permineralization 4. Uplift

Method of fossil dating

Radiometric dating: is the most common method used to determine age of rocks and the fossils trapped in them.

- Isotopes of some elements are **radioactive**. They are unstable and decay at a constant rate. This is known as **radioactive decay**.
- Radioactive parent elements decay to stable daughter elements.
- By determining how much decay has taken place since the rocks first formed, a date can be assigned to the rocks.
- When a molten rock cools and solidifies any radioactive trapped in the rock will begin to decay into its daughter elements.
- The amount of parent and daughter elements in the rock is then measured.
- Next, the rate at which the parent element decays into its daughter element is determined.

➢ From this information the date when the rock was formed and hence when the fossil was deposited, can be estimated.

➢ The rate of decay is expressed in terms of the **half-life** of that **isotope**.

Half-life:- refers to the time taken for the radioactive isotope to fall by half.

➢ Examples of radioisotopes commonly used in the determination of the ages of rocks are:-

1. **Carbon-14** 2. **potassium-40** 3. **Uranium 235**

Table:14.1 Some radioisotopes used in radiometric dating:

Radioactive isotope	*Half-life (in years)*	*Stable daughter product*	*Useful range (years)*

Carbon-14	*5730*	*Nitrogen-14*	*o-50,000*
Potassium 40	*1.25 billion*	*Argon-40*	*>100,000*
Uranium 235	*704 million*	*Lead-207*	*>100 million*
Uranium 238	*4.5 billion*	*Lead-206*	*>100 million*
Thorium 232	*14 billion*	*Lead-206*	*>200 million*
Rubidium 87	*49 billion*	*Strontium-87*	*>100 million*

- *Note that the number is the **mass number**.*
- *This is the total number of **protons** plus **neutrons.***
- *Mass number may **vary** for an element, because of a **differing number of neutrons**.*
- *Elements with various numbers of neutrons are called **isotopes** of that element.*
- *The **shorter** the half-life, the faster is the rate of decay.*
- *Many radioactive elements can be used as **geologic clocks.***
- *Each radioactive element decays at its own nearly constant rate.*
- *Ones this rate is known, geologists can estimate the length of time over which they decay has been occurring by measuring the amount of radioactive parent element and the amount of stable daughter elements.*

Radiocarbon dating: is a common method of determining the age of rocks.

- **Carbon** is an example of a naturally occurring radioactive elements.
- Most of the carbon on earth is **^{12}C**, which is a **stable isotope**.
- However, a little bit of carbon exists as **^{14}C**. This is formed at a constant rate by the action of cosmic radiation.
- **Atmospheric Carbon** is broken down into an unstable isotope of carbon-14.
- The carbon -14 formed by this process is radioactive i.e., it is unstable and decays slowly changing to ^{14}N.
- Ordinary carbon (**^{12}C**) is found in carbon dioxide in the air.
- This CO_2 is taken by **plants,** which in turn are eaten by **animals**.
- The radioisotope, **^{14}C** also combines with **O_2** to form radioactive **CO_2**.
- By counting how many ^{12}C atoms are there for every radioactive ^{14}C atom in a sample of air, scientists can calculate the ^{14}C and ^{12}C ratio.
- All living things contain a constant ratio of ^{14}C to ^{12}C.
- This is because although the ^{14}C atoms are changing back to ^{14}N, the organisms are exchanging carbon with their surroundings.
- As soon as the organism dies, the **^{14}C** atoms that decay can no longer be replaced.
- Therefore, over a period of time the **^{14}C** in the dead body decreases.
- The **^{14}C** : **^{12}C** ratio gets **smaller**. It takes **5,730** years for half of the carbon isotope, **carbon-14** to convert back to nitrogen isotope at its normal rate of decay. This is its **Half-life**.
- After about **11,460** years or two half-lives only a quarter of the original amount of carbon isotope **C-14** would remain.
- For this it can be concluded that if the amount of the carbon isotope of **C-14** relative to carbon isotope **C-12** in a sample is one quarter of that in present living organisms, then the age of that fossil is estimated at 11,460 years.

There are two drawbacks of this dating method:

1. It can only be used to date fossils that are up to **50,000 years old**.

2. Carbon dating can only be used to determine the age of once living things. It **cannot be used to date volcanic rocks.**

- Therefore, carbon dating cannot be used to determine the age of fossils that may be millions of years old.
- To do this radioisotopes with much longer half-lives have to be used.
- One example of this is the **potassium-argon (K-Ar) method**.
- This involves the conversion of the:-
- potassium isotope **K-40** to Argon isotope, **Ar-40**.
- The isotope **K-40** is discharged in the lava flow volcanoes.
- At this temperature the argon boils away and lost.

- ➲ As the lava cools, argon is released by radioactive decay.
- ➲ By measuring the ratio of argon to potassium in lava deposits, geochemists can estimate the ages of fossils up to **500,000 years old**.
- ➲ This is assumed that the fossils found in the lava rocks are of the same age as the lava.

Steps of Radioactive Dating Techniques of fossils

1. The half-life of the isotope should be determined.

2. The amount of the isotope originally present in the fossil or the rock containing it should be known

3. The amount of the isotope left in the fossil or rock should be determined

- ✓ Before radiometric dating, the age of fossils was determined by approximating the age of the layers in which fossils were found
- ✓ This method is not reliable because the earth's crust has not been stable in many parts.

2. Evidence from Comparative Anatomy(from Body Structure)

- ❖ Comparative body structures of various organisms reveals evolutionary linkages between many organisms.
- ❖ **Homologous structures** are structures having similar form, body position and embryonic development but **different functions** in different species.
- ❖ For example, the limbs of all tetrapod (four-legged) vertebrate groups show a basic pentadactyl (five digits) pattern.

The specialization in function of the limbs illustrated in:

1. bats----for flying 3. seal-------for swimming
2. horse---for running 4. mole-----for digging 5. human ----for grasping and manipulating

- ❖ This **homology** in structure may be considered as an evidence of such organisms to have had a common descent and probably evolved from a **common ancestor**.
- ❖ **Analogous structures**:- are structures that are similar in function and appearance, **but not in origin.**
- ❖ They show some superficial similarity.
- ❖ These analogous structures are **similar in function** in that they provide movement, but they have **different inside structures**.
- ❖ For example, **wings of birds and wings of insects** have similar function but internally they are made from different structures.

3. Evidence from comparative Embryology

Embryology: is the study of organisms in the early embryonic stages of development.

- ⌗ In the late 1800s, scientists noted the striking similarity between the embryos of different species to such an extent that sometimes it was found very difficult to distinguish between preserved embryos of various vertebrate groups in the early stages of their development.
- ⌗ The resemblance of the embryos was not only external but also internal, i.e., the arrangement of the **arteries** and the structure of the developing **hearts.**
- ⌗ This has initiated scientists to suggest that this similarity may be due to evolution of the species from a common ancestor. Fig. 4.26 p.198
- ⌗ **Comparative embryology** studies the way in which the embryos of vertebrates develop before they hatch or are born.
- ⌗ This development shows similarities which supports a common ancestry.---For example, early in development, all vertebrate embryos (including humans) have **gill slits** and **tails**, shown in figure 4.26 page 198.

- However, the 'gill slits' are **not gills**; they connect the throat to the outside, but in many species they close later in development. However, in **fish** and **larval amphibians** they contribute to the development of **gills.**
- The embryonic tail **does not develop** into a tail in all species.
- In humans, it is reduced during development to the **coccyx**, or **tail bone.**
- The **more similar** the pattern of embryonic development, the **closely related** species is assumed to be.
- The similarity in the pattern of development of vertebrates suggests, again, a common ancestor.
- We must be careful when describing what comparative embryology shows.
- It does **not** show that an embryo is retracting (ወደ ኋላ መመለስ) its evolutionary history, as some people, mistakenly, believe.
- This observation led the German biologist; **E.H. Haeckel** to propose the theory of recapitulation, which states that every organism recapitulates (**repeats**) its evolutionary development (**phylogeny**) in its own embryological development (**ontogeny**), i.e., **ontogeny** recapitulates **phylogeny--the history of the individual is repeats the history of the race.**

4. Evidence from comparative biochemistry

- **Biochemistry**: deals with biological compounds that the body is made up of Various chemicals have been studied in order to find evidence of evolutionary relationships.
- The idea behind this is that if organisms **share** very similar molecules and biochemical pathways, then they must be closely related evolutionarily.
- The most important biological compounds (chemicals) in the body of all organisms that have been used is such analysis are
    1. **DNA**-the base sequences of DNA from different organisms is compared
    2. **proteins**, such as
- **cytochrome**-C (found in the electron transport chain of respiration) and
- **haemoglobin**, which are compared in terms of amino acid sequences.
- Species that are **closely related** have the **most similar DNA and proteins**; those distantly related share fewer similarities.
- A comparison of DNA sequences shows that it is 99.9% certain that **chimpanzee** is humans' **closest relatives** (98% of our DNA is the same as that of chimpanzees).

Comparison between DNA of humans and other primates

Primates	Degree of relatedness
Chimpanzee	97.6%
Rhesus monkey	91.1%
Vervet monkey	84.2%
Galago	58.0%

- To measure the similarity of one species' DNA with another species, we use a technique called **DNA hybridization**.
- The technique measures the extent to which a strand of DNA from one species can **bind** with (**hybridize with**) a strand of DNA from another species.
- In this technique, the double helix of the DNA molecule is heated to separate it into single strands and then the single-stranded DNA (ssDNA) from both species is mixed and the mixture cooled.

- Although the ssDNA from specie A and species B will hybridize (bind) as it cools, it will not do so along all its length.
- There will be regions that are mismatched (the base pairs are not complementary) and so do not bind and there are techniques available to measure the percentage of this mismatching.
- The information can then be used to calculate the percentage similarity of the DNA samples.
- Vertebrates have similar patterns of embryonic development.
- All vertebrates have a basic set of genes (called the **homeobox genes**) that define the basic body plan of a vertebrate.
- These operate **early** in development to ensure that a **back bone and skull** etc. develop.
- Later, **other genes** (which are different in different groups) define the development of those features that will make them the species that they make are.
- We may share 98% of our DNA with chimpanzees, but we share **50%** of our DNA with banana.
- See figure 4.27 page 200 which shows the phylogenetic (evolutionary) tree of some animals based on differences in DNA.
- **Haemoglobin:** is the molecule found in RBC that carries oxygen to where it is needed.
- 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, **not four**.
- Most animals have haemoglobin with **four chains**, the chains do vary.
- **Figure 4.28** page 200 shows the differences in the amino acid sequences of the chains of human and several other animals.
- The diagram is presented in such a way as to show when the different animals may have diverged from the evolutionary line that led to humans.

- Difference in DNA is largely due to **mutations.**
- By using estimates of mutation rates, biologist can calculate how long it might have taken for a certain number of differences in DNA to have arisen.
- **Differences in the amino acid sequence of cytochrome-C** give a similar picture.
- The molecules that are used to show evolutionary relationships are those that are common to large numbers of organisms.
- But, clearly, haemoglobin analysis **cannot** be used to include **plants** and **algae** in any phylogenetic tree.

5. Evidence from Plant and Animal breeding

- Humans have long been calculating plants and animals from wild forms.
- This has allowed humans to select some desired favorable characters.
- This technique is known as **artificial selection**, by which desirable characters are preserved whereas undesirable characters are tactically **eliminated**.
- This method has been employed to **domesticate** both animals (dogs, cats, birds) and plants (e.g. flowers and other crops), for sporting and decorative as well as economic purposes respectively.

Then, evolutionary biologists suggest that this artificial selection is a good indicator that nature (environmental conditions) also can select desirable characters and eliminate the **unit characters** from a population.

- The **accumulation of such changes** in the population would gradually bring about evolution.
- For **thousands of years**, humans have been trying to improve the yields of their crop plants and stock animals.
- They have done this by **selective breeding**, in which:

→ those animals (or plants) that show the desired trait (e.g., high milk yield or large number of seeds per pod) are selected and mated, and

→the offspring are monitored carefully and, again, only those with the desired trait are allowed to breed.

- Over many generations, **selective breeding** can bring about significant changes to the organisms involved.
- One example of this is the **modification by selective breeding of the wild pig** (wild boar) into the many different varieties of the domestic pig.
- If new varieties can be produced by selective breeding (in which humans choose which individuals will "survive to breed") then **natural selection** (in which environmental pressures select which will survive to breed) should also be able to produce **new varieties** and, eventually, **new species.**
- **Selective breeding**--is a technique used to produce organisms with a desired trait by allowing only those organisms with that trait to reproduce. **Assignment**:--Answer review questions page 202-204

The processes of Evolution

The word **evolution** is derived from the word '**evolve**'. This means '**to change**'.

- So evolution refers to the changes that take or took place, in organisms over time. How did those changes take place?

What are the different types natural selection?

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

- They will **pass** on their advantageous alleles to their offspring and, in successive generations, the frequency of these alleles will increase in their gene pool.
- The advantageous types will, therefore, increase in frequency in successive generations.

Natural selection: is the 'driving force' behind evolution

- It is the process that brings about changes (over time) in populations that can, eventually, lead to different populations of the same **species** becoming different species.

Speciation: is the process by which a **new** species evolves.

Natural selection: is the theory that explains the origin of species in terms of survival of those best adapted to a specific environment.

Species: is a group of related organisms that can reproduce with each other so that they produce fertile offspring.

Species: is a group of similar organisms with a similar biochemistry, physiology and evolutionary history that can interbreed to produce offspring that are fertile.

- This explains why all humans are members of the same species, but belongs to a different species from the chimpanzee. All types of natural selection work in the **same manner** (as described above), **but their influence on a population is different.**
- There are three types of Natural Selection: 1. Directional selection
  2. Stabilizing (normalizing) selection
  3. Disruptive (diversifying) (selection)

1. **Directional selection**: operates in response to gradual changes in environmental conditions.

- A feature may show a range of values. Individuals at **one extreme** could have a disadvantage where as those at the other extreme have an advantage.
- For example, **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 an environment were to change so that it became significantly colder, or a group of the foxes were to establish a population in a new, colder environment, there would be a selection pressure in favor of the foxes with long fur and against those with short fur.
- Over time, selection operates against the disadvantaged extreme and in favor of the other extreme.
- The mean and range of values shift towards the favored extreme.
- The **frequency of the alleles** causing longer fur will **increase.**
- If you look at the graph (in page 205 fig. 4.30) carefully, you will see that the whole distribution has shifted.
- As we might expect, there are now no foxes with the very shortest fur –they could not survive in the new environment.
- But there are foxes with fur lengths that are longer than any of those in the original distribution.

Where have they come from? They must be the result of either:

1. new mutation or 2. new combinations of alleles.

- In either case, if they had existed in the original population, they would have been disadvantageous as they would prevent the foxes from being able to cool themselves effectively and so would have died.

2. Stabilizing (normalizing) selection: In a stable environment, individuals at both ends of the range of values for a feature are the least well adapted.

- Selection often operates against both these extremes to reduce the variability in the population and to make the population more uniformly adapted.
- Birth mass in humans is an example. Babies who are very heavy or very light show a higher neonatal mortality rate (die more frequently at, or just, after birth) than those of medium mass.
- Over time selection is operating to reduce the numbers of heavy and light babies borne. Fig. 4.31 in page 206 illustrates the effect stabilizing selection on a rate.

3. Disruptive (diversifying) selection: This is a converse of stabilizing selection.

- In this instance, individuals at both extremes of a range have some advantage over those displaying the mean value.
- As a result, the frequency of those individuals at the extremes of the range will increase over time and those in the middle of the range will decrease over time. Figure 4.33 in page 206 summarizes different types of selection.

Directional selection --favors one of the extreme phenotypes; **Stabilizing selection** --favors the intermediate phenotype; **Disruptive selection--** favors more than one extreme phenotype.

How can Natural Selection lead to the formation of new species?

- **Natural selection** provides a mechanism by which new populations of a species can arise.
- But at what point can these populations be considered as distinct species?

Species:-is a group of similar, interbreeding organisms that produce fertile offspring.

- If two populations become so different that individuals from different populations **cannot interbreed** to produce **fertile** offspring
- Then we must think of them as different species.
- There are a number of ways in which this can occur.
- The two main ways are:-1. **Allopatric speciation** and 2. **Sympatric speciation**
- **Allopatric speciation**:-occurs in populations that are geographically separated by physical barriers. e.g., a river, mountain, land mass etc.

- This is a type of geographical isolation. Interbreeding between the population becomes impossible and speciation could result.
- **Sympatric speciation**:-occurs in populations inhabiting the same geographical area.

Geographical Separation of Finches in the Galapagos Islands

- The islands and thus the particular finches on them are separated by a wide area of water.
- A physical barrier cuts off flow between populations allowing them to evolve independently and **accumulate genetic differences**.
- This is a type of geographical isolation.
- Interbreeding between the populations becomes impossible and speciation could occur.
- If these differences result in reproductive isolation, then speciation has occurred.

Note: in this case new species can be formed only when there are barriers, which lead to reproductive isolation between members of the population.

- This means gene flow does not occur between them.
- The mechanisms, which result in reproductive isolation, are known as **isolating mechanisms**.
- A small isolated population is called a **deme.**
- **Physical barriers** such as mountain ranges, rivers, seas and deserts may geographically isolate these populations.
- The **squirrels** are geographically isolated by the mountain range.
- Gene flow is inhibited, over a period of time this results in genetic differences.
- In this instance **two species** of squirrels evolved.
- The accumulation genetic differences in isolated demes may eventually prevent interbreeding if members of the two demes come together.
- The end result is the formation of **two new species.**

There are two types of speciation: 1. Intra-specific speciation 2. Inter-specific speciation

- The type of speciation depends of the number of parents involved.
- If both parents were from the same species, then it is **intra-specific** speciation.
- In intra-specific speciation new species arise from a **single** species. The finches are examples of intra-specific speciation.
- In **inter-specific speciation,** a new species is formed from a cross between **two different** species.
- An example of this is the cross between a **horse** and a **donkey**.

→The offspring is a hybrid new species called **mule.**

Intra-specific speciation: can take place in two ways: 1. **Phyletic speciation** 2. **Divergent speciation**

- In **divergent speciation**, the ancestral form diverged or **branched into two distinct sub-species.**
- In **divergent** species the population **splits** into two or more sub-populations
- These sub-populations become **geographically isolated** from each other.
- The two populations develop **different allele frequencies** over time.
- These genetic differences **accumulat**e to the point where the two groups can no longer successfully interbreed. Eventually each group forms a **new species.**
- In **phyletic speciation** a species undergoes changes over a long period of time involving many generations.
- Eventually a new form of species arises which is different from the ancestor species.
    - Intra-specific speciation can be **allopatric** or **sympatric**.

→**Allopatric speciation** occurs in populations that are geographically separated by physical barriers.

- ➲ It occurs when a population from an existing species becomes geographically isolated and the isolated population develops into a new species (see figure 4.34 page 207)

→**Sympatric speciation** occurs in populations inhabiting the same geographical area.

- ➲ It occurs when a population from an existing species develops into a new species without becoming geographically isolated from other members of the original species.
- ➲ **Sympatric speciation** need not involve physical separation.
- ➲ The two diverging populations may inhabit the same area, but be prevented from breeding in a number of ways, including:

1. **seasonal isolation** --members of the two populations reproduce at different times of the year
2. **Temporal isolation** --members of the two populations reproduce at different times of the day
3. **Behavioural isolation**--members of the two populations have different courtship patterns

- ⇨ **Speciation** following any of these methods of isolation is referred to as **sympatric speciation** (read page 207 and 208).

What is polyploidy and why it is important in plant evolution?

- ⇨ **Poly**--means many. **Polyploidy** cells have many sets of chromosomes per cell--sometimes four sets, sometimes eight or more.
- ⇨ Some human liver cells have **92** chromosomes per cell--they are **tetraploid**--they have **four sets** of homologous chromosomes per cell.
- ⇨ **Polyploidy** has been important in plant evolution because it has allowed otherwise infertile hybrids to become fertile again.
- ⇨ When different species form hybrids, very often the hybrid **cannot** produce offspring **because all the chromosomes cannot form bivalents** (homologous pairs) in meiosis.
- ⇨ So they cannot form sex cells and cannot reproduce. If the chromosome number were to double, then all chromosomes are able to form homologous pairs.
- ⇨ **Meiosis** and **sex cells** formation can take place and the hybrid is now **fertile**.
- ⇨ **Hybridization** and **polyploidy** have both were important in the evolution of modern wheat from wild grasses. Figure 4.36 page 209 shows how this occurs.
- ⇨ In figure 4.36 page 209, hybrid B is infertile because each cell contains one set of chromosomes (7) that came from *Aegilops squarrosa* and one set of chromosome (14) that came from *Triticum durum*.
- ❖ Clearly, when 21 chromosomes per cell, there are not enough chromosomes for them all to form homologous pairs -- even if they were homologous.
- ❖ But when the hybrid doubled its chromosome number, there were two of each chromosome. Now homologous pairs can form in meiosis and the hybrid is fertile.
- ❖ *Triticum vulgare* is one form of modern wheat. **Polyploidy**, in addition to restoring fertility to infertile hybrids, often results in bigger plants with more and bigger seeds.

What are Divergent evolution and Convergent evolution?

- ❖ We have looked so far at mechanisms that drive speciation.
- ❖ Now we shall turn our attention to the situations that dictate the lines along which speciation progresses in a given situation.

What is Divergent evolution?

- **Divergent evolution** is another name of **adaptive radiation**.
- In divergent evolution, a basic type 'diverges' along different lines because of different selection pressures in different environments.
- If different selection pressures are placed on populations of a particular species, a wide variety of adaptive traits may result.
- If only one structure on the organism is considered (such as a limb) these changes can either improve the original function of the structure, or they can change it totally.
- **Divergent evolution** leads to the development of a new species.

Examples of divergent evolution (adaptive radiation) include:

- **The evolution of different species of finches** on the Galapagos Islands--see figure 4.37 page 209
- The evolution of different forms of the **pentadactyl** limb.

What is the convergent evolution?

Convergent evolution: is the process by which **unrelated** organisms evolve similar structures, adapted for the same function.

- It takes place when different organisms occupy similar niches.
- The selection pressures on the populations are the **same** and so similar adaptations evolve over time.
- One example is the convergent evolution of the giant armadillo, giant pangolin, giant anteater and spiny anteater.
- They are **not related evolutionarily**, but all feed on ants and must obtain the ants from narrow cracks in the ground.
- The similarity between the four is the **result of convergent evolution.**
- The same selection pressures result in similar structures appearing in **unrelated organisms.**
- Convergent evolution is also responsible for the wings of a bird, a bat and the extinct pterodactyl.

The Evolution of Humans

- There is considerable evidence, anatomical, physiological and behavioral, which points to close relationship between humans and the great apes.
- This **does not**, however, mean that humans evolved any ape, living or fossil, but at some stage humans and ape stocks had a common ancestor.
- The evolution of Homo sapiens is still debated a lot and remains to be studied.
- However, evolutionary biologists generally agree that the modern human has descended from **ancient primates.**
- Humans and chimpanzees both evolved from a common ancestor that lived about 6 million years ago.
- We talked about 'humans' rather than one specific type of human (ourselves—*Homo sapiens*) that now inhabit the planet.
- There were other humans before us and, before them, what we might call 'pre-humans'.
- All humans belong to the **genus** Homo.
- Figure 4.41 in page 215 shows a timeline for the major **hominine** and **hominid** species according to currently available fossil evidence.

The primates represent a diverse order of mammals including:

1. small sized lemurs and tarsiers
2. huge gorillas
3. chimpanzees
4. extinct and extant (living) human species.

- The order of primate consists of **three groups** of animals collectively called **anthropoids**. These are:-

1. **The New World Monkeys** --marmosets and spider monkeys

2. The **Old World Monkeys**--baboons and proboscis monkeys

3. Hominoids--**apes** and **humans**

The **living apes** are classified **into two families:**

1**. Pongidae-** chimpanzees, gorillas and orangutans

2. Hylobatidae (gibbons)

- ♥ All the living apes are confined to small areas in **Africa** and **Asia**.
- ♥ On the other hand, the fossil (ancestral) forms and modern humans belong to the family **Hominidae.**
- ♥ There has been a 'line of evolution' for millions of years that has given 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* and we are the **latest** of several humans to live on the planet.
- ♥ We have **two features** in particular that distinguish us from other primates.

These are: 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 and also about exactly how this evolutionary tree has given rise to the various groups.

- ❖ But although they may disagree over the details, they are all agreed about the idea--**a line of evolution that has branched to give the different groups of primates (including apes and humans) that exist today and have existed in the not too distant past.**

Figure 4.40 page 214 shows the part of the **'evolutionary tree'** of humans and the living great apes in more detail. We can see that at several points there are 'common ancestors'

- ⌗ This represent branching points in the evolutionary tree.
- ⌗ At these points it is assumed that an ancestral type became divided into at least two populations which subsequently evolved along different lines.
- ⌗ We can see from this evolutionary tree why statements like 'humans evolved from chimpanzees are **incorrect**'
- ⌗ **Humans and chimpanzees both** evolved from a **common ancestor** that lived about 6 million years ago.
- ⌗ There were other humans before us (Homo sapiens) and, before them, what we might call 'pre-humans'.
- ⌗ All humans belong to the **genus** Homo.
- ⌗ Figure 4.41 page 215 shows a timeline for the major **hominine** and **hominid** specie according to currently available fossil evidence.
- ⌗ Looking carefully at figure 4.41 page 215, we begin to see just how important Ethiopia has been in the evolution of humans.
- ⌗ Fossils of many of the species along the early part of the timeline were found in Ethiopia. It is indeed the **'cradle of mankind' (የሰው ዘር መነሻ)**.

What is significant about Lucy and Ardi?

- ⌗ Both **Lucy** and **Ardi** are important fossils in explaining the evolution of modern humans and chimpanzees from a common ancestor.
- ⌗ Lucy was discovered by **Donald Johanson** and **Tom Gray** in **1974** at **Hadar** in Ethiopia.
- ⌗ **Lucy** is a fossil dated at about **3.2 million years**.
- ⌗ She was an adult female of about 25 years and belonged to the species *Australopithecus afarensis.*
- ⌗ Her skeleton was about 40% completed, an unusually high proportion for a fossil skeleton.
- ⌗ Her pelvis, femur (the upper leg bone) and tibia show that she was bipedal (could walk upright on two legs)

- However, there is also evidence that Lucy was also partly arboreal (tree-dwelling).
- She was about 107 cm tall and about 28kg in weight.
- At the time she was discovered, Lucy represented one of the oldest fossil **hominines**.
- The proportions of her humerus and femur were mid-way between those of modern human and chimpanzees.

Lucy had a brain about the **same size as that of a chimpanzee,** so her discovery was able to settle a debate amongst biologists all the time

- Which came first, large brain or bi-pedalism? Clearly **bi-pedalism** came **before** big brains.)
- The **Ardi** fossil (together with many other similar fossils) was first discovered in **1992**, in the Afar desert in Ethiopia, but it was only in 2009, after many years' analysis, that research papers were finally published that gave **Ardi** a unique position in human evolution.
- **Ardi** was 1.2 million years old than Lucy, was also female and belonged to the species *Ardipithecus ramidus.*
- One significant feature about **Ardi** was that she was also bipedal.
- At 4.4 million years old, **Ardi** is the nearest fossil to the 'common ancestor' of humans and chimpanzees that has so far been found.
- This finding finally proves that the ancestor of humans and chimpanzees could not have resembled a chimpanzee, as chimpanzees are not truly bipedal.

HOW HAS BRAIN SIZE CHANGED DURING HUMAN EVOLUTION?

- During the course of human evolution, the **brain** has got **bigger.**
- We know from comparing fossils that the **cranial capacity has increased** with each new hominid species that evolved.
- However, that is not the whole story.
- Besides becoming bigger overall, the brain has increased in size as a proportion of the body mass, modern humans have a brain that is between 1.8% and 2.3% of their body mass.
- The brain of Homo sapiens uses 25% of the resting energy requirement, compared with 8**%** in the great apes. **A larger brain allows humans to:** 1. Run faster and in a more upright posture
  2. Plan in advance to avoid attack
  3. Develop and use tools and weapons
- These abilities clearly also depend on other **physical adaptations** such as longer legs, more nimble (fast moving) fingers and a straighter spine, but, without the larger brain to co-ordinate the activities, the physical changes would **not** confer the same advantage.

Are we still evolving?

- Homo sapiens (modern humans) first appeared in Africa and have since migrated to all other parts of the world.
- Figure 4. 45 (page 217) shows these migratory patterns together with the time (in thousands of years before present) when they took place.
- As humans moved from Africa into different areas of the world, they encountered different environments resulted in the different human populations evolving along different lines.
- For example, as humans encountered **colder climates**, **body features** that gave a survival advantage by helping to conserve heat were selected for.

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' thousands of years
- ❖ The classification of these races is difficult and there is some disagreement about their exact nature.

One classification is given below

- ❖ In this there are **three main races** with several sub-divisions.
- ❖ This is based on a recent **genetic analysis of the different races.**

1. **Africa (Negroid)**--100 million people from Africa and Melanesians of the South Pacific
2. **Eurasian (Caucasoid),** 1000 million people with variable skin color ranging from white to dark brown.

There are three sub-divisions exist:

A. **Nordic**--often tall, blonde and narrow-headed; includes people from Scandinavian and Baltic countries, German, France, Britain

B. **Mediterranean**--usually lighter in body build, dark and narrow-headed ; includes people from Southern France, Spain, Italy, Wales, Egypt, Jews, Arabs, Afghanistan, Pakistan, India

C. **Alpine**--usually broad-headed, square jaws, olive skin, brown hair; includes people from countries from Mediterranean to Asia

3. **East Asia (Mongoloid):-** Most numerous of the present day populations and split into **three** groups:-

- ⌗ **Eastern Siberian**, **Eskimos** and the **Northern American Indians**
- ⌗ **Japanese, Koreans** and **Chinese**
- ⌗ **Indonesian**s and **Malays**

- ✠ However, this classification does not include Central African pigmies, the **bushmen** and the **Australoids.**
- ✠ It seems that some thousands of years ago the human populations or races might have been beginning to evolve into separate species.
- ✠ Certainly **physical and genetic differences** were emerging between the different races.
- ✠ However, our large brain has intervened in two major ways, described below:-

1, We develop the skill to design and manufacture all kinds of things from building to tools of clothes.

- ✓ This effectively allowed us to become able to modify our environment, rather than having to evolve to adapt it.
- ✓ Anyone can now live perfectly easily in Sweden or any other Nordic country.
- ✓ They must simply wear the right clothes.

2. We developed global travel. This has allowed humans of all races to interbreed, throwing many of the genetic difference that have evolved into a huge human melting point.

✠ We may still evolve into diverse species, but, at the moment, mechanisms that usually drive speciation have been modified by our large brains.

Figure 4.49 (page 219) gives a' best guess' as to the evolution of hominids from 5 million years ago to the present day.

- ☞ There are more species of **Homo** and **Australopithecus** shown in this diagram than have been discussed in the text.
- ☞ We could do a library search to find out about some of them.

Review Questions

1. Which of the following animals is found at a lower level of evolutionary advancement than the rest?
   A. Tilapia -- B. Hornbill C. Crocodile D Rat E. Frog
2. Select the correct sequence that occurred in the primitive earth.
   A. Gases, macromolecules, small molecules and protocells
   B. Macromolecules, small molecules, protocells and gases
   C. Gases, small molecules, macromolecules and protocells -
   D. Protocells, macromolecules, small molecules and gases
3. Evolution by natural selection requires.
   A. heritable genetic difference
   B. Differential adaptation D. Differential reproduction
   C. Variation E. All of the above-
4. Some species gradually evolve into a new species without splitting into two or more species. Which mode of evolution is operating in this case?
   A, Allopatric speciation C. Convergent speciation
   B. Sympatric speciation D. Phyletic speciation E. Divergent
5. Compared to the others, which one of the following plants is found at a higher level of evolutionary advancement?
   A. Podocarpus B. Moss C. Grass D. Algae
6. In earliest fossils found in the geologic record are:
   A. Protozoa B. Fungi C. Bacteria D. Angiosperms
7. On which of the following evolutionary ideas do Lamarck and Darwin fully agree?
   A. Life is a result of natural process - C. Acquired characteristics are inherited
   B. Natural selection leads to evolution D. A and B
8. Which group of hominids is called the handy human?
   A. *Homo sapiens* B. *Homo habilis* C. *Homo erectus* D. Australopticus
9. Which evolutionary evidence was very unlikely to have been used by Darwin in the formulation of the theory of evolution?
   Comparative anatomy B. Geographical distribution C. Comparative biochemistry- D. Fossils
10. Which of the following theories is most accepted by scientists?
    A. Neo-Darwinism B. Darwinism C. Lamarckism D. A and B
11. The paper entitled '**philosophie zoologique'** was written in 1809 by:
    A. Aristotle B. Darwin C. Lamar D. Alexander
12. According to Lamarck's theory of evolution, what is the origin of new structures that are necessary foe evolution?
    A. Mutation B. Gene recombination C, Natural selection D. Use and dis-use of body parts –
13. The bones in human hands, flippers of the whale and wings of the birds are known as what?
    A. Homologous structures C. Analogous structures C. Divergent selection D. Vestigial structures
14. Which kind of selection does a bell-shaped curve in a variable indicate?
    A. Disruptive selection C. Stabilizing selection
    B. Unidirectional selection D. Divergent selection
15. Which of the following processes of evolution best explains the phenomenon known as industrial melanism?
    A. Adaptive radiation B. Stabilizing selection C. Disruptive selection D. Directional selection
16. Animals without close evolutionary relations are sometimes seem to have similar structures adapted for the same function. Which evolutionary principle is illustrated by this observation?
    A. Convergent evolution B. Divergent evolution C. sympatric evolution D. Allopatric evolution
17. 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. Habitat isolation B. Temporal isolation C. Behavioral isolation D. Seasonal isolation
18. Which of the following includes all the others?
    A. Hominids B. Hominins C. Great apes D. Primates
19. What percentage of the amount of carbon 14 originally present in a fossil would be left after its second half life? A. 75% B. 50% C. 25% D. 12.5% E. 6.25%
20. 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

21. Directional selection:
A. Operates in response to gradual change sin environmental conditions
B. Favors one extreme phenotype from the population
D. Leads to a shift in the population mean for the selected character
D. Reduces variation E All of the above

22. Which of the following statements is correct?
A. Natural selection helps in the development of new phenotypes.
B. Stabilizing selection is one main process of natural selection.
C. Stabling selection favors the extreme phenotypes.
D. Stabilizing selection cause a shift in the direction of variation due to environmental change.

23. Stabilizing selection:
A. selects those individuals with a phenotype near the mean
B. Operates to reduce the population's variability
C. Is common in an environment that has been stable for an extended period of time.
D. All of the above

24. Which of the following is a wrong statement?
A. In hunter/ gatherer societies, everyone was responsible to obtain food
B. Obtaining food by hunting and gathering was more time consuming than agriculture for early man.
C. The development of agricultural societies made people to deal with religion, art and art crafts.
D. A and B

25. Which of the following is man's distinctive biological feature?
A. Bipedal, gait, learning and intelligence C. Mechanical skills
B. Making and using tools, C. rapid development of cerebral cortex D. All of the above

26. Which of the following is **not** a significant advancement in agriculture revolution?
A. The development of hunter /gatherer societies C. The development of agriculture
. B. The industrial revolution D. None of the above

27. The Peking man and Java man are examples of
A. *Homo erectus* B. *Homo hablis* C. *Homo sapiens* D. *Neanderthalis*

28. Homo erectus: A. evolved in Africa and migrated to Europe and Asia
B. was taller than *Homo habilis* B. was bipedal and fully erect D. A and B

29. Humans do possess a greater intelligence and have been able to maximize this intelligence through: A. Cultural evolution C. Natural selection
B. Artificial selection D. Genetic engineering

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

31. Which one of the following is wrong?
A. Plants do not exhibit hybrid inviability
B. Speciation is more likely to occur if the original isolated population is large
C. Gametes of interspecific hybrids become abnormal if its parents have different chromosome number
D. Geographical speciation is the most common and most important in the evolution of new species of animals

32. To which genus of human like organism does Lucy belong?
A. The genus Australopithecus B. The genus Homo C. The genus Ardipithecus D. None of the above

33. Which of the following features is more characteristic of human than of apes? A. Large supraorbital ridges B. Opposable big toe C. Small canines D. A and B

34. Which of the following is the nearest to the common acestors of the hominid and the apes?
A. *Homo habilis* B. *Homo erectus* C. *Ardipithecus ramidus* D. *Australopithecus afarensis*

35. The first hominid to have enough human features to be placed in the same genus as modern humans is:
A. *Homo erectus* B. *Homo sapiens* C. *Homo habilis* D. *Homo afarensis*

36. The earliest hominids belong to the genus:
A. Australopithecus B. Homo C. Afarensis D. Prosimians

37. *Homo habilis*

A. Is the first hominid to have enough human features C. Had a large cranial capacity

. B. Was the first to consciously design tools D. All of the above

38. The most ancient hominids are assigned to the species.

A. Australopithecus B. A. robustus C. A. africanus D. H. habilis

39. Which of the following statements are correct?

A. In early hominids a bipedal posture evolved after their brain enlarged

B. Human evolution occurred in Asia

C. The greater curvature of the spine in human skeleton allow for better balance and weight distribution

D. In human skull the foramen magnum (opening at the base of skull) is located at the back

E. Human evolution occurred in Asia

40. One of the most significant features of primates is that:

A. The have five digits on their hands and feet C. They have an opposable thumb

B. Their eye is located in front of the head D. All of the above

41. In convergent evolution

A. Populations of the same species become increasingly different

B. Species in the same environment have evolved in similar ways

C. Two species look very much alike and are adapted to similar evolutionary conditions, but they are evolutionary unrelated D. A and C

42. If two species look very much alike and adapted to similar environmental conditions, but are evolutionary unrelated, the type of their evolution is referred to as:

A. Parallel evolution B. Divergent evolution C. Convergent evolution--- D, Sympatric evolution

43. An individual that possesses multiple sets of chromosomes, in which one or more of those sets came from a different species is known as: A. Polyploid B. Cladogenetic C. Anagenetic D. Trisomic

44. The most important method of speciation in animal evolution is

A. Polyploidy B. Allopatric speciation C. Sympatric evolution D. Ecological isolation

45. When two closely species that are found in the same geographical range reproduce at different times of the year, this is known as:

A. Seasonal isolation C. Temporal isolation B. Geographical isolation D. Temporary isolation

46. The first photo-autotrophic organisms were likely to have been

A. green algae B. sulfur bacteria C. plants D. blue green algae

48. All forms of the cosmozoan (panspermia) theory suggest that:

A. Life forms arrived on Earth from other celestial bodies

B. Life forms arrived on Earth due to radiation pressure

C. Organic molecules arrived on Earth in meteorites

D. Other celestial bodies have been important in the origene of life on Earth.

49. From the time when oxygen was first produced on the planet, it took approximately how many years for the levels to begin to rise? A. 1. 000,000 B. 1, 0000,000 C. 100,000,000 D. 1,000,000,000

50. The eternity of life theory suggests that:

A. all life forms are eternal C. life will go on forever

B. life has always existed and always will D. all of the abov

51. The scientists who developed the theory of abiogenesis were

A. Miller and Bernal B. Miller and Oparin C. Bernal and Haldane D. Oparin and Haldane

52. All forms of the cosmozoan (panspermia) theory suggest than

A. life forms arrived on Earth from other celestial bodies

B. life forms arrived on Earth due to radiation pressure

C. organic molecules arrived on Earth in meteorites

D. other celestial bodies have been important in the origin of life on Earth

53. In the past spontaneous generation has suggested that

A. life can be created from non-living matter B. flies can be created from rotting meat

C. microorganisms can be created from non-living matter D. all of the above

54. In comparing Darwin's theory of evolution with Lamarck's it is true to say that

A. Darwin based his theory on natural selection whilst Lamarck based his theory on use and disuse

B. Lamarck believed that variations arose out of a need to change whereas Darwin suggested that variations were already present in populations

C. Both suggested that new species could evolve eventually D. all of the above

Answer for Review Questions (Unit 4)

1	A	6	C	11	C	16	A	21	E	26	D	31	A	36	A	41	C	46	D	51	D
2	C	7	A	12	D	17	C	22	D	27	A	32	A	37	D	42	C	47	D	52	D
3	E	8	B	13	C	18	D	23	D	28	D	33	C	38	A	43	A	48	D	53	D
4	D	9	C	14	C	19	C	24	B	29	A	34	A	39	C	44	B	49	D	54	D
5	C	10	A	15	D	20	D	25	D	30	A	35	C	40	D	45	C	50	B	55	D

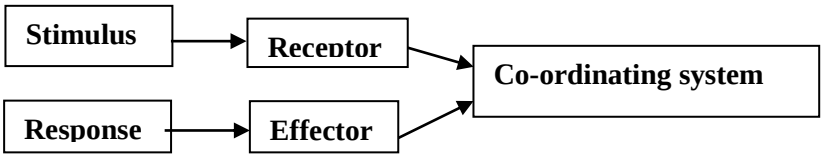
UNIT 5
BEHAVIOUR

Behavior: is a conditioned response to changes in external and internal environment.

- It is brought about because of sensory, neural and hormonal factors.
- Behavior:- is a co-ordinated response of the organism to an internal or external stimulus.
- The activities that would fall into the category of behavior are things like feeding, courtship, mating, nest building, communication, etc.
- The study of this behavior is known as Ethology.
- Ethology is derived from two Greek words: Ethos meaning custom and logos meaning study.
- Behavior is the way that the organism interacts with its environment.
- Therefore, the study of the behavior is very important to give us a greater understanding of ecology.
- For an organism to show a coordinated response, then any behavior must have three components:-

1. Receptors -- which are sensitive to some changes in the external and internal condition
2. Effectors -- which include muscles or glands, which operate to produce particular effects.
3. **Well-developed nervous system** (or coordinating system)--that is influenced by the receptors and can influence the effector(muscle or gland).

- We can apply the following model to specific behaviors in both animals and plants

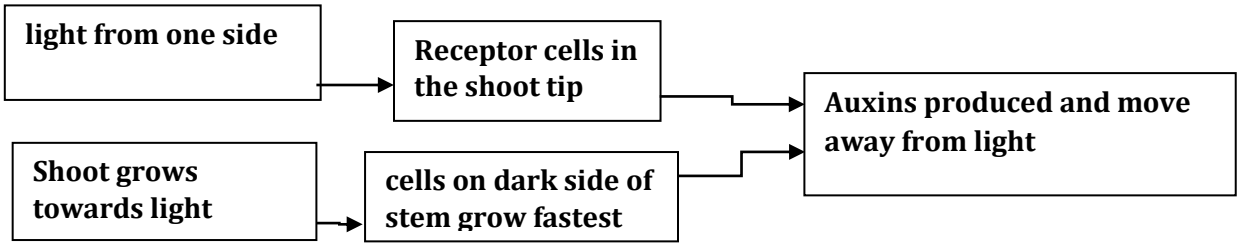


How do plants respond to unidirectional stimuli?

- Plants need to respond to factors such as **light**, **wate**r and **gravity** to make sure that they grow to the right way up, and that they make as much food by **photosynthesis** as possible.
- Plants achieve their co-ordination and responsiveness through a system of **hormones.**
- **Tropism:** -is the reaction of plants to stimuli. Plants grow towards the greater light intensity. This behavior is called **phototropism.**
- The benefit in plant stems growing towards the greater intensity of light is that stems automatically direct their leaves in this direction as well.
- This means that the chlorophyll and other pigments in the leaf cells can absorb the maximum amount of light for **photosynthesis.**
- This response is co-ordinated by plant growth substances called **auxins.**
- **Auxins** are produced in the shoot **tip** in response to light and move downwards and **away from light** to the **'dark'** side of the shoot.

- The auxins stimulate the shoot cells to **divide and enlarge**, so growth is greatest on the side away from the light.
- As this side grows more, it causes the shoot to bend towards the light.

Figure 5.3 (page 233) shows how this fits our general model of behavior



Plant shoots grow upwards, away from the gravity, and is called **negative geotropism** (but positive phototropism).

- Roots grow downwards, away from the light =**negative phototropism** (but positive geotropism).
- Roots will grow towards an environment, in which they can **anchor** the **plant, absorb water** and **absorb mineral ions.**

How do simple animals respond to stimuli?

- **Two** different types of responses in simple organisms are given below:-

1. **Taxis** (plural-Taxes)--is a movement towards or away from a stimulus.
   - The animal moves along a gradient of intensity of a stimulus towards the greatest intensity of the stimulus (a positive taxis) and sometimes away from the greatest intensity (a negative taxis);

---there is a **directional response to a directional stimulus.**

e.g. **Euglena** swims towards area of increased light intensity.

- This is **positive phototaxis** and allows the organism to photosynthesize efficiently.

2. **Kinesis** (plural--Kineses)--involves a change in activity rate in response to a stimulus.

e. g. **Wood lice** are small land-dwelling crustaceans. Because of their flattened shape and small size, they have a relatively large surface-area-to volume ratio.

- This means that **they tend to lose water quickly through their body surface.**
- This happens quickly because they **have no waxy cuticle covering their bodies** to limit loss of water
- They are typically found **under** logs, stones, bark and amongst leaf litter.
- These areas all have a more humid atmosphere, which reduces the rate of water loss from the woodlice.
- They are all also dark areas.
- When brought into the **light**, the woodlice start to move around much more quickly.
- This increased rate of movement is a response to the **increased intensity of light**-----it is a **kinesis**.

Light/dark → Detected by Ocelli (simple eyes) → Nerve cells transmit Impulse to/from CNS → → Increased rate of muscle contraction → Increased movement

- The increased movement makes it more likely that the woodlice will, **quite by chance**, move into **dark, humid** conditions once more.

- Once they do their rate of movement decreases again, making it more likely that they will remain in these more favorable conditions.

WHY IS IT IMPORTANT TO STUDY BEHAVIOR?

- The study of animal behavior is often called **ethology** and the biologist who works in this field is are known as **ethologists.**
- Studying animal behavior is important in its own right as a field of scientific knowledge, Just as physics or chemistry.
- But studying animal behavior has made many contributions to other areas of science, in particular to the study of human behavior, but also including:

1. Neuroscience 2. Science education 3. Animal welfare 4. The environment and resource management

The impact of the study of animal behavior on human society

- Many problems in human society can be related to the interaction of environment and behavior, or genetics and behavior.
- Social scientists often now turn to animal behavior as a basis for interpreting human society and understanding possible causes of problems in society.

Specific examples include:

1. Research by the de Waal on chimpanzees and monkeys has illustrated the importance of co-operation and reconciliation in social groups.
   - This work has implications for aggressive behavior among human beings.
2. Harlow's work on social development in rhesus monkey has been of major importance to theories of child development and attachment formation.
3. Basic research on circadian and other endogenous rhythms in animals has led on to research relevant to humans in areas such as coping with jet-lag or shift-working.

The impact of the study of animal behavior on Neuroscience

Specific examples of these include:

1. **Neuroethology:** carefully collected behavioral data allows neurologists to focus their studies on specific stimuli and specific responses to determine **neural pathways.**

2. Recent work in animal behavior has demonstrated the influence of behavior and social organization on physiological and cellular processes.Variations in social environment can **inhibit or stimulate ovulation**, **induce miscarriages** and so on; the neural pathways for these effects are being studied.

3. Other animal studies show that the quality of the social environment has a direct effect on immune system functioning.

Again research is currently being undertaken to discover the neural pathways controlling these responses.

The impact of the study of animal behavior on Management of the environment and resource

- The behavior of animal often provides early clues of environmental damage.

- ❖ Changes in sexual and other behavior occur much sooner and at lower levels of environmental disruption than changes in population size.
- ❖ Waiting to see if numbers of animal populations are declining may be leaving it too late to take action to save the environment if it is needed.
- ❖ Specific examples related to resource management include:

1. research on how Salmon migrate back to their home steams has taught us much about the mechanisms of migration. This has been valuable in preserving the Salmon industry in the Pacific North west and has also helped in the development of a Salmon fishing industry in the Great Lakes of the USA.
2. Knowledge of honey bees' foraging behavior has given important information about mechanisms of pollination, which in turn has been important for plant breeding and propagation.

The impact of the study of animal behavior on Animal Welfare

- ➲ Animal behavior researchers look at the behavior and well- being of animals in the lab and in their natural environment.
- ➲ Such research has ensured reasonable and effective standards for the care and well-being of research animals.
- ➲ Further development in animal welfare will require information from animal-behavior researchers.
- ➲ Improved conditions for farm animals, breeding of endangered species and proper care of companion animals all require information about behavior patterns.

The impact of the study of animal behavior on science education

- ➲ In some countries the is a concern about the lack of interest in science and the fact that women and minority groups are under-represented in science.
- ➲ Courses at universities in animal behavior and behavioral ecology often interest students in behavioral biology.
- ❖ For many students these courses are a first introduction to behavioral biology and may lead on to wider scientific studies.

→Answer all questions on page 237.

What is innate behavior?

- ☞ The word **innate** literally means **inborn**.
- ☞ **Innate behavior**:- is behavior that is present (potentially) at **birth hatching.**
- ☞ **Innate** behavior **does not** have to be learned.
- ☞ See figure 5.7 (page) 238
- ☞ The young herring gull (bird) '**knows**' that if it pecks the orange spot on the beak of the adult gull, it will receive food.
- ☞ It did not have to learn this behavior.
- ☞ However, this is not quite the same as saying that the behavior is coded for '**directly**' in the genes.
- ☞ There is not a gene that directly codes for 'pecking mother's beak'.

- ☞ However, there are genes that code for the development of the neural pathways to allow the behavior to be carried out as well as other genes that code for the presence of a mechanism that causes the behavior to be carried out.
- ☞ This varies according to the type of innate behavior.

What type of innate behavior is there?

There are 3 types of innate behavior:

1. Reflex actions--these are the simplest of the innate behaviors; a single action is performed in response to specific stimulus.
2. They are nearly always protective.

For example, the withdrawal reflex in which a limb is moved from a stimulus such as heat or pain.

3. **Orientational**: such as the kinesis and taxis of woodlice and other simple animals.

- ❖ These more complex behaviors result in the organism behaving in a way that it is most likely to move from unfavorable conditions and remain in favorable conditions.

4. Instinctive behaviors:---These often involve the most complex behaviors, but there is always a **fixed action pattern** for each **key stimulus.**

- ❖ Once began, the fixed action pattern is carried out to completion even if other stimuli intervene.
- ❖ Examples of innate behavior include:

1. Withdrawal of our hands from a hot object ⟶ Reflex action
2. Blinking of our eyes when some dust gets in ⟶ Reflex action
3. Nest building ⟶ Instinctive
4. Imprinting ⟶ Instinctive
5. Weaving a web ⟶ Instinctive
6. Kinesis of woodlice in responding to changes in light intensity and humidity---Orientational

How have Human Reflection Actions brought about?

1. Those that involve our special senses (eyes, ears, pressure detectors, etc.) and produce a response by a muscle called **somatic reflexes.**

These include the '**knee- jerk reflex**' and '**withdrawal from heat' reflex.**

- ➲ Many of these reflexes are **protective.**

2. Those that involve sensors in internal organs and produce responses also in internal organs, called **autonomic responses.**

- ➲ These include the reflex actions controlling **heart rate** and **breathing rate.**
- ➲ To understand how these two types of reflex action operate, we must look at the structure of nervous system.

Our nervous system is divided physically into two main components.

1. **Central Nervous system (CNS)**--comprising brain and spinal cord.
2. **Peripheral Nervous system (PNS)**--comprising cranial nerves and spinal nerves.

We can also divide our Nervous system functionally into two:

1, **Somatic Nervous system (SNS)**--integrates information from the special senses to produce responses in skeletal muscles, and

2. **Autonomic Nervous system (ANS)--** integrates information from receptors in internal organs and produces responses in the same or glands.

The Autonomic Nervous System is further subdivided into three:

1. **Sensory division**----transmits sensory nerve impulses into CNS.
2. **Sympathetic division**---transmits impulses from the CNS to the organs, generally preparing the body for '**fight or flight**' ---e. g. by increasing cardiac output and pulmonary ventilation, and
3. **Parasympathetic division**---acts antagonistically to the sympathetic branch and prepares the body for **'rest and repair'**, decreasing cardiac output and pulmonary ventilation.

What are Biological Clocks?

- The term **'biological clock'** is used to describe some internal regulatory mechanism that controls various cyclical responses in living things.
- Both plants and animals show yearly, monthly, daily and other cyclical changes that are genetically programmed.
- Because these clocks are present in some many different types of organisms, biologists believe that they have evolved independently in these groups and are an example of **convergent evolution.**

Daily rhythms are called **circadian rhythms** (from the Latin words 'circa', meaning **about** and 'dies', meaning a **day**.

Circadian clocks have two main features:

1. They will persist with a period about 24 hours in the absence of environmental cues (ጠቋሚዎች).
2. They can synchronize to a 24 hour cue, such as the light-dark cycle; this is called **entrainment**.

Synchronize: 1. to make things work at same time or to make something work at the same time
2. to set time pieces to indicate the same time as each other

- The biological clock of mammals and some other animals is found in a small area of the **hypothalamus** of the brain, called the **suprachiasmatic nucleus.**
- **Supra-chiasmatic Nucleus**: is an area in the front part of the hypothalamus, on the underside of the brain, responsible for maintaining the **circadian rhythm.**
- **Supra-chiasmatic Nucleus:** sends impulse to glands called the **pineal gland**, which secretes a hormone called **melatonin** during the **night**, which **promotes sleepfulness** and so controls the **sleep-wake cycle**. See figure 5.10 page 241 (location of the supra-chiasmatic nucleus.
- Because of this, if we did not have other cues to wake us and send us to sleep, we might expect to have a different sleep-wake cycle in the summer compared to the winter.
- In a study of 26 people maintained in a constant environment for 6 days in summer and 6 days in winter, the results shown in table 5.1(mean sleep time and wake time in summer and winter)

Season	Mean wake time and sleep time	
	Wake time	Sleep time
Winter	08.53	23.48
Summer	08.05	23.21
Summer vs. winter	48 minutes earlier	27 minutes earlier

- Clearly the shorter **nights of summer** have an effect- but not quite what we would expect.
- The subjects work earlier in summer, but also went to bed earlier. However the shorter nights did result in a **reduction of 21 minutes of sleep.**
- Changes in the light-dark ratio can also control reproductive behavior on the on an annual
- Basis. Such rhythms are called **circannual** (yearly) rhythms.
- As the day length changes, so will the duration of melatonin secretion.
- This change in duration links the reproductive behavior in many animals to specific times of the year.
- Seasonal cycle of a long-day breeder---See fig. 5. 241 11 page---the relationship between
- Size of testis and time of year in a hamster (a long-day breeder).
- Some animals are long-day (summer) breeders and others are short-day (winter) breeders.

- The point is that it is the day length that triggers the changes.
- Many other animals show circannual rhythms in behaviors such as:

1. *Migration* ----------*e.g. swallows*
2. *Hibernation*----------*e.g. hedgehogs*
3. *Coat growth* ----------*e.g. arctic foxes*
4. *Camouflage coloring*----------*e.g. arctic foxes*

What is Instinctive Behavior?

Instinctive behaviors: are pre-programmed patterns of behavior.

- They are not just single actions in response to a simple change in the environment like **reflex actions.**

Instinctive behaviors often involve a complex sequence of actions.

- A good example to illustrate this point is the **spinning of a web by spiders.**
- It involves many complex actions, yet the spider does not have to learn how to do it.
- It spins a perfect web the very first time -----as well as every other time afterwards.

Instinctive behaviors have the following characteristics:

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

- The behavior of herring gulls discussed at the start of this chapter is an example of instinctive behavior.
- The **orange spot of the beak is the key stimulus** and **pecking it is the fixed action pattern**.

- This is **not** much more complex than some reflex actions.
- However, aggression in sticklebacks (fish) involves more complex responses.
- Male sticklebacks are very territorial; they will attack any other male that invades their territory.
- In some famous experiments, the **ethologist Nicko Tinbergen** was able to show that the **key stimulus** was the **red belly of the entering male.**
- The **'defending' male** attacked any non-fish model that had red on its ventral (lower) surface.
- However, it turns out that the **red belly –the key stimulus provokes** a very different fixed action pattern in female sticklebacks.
- They find it **irresistible** and it stimulates mating behavior.
- Irresistible means not able to be resisted or successfully opposed or very desirable (so desirable as to be very difficult to resist).
- There is some evidence that some fixed action patterns can be modified slightly by experience.

In an investigation into nesting behavior in lovebirds, two different species of lovebirds with different nesting behaviors were interbred.

1. Female Fischer's lovebirds cut long strips of nesting material, which are carried individually to the nest.
2. Female Peach-faced lovebirds cut short strips and carry several at a time by tucking them into their back feathers.

Hybrid females from the crosses exhibited the following behaviors.

In the first mating season they:

1. Cut intermediate length strips
2. Tied, but failed, to transport them by tucking into back feathers.
3. Learned to carry strips in their beaks

In subsequent seasons they always carried the strips in their beaks, **but never gave up all 'tucking´ behavior.**

What is imprinting?

Imprinting:-is another kind of instinctive behavior in which the fixed action pattern is for newly born/hatched organism to imprint on (or become attached to) the **first thing they see** that has certain general features (those of an adult of its species).

- In a famous experiment, Konrad Lorenz split a batch of goose eggs into **two batches.**
- One batch was hatched normally by the goose (ዳክዬ). The other batch was hatched by Konrad Lorenz. He was the first moving thing they saw…
- There is a **'time window'** for imprinting to take place.
- Generally, if it does not take place in the first two days after hatching, then gosling (a young goose) will **not** imprint. This, too, may have survival value.
- If 'mother goose' hasn't appeared in the first two days, imprinting on and following the **first moving object** after that could be more dangerous than not imprinting at all.
- Many evolutionary psychologists believe that a similar pattern of behavior is found in **human Infants**.

- It is called attachment formation and involves the formation of strong emotional bond between an infant and its primary care giver—often, but not exclusively, the mother.

This **occurs in 3 stages:**

1. **0—2 months**—pre-attachment; the infant prefers people to objects but does not really discriminate between different people.
2. **2—3 months**—indiscriminate attachment ; the infant begins to show a preference for familiar people, a
3. **7 months onwards**—true emotional attachment to one person initially, although multiple attachment often form soon afterwards.

- According to John Bowlby (who was influenced by the work of Lorenz and other ethologists) attachment formation in humans would also have survival value and natural selection could act to make this behavior pattern widespread in the species.

Learned Behavior

- **Learned**: is a process through which experiences change an individual's behavior.
- It is a complex adaptive behavior due to a combination of **genetic inheritance** and the **environment**.
- Since learning ability is a product of natural selection, the mechanisms and processes of learning among species is difficult.
- Unlike innate behaviors, learning behavior patterns are rarely fully functional the first time they are performed.
- At the very simplest level learning, trial and error brings about an improvement in the effectiveness of the behavior pattern.

Table 5.2 the difference between innate and learned behavior

Innate behavior	**Learned behavior**
Genetically determined and common to all members of a species	The behavior is changed by, or develops through, experience and may vary from individual to individual
Behavior is fully functional at the first attempt	The animal develops the behavior through trial and error or by insight
There is, generally no modification of the behavior	The behavior may be modified by new experiences
Adaptive behavior that has been retained as a result of natural selection	Behavior is learned anew by each member of the species and may **not be adaptive**

- Table 5.2 describes the main differences between innate behavior and learned behavior.

There are many different types of learned behaviors, including:

1, Habituation *4. operant conditioning*

2, Sensitization *5. Latent learning*

3, Classical conditioning *6, insight learning*

1, **Habituation**: is a process which results in a **decreased** response to a stimulus after repeated punishing exposure to that stimulus over a period of time.

- This is considered to be the **simplest** form of learning.
- **Habituation** is simply dropping response instead of adding or changing them as a result of repeated stimulation, which is **NOT** followed by any kind of reinforcement.

- For example, a dropping leaf from a tree could at first frighten a bird, but the bird would NOT respond to subsequent drops.

2, **Sensitization**: is an increase in the response to a **harmless stimulus** when that stimulus occurs after a **harmful** stimulus.

Sensitization—is a period of high responsiveness following arousal by rewarding or punishing experiences.

- An alert animal which has just fled from a predators attack, is more sensitive to different stimuli occurring thereafter, even from a falling leaf.
- In higher animals, **peripheral sensitization** refers to the sensitization that results from changes in the neurons of the peripheral nervous system.
- **Central sensitization** refers to the same process occurring in neurons of the central nervous system

3, **Associative learning**: After some repetitions of stimuli followed by the same consequences, a long-term association is built up between the event and its result.

- This type of learning is called **associative learning**.
- **There are two types of associative learning:**

1. Classical conditioning 2. Operant conditioning (trial and error)

A, **Classical conditioning**:-creating an association between that causes a reaction and one that does not cause it is called **classical conditioning**.

- The first stated principle on classical conditioning was done by **Ivan Pavlov**.
- Pavlov observed that dogs salivate when meat extract was placed on their tongue.
- The meat was a common stimulus (**unconditioned stimulus**) because an animal did not have to learn the response to it, and the response (**salivation**) was the **unconditioned response** because it the one that any untrained dog would automatically have.
- Pavlov then began a training period. Every time he gave the dogs the meat extract, he rang a bell.
- After a period of time, he found that if he rang the bell, just before giving the meat extract, the dogs would salivate to the bell alone.
- The **bell** became a **conditioned** stimulus. In other words, the dogs were conditioned (**trained**) to associate the ringing of the bell with the meat extract.
- Because of the **association**, the dogs responded by salivating to the bell alone.
- Pavlov called this phenomenon a **conditioned response.**
- **Pavlov** demonstrated that the **order of the presentation** of the unconditioned stimulus (**US**) and conditioned stimulus (**CS**) is important.
- The **CS** must come **first** before the **US** and the **CS** serves as a **signal** that the **US** will appear.
- There is also an **optimum interval** between the **CS** and the **US** is to serve efficiently as a **signal**
- Experiments have shown that an **interval of 0.5 seconds between the two stimuli is most effective.**
- If the **CS** (sound of the bell) is presented frequently without being followed by the **US** (the meat extract), the association between the stimuli is **gradually lost.**
- The loss of the response is called **extinction**. Read page 248-249.

B. Operant conditioning (Trial and Error)

- ☞ In operant conditioning, the animal takes an action (**operates**) to **gain a reward or top avoid punishment.**
- ☞ If the response is the one required by the trainer, the animal is **rewarded**.
- ✠ This process is called **positive reinforcement**.
- ✠ If the response is **incorrect** or **not desired** by the trainer, the animal is '**punished**' and a process is called **negative reinforcement**.
- ✠ In this type of learning also the **timing of events is critical**. In this case though, the behavior must be spontaneously emitted, not initiated by a stimulus as it is in classical conditioning, the favorable result or reinforcement, must follow it closely.
- ✠ A stimulus that alters the probability of a behavior being repeated is called a **reinforcer**.
- ✠ The most common work on operant conditioning was done by **B.F. Skinner** (fig.5.22 pp251).
- ✠ Skinner noted that if an animal motivated by a very basic need like hunger (e.g. a hungry rat) was placed in a box, would wander about, actively seeking to satisfy its need.
- ✠ The box was so constructed that if the rat accidentally tripped a lever O pecked a certain object, food was released. The food was a **positive reinforcement** for the behavior.
- ✠ In a very short period, the rat learned (or was conditioned) to associate tripping the lever or pecking the object with acquiring food.
- ✠ Here also a behavior becomes **extinct** (it becomes less predominant) if the reinforcement is not available. Without positive reinforcement or reward, the animal learns **not to respond.**

5. Latent Learning

Latent learning:-is the association of the stimuli or situations **without reward.**

- ⌗ The essential difference between latent learning and operant conditioning (trial and error) is the **absence of reward in the latent learning.**
- ⌗ There are situations in which animals learn without any obvious reward.
- ⌗ For example, if a rat that is neither hungry nor thirsty is placed in a maze that holds no reward, the rat will still investigate the paths.
- ⌗ Having been permitted to explore the maze, this rat will then learn to run the maze in fewer trials than inexperienced rats when food is finally offered as reinforcement.
- ⌗ This shows that the rat learned some of the characteristics of the maze during its unrewarded exploration, even though the knowledge was not put to immediate use, i. g. it was latent.

4. Insight Learning

- ⇨ **Insight** is most common in higher primates, particularly in human beings.
- ⇨ Essentially, insight is the ability to respond correctly the first time to a situation different from any previously encounter experience.
- ⇨ Though insight, an animal is able to adapt to new situations due to prior learning in other situations and, in effect, solve the new problem mentally without the necessity of trial and error.

- ⇨ A famous example of insight learning comes from the behavior of **Wolfgang Kohler chimpanzees**, particularly from one called **Sultan**.
- ⇨ A hungry chimpanzee, released in a room with various boxes scattered around a floor and a bunch of bananas hanging from the ceiling above his reach.
- ⇨ The chimpanzee will often survey the situation for a short time and then begin gathering the boxes and piling them on top of each other under the bunch of bananas. He can then climbs on top of the boxes and reach the bananas.
- ⇨ Read the topic on page 253 and answer review questions page 253.

Examples of Behavior Patterns

1. **Courtship behavior**:- is a complex behavior that is unique to the species and is required between the male and the female before mating. Courtship behavior allows members of a species to recognize each other and prevents or reduces attempts at interbreeding between different species.

- ❖ Courtship may simply involve:
  -- a few chemical,
  --visual or auditory stimuli, or
  --It may be a complex series of acts by two or more individuals using several methods of communication
- ➢ Elaborate courtship rituals can also help to strengthen already established pair bonds.
- ➢ These may then last through the time it takes to rear the young and, in some cases, even longer.
- ➢ There are many different methods of communication that are used to attract a mate.

These include: 1. The use of pheromone by some female insects to attract males from a distance
2, The courtship songs heard on spring nights in many different countries
3, The songs of a humpback whale under the sea, which can be heard hundreds of miles away
4, The use of touch by painted turtles.

- In most animals, courtship behavior is innate and consists of a **pre-programmed** set of fixed action patterns in response to a **key stimulus**.
- This interaction of fixed action patterns continuous until courtship is successful or until one of the pair tiers. Fig. 5.26 page 257 shows the sequence of fixed action patterns that make up the courtship behavior of zebra fish.
- Figure 5.27 shows the role of each fixed action pattern in the overall courtship behavior.
- Fixed action patterns in courtship form an important part of the mating displays of birds also.
- Fig. 5.28 page 257 shows the fixed action patterns of a **mallard drake (male)** during courtship.

2. Territorial Behavior

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

Territorial behavior is found in nearly every species of animal, even humans.

- ➢ Possessing the territory gives the holder areas to forage for food and so increases the chances of attracting a mate.

- It also reduces vulnerability to predators. Animals that do not have a territory of their own may contest with the owner for a territory that is already occupied.
- Such contests are called **conspecific conflicts** (same species conflicts).

Territorial animals usually defend areas that contain one or more of:

1. a nest 2. a den, or mating site 3. sufficient food for themselves and their young

- **Males** are usually the **territorial sex**, but in some species (such as fiddler crabs) females maintain a territory also.
- When conspecific conflicts occur, they usually involve **ritualistic displays** and rarely involve the animals actually fighting.
- Residents of a territory are difficult to dislodge as they are often older and more experienced.
- Defense threats displays may be: 1. visual as in the color of feathers or fur,
  2. auditory as in bird song, or
  3. a howl of gibbons,
  4. olfactory through the deposition of sent marks.
- Many territorial mammals use scent marking (containing pheromones) to signal the boundaries of their territories.
- The resident animal usually holds on to his (or her) territory only by expending considerable time and effort in its defense.
- The Ethiopian wolf (*Canis simensis*) is a social animal; the wolves live and hunt in **packs.**
- **Packs**:-a group of animals that live and hunt together, especially wolves or dogs.
- As a result, they maintain a group territory by marking with urine (containing pheromones).
- All adult animals (males and females) contribute to this marking behavior particularly during patrols of the territory.
- Some of the sub-adult (younger) males occasionally mark but **sub-adult females never mark.**

Defending a Territory

- Some animals defend their territory by fighting with those who to invade it.
- But this is the exception, rather than the rule. Fighting uses up a large amount of energy, and can result in injury or death. So, behavior has evolved that makes fighting the **'last resort.**'
- Making a territory usually **'warns off'** intruders. Animals that do not mark territories use threats from one, or more, of **vocalizations**, **smells** and **visual displays**.
- The songs of birds and the loud calls of monkeys are warnings that carry for considerable distances, and warn intruders that they are approaching someone else's territory.
- If these warnings are ignored, and the intruder enters the territory, or two animals meet near the border of their adjacent territories, they usually threaten each other with visual displays.

These display often either:

- exaggerate an animal's size by the fluffing up of feathers or fur, or
- show of the animal's weapons.

- Also, the animals may go through all the motions of fighting **without** ever actually touching each other, a behavior known as **ritual fighting.**
- **Ritual fighting**—is a behavior in which the acts of fighting are displayed, without any physical contact.
- **Ritual fighting** is more intense the further into an animal's territory it takes place.
- In this situation, the territory holder has '**nowhere to go**'—he cannot retreat.
- If the encounter takes place nearer to the border, the ritual fighting becomes less intense and more fragmented because the territory holder has the option of retreating.
- This variation in the intensity of the display helps to define territorial boundaries, where the displays of neighbors are about equal in intensity, or where the tendency to attack and tendency to retreat are about equally balanced.
- Actual fighting usually only happens in overcrowded conditions **where resources are scarce.**
- Serious injury can result, and old or sick animals may die, leading to a more balanced and biologically fit population.
- **Fighting** can occur when a young male animal challenges and older one for the territory, which may be '**home**' for several females as well as being a foraging area.
- Older animals are more experienced, but, eventually, experience will give way to the strength of a younger animal and the territory holder will be displaced.
- Usually, however, **territoriality** is an effective way of maintaining a healthy population.

What is Social Behavior?

Social behavior is the set of interactions that occur between two or more individuals of the same species in a way that is usually beneficial to the group as a whole.

- Social behavior serves many purposes and is found in a wide variety of animals, including some invertebrates, fish, birds and mammals.

Some of the benefits of social behavior are that it allows animals to:

- form stable groups in which intra-specific aggression is reduced, sometimes as a result of hierarchies being established.
- improve the effectiveness reproduction and/ or parenting through **courtship behavior** and **pair-bond formation.**
- forage more efficiently –especially if sources of food are localized.

  Examples of these include:
  - ❖ dolphins often surround shoals of fish and take turns to swim quickly in and eat the fish trapped in the center of the shoal (a large group of fish or other sea animals swimming together
  - ❖ lions hunt in small groups when hunting large prey (such as wild beast) but may hunt smaller prey singly
- Protect them against attack more effectively. Examples of these include:
  - ➢ Baboons co-operate to fight off a leopard, which would be extremely difficult for a single baboon.

- Fish and birds moving in groups in which the movement of the whole group is co-ordinated; rapid movements one way and then another make it more difficult for a predator to attack; individuals who cannot maintain position in the group are vulnerable.
- Increase the chance of surviving migration—some birds travel in large groups, for example, many geese fly in a " **V** " formation, which reduces the total wind resistance on the birds; the lead position is rotated as this is the position that receives most wind resistance
- Increase the chance of surviving extreme conditions—some birds huddle (መቆላለፍ) together in very cold weather, this effectively reduces the overall surface- area -to-volume ratio and can reduce heat loss by up to 50%; the birds constantly change position as the ones at the outside of the group lose heat most rapidly.
- Communicate across long distances

Social Behavior in Bees

Honeybees and **bumblebees** and other species of insects exhibit what is called **eusociality.**

Eusocial= socially highly organized or living as a species in a highly complex form of social organization. Ants, honeybees, and humans are **eusocial.**

Eusociality has three main features:-

1. There is co-operation in caring for the offspring; as a consequence, many individuals are caring for spring that are not their own.
2. There are usually several generations in the colony so that it will sustain for longer and allow offspring to assist parents, and
3. There is division of labor—**not every** individual in the group is reproductively active; in the case of bees, the **queen** is the only reproductively active female with the male drones also being active; the **female worker** bees are more or less **sterile**.

Honey bees nest in larger cavities such as hollowed-out trees or other enclosed spaces.

- They will use man-made beehives just as readily as a hollow tree trunk.
- Honey bees build vertical sheets of hexagonal **honey comb** from **wax** secreted by glands in their abdomens, in which they store **honey** and **pollen**.
- An individual hexagon (a cell) can also be used as a **home** for a single **developing bee larva**.
- There are three different types or **castes** of bees in a nest. These are:

1. **Queen**—the only truly reproductively active female (first caste)
2. **Workers**—none reproductively active females (second caste)
3. **Drones**—reproductively active males (third caste)

Table 5. (page 261)—A summary of the Roles of different Castes of bees

Type of Adult bee	What they do	How many in a honey bee colony	How many in a honey bee colony	What they look like in a honey bee colony	What they look like in a bumble bee colony
Queen	Lay egg	1	1	See page 261	See page 261
Worker	Take care of larva, build and	10000-50000	Less than 50 to over 400, depending on	See page 261	See page 261

	clean nest, forage		species		
Male	Leave nest to mate, then die	100-500	0-50, depending on species and season	See page 261	See page 261

Caste----is a group in within the social structure.

- The **queen** secretes **powerful pheromones** within the nest that control the behavior of workers at different stages of their development and so help to maintain the social structure of the nest.
- The queen may also make aggressive attacks on maturing worker bees.
- **If the queen does not** produce these pheromones, or if she produces too few eggs, the structure of the nest **breaks down**. She may be attacked by mature workers, one of whom will replace her.
- A honeybee colony may last for several years, with the male drones being driven out of the nest
- Over winter to preserve resources for the workers and the queen.
- More **drones** will emerge the following spring.
- At the end of the colony cycle, the queen, the drones and most workers will **die**, leaving just a few large workers, who will assume the status of queens and, the following spring, fly away to establish their own colonies.
- Worker bees **communicate with each other** in a very special way to convey information about a **source of nectar.**
- Foragers perform a ˝**wag-dance**˝ on the honey comb to inform other workers of the direction of the nectar source and its distance.
- The dance takes the form of a ˝**figure of eight**˝ on the vertical face of the honey comb (page 262).

Information about the nectar is conveyed in two ways:

1. The angle the dance away from the vertical corresponds with the angle of the nectar from the sun.
2. The length of the ˝**straight –run**' part of the dance is proportional to the distance from the nest

Figure 5.35A and B show the orientation of the wag-dance on the honey comb.

Figure 5.35C shows the relationship of this dance to the position of the Sun and the position of the nectar source.

- Recent research shows that the foraging bees also use **sound** to inform other bees about the distance of the source, and, perhaps, to help to ˝**recruit**˝ **these other workers**.
- The time for which they produce their sounds is directly correlated with the distance to the nectar source, as figure 5.36 (page 263).
- The **roles of the castes are the same in bumblebees** and the queen maintains '**order**' in the same way.
- However, these nests are annual and a new colony establishes itself every spring.

Review Questions (Unit 5)

1. What does an etiologist study (2007E.C)?
   A. Insect diet B. Soil type C. Fossil fuel D. Animal behavior
2. Which one of the following behavioral biologists is known for his study about imprinting behavior in animals (2007 E.C)? A. W. Kohler B. B.F. Skinner C. Ivan Pavlov D. Konrad Lorenz
3. Baby ostriches tend to follow the first moving object that they see as they hatch out of the eggs. What kind of animal behavior does this demonstrate (2007 E.C)?

A. Positive taxis B. Positive kinesis C. Innate behavior D. Learned behavior

4. Behavior that is repeated on a daily basis is referred to as
   A. Lunar B. Circadian C. Imprinting D. Seasonal

5. Innate behavior involving a set of complicated responses to a stimulus or stimuli is called
   A. Imprinting B. Instinct-- C. Conditioning D. Operant

6. An experimental animal stopped responding to a stimulus that has been repeated to many times. What type of learned behavior is this (2006 E.C)?
   A. Latent learning B. Imprinting C. Habituation D. Operant conditioning

7. Choose the one that had the LEAST contribution to human evolution (2008 E.C)?
   A. Development of bipedalism C. Attaining opposable thumb
   B. Adaptation to flight D. Increasing brain size

8. Which of the following component is NOT needed for behavior of an organism?
   A. A receptor B. Well-developed nervous system C. An effector D. None of the above--

9. A mouse is more active during certain times of the night. The behavior involves
   A. Reflex B. A biological clock-- C. Learning D. None of the above

10. Which of the following involves trial and error learning (2008 E.C)?
    A. Operant conditioning C. Sensitization
    B. Habituation D. Classical conditioning

11. Which of the following is a learned behavior (2008E.C)?
    A. Suckling of the new born at mothers breast
    B. Salivation by conditioned dogs at the sound of a bell
    C. Withdrawal of hands suddenly from hot objects
    D. Blinking the eyes when something gets into them

12. Which of the following is an example of an orientational innate behavior
    A. Kinesis in woodlice C. Sudden withdrawal of limbs from hot object
    B. Blinking of the eyes D. Nest Building by weaver birds

13. Which of the following is necessary for learning to occur?
    A. Punishment B. Reward C. Motivation D. All of the above

14. In Pavlov's experiment on the classical conditioning of dogs, what does the reaction of to the sound of the bell represent (2007E.C)? A. The conditioned stimulus C. The unconditioned stimulus
    B. The conditioned response D. The unconditioned response

15. Suppose when you first enter a room you notice an unpleasant smell which you eventually forget about its presence, what is this behavior called (2007 E.C)?
    A. Latent B. Insight learning C. Habituation D. Operant conditioning

16. The unicellular organism, Euglena, swims using its flagellum towards areas of increased light intensity. What is the kind of response to stimulus called?
    A. Positive phototaxis B. Negative phototaxis C. Positive kinesis D. Negative kinesis

17. Which of the following is true about an innate behavior (2003 E. C)?
    A. It is non-adaptive behavior C. It is learned behavior
    B. Members of a species behave similarly D. It is environmentally determined

18. Which of the following is more true about the male of the honey bee (2006 E,C)?
    A. It has no father B. It is diploid C. It is sterile D. It regulates the colony

19. The modification of behavior as the result of experience is called

    A. Sensitization B. Innate C. Learning D. Instinct

20. In which of the activities of the honey bee colony are worker bees involved (2006 E.C)?

    A. Laying eggs B. Reproductive functions C. Serving as queens D. Taking care of the larva

21. Which one of the following do bees use to inform other bees about the location and distance of new nectar discover (2005E.C)?

    A. Pheromones B. Buzzing noise C. Waggle dance D. Vibration of wings

22. Which of the following is NOT classified as a learned behavior (2005 E.C)?

    A. Insight B. Innate C. Latent D. Conditioned

23. Which of the following scientists was credited for his experiment on trial and error?

    A. Pasteur B. Pavlov C. Skinner D. Rudolf Virchow

24. What do we call the learned behavior in a mouse that had just escaped from the mouth of a cat jumped violently at a sight touch by a trivial object (2005 E.C)?

    A. Latent learning B. Conditioning C. Sensitization D. Imprinting

25. In the classical conditioning experiment performed by Pavlove on dogs, which of the following alternatives is the unconditioned stimulus?

    A. The salivation of at the sound of the bell C. The salivation at the smell of food

    B. The sound of the bell D. The smell of the food

26. To what kind of animal behavior can a spinning of a web by spider be classified (2005 E.C)?

    A. Learned behavior B. Instinctive behavior C. Experimental behavior D. Accidental behavior

27. In the classical conditioning experiment performed by Pavlov on dogs, which of the following alternatives is the unconditioned stimulus (2004E.C)?

    A. The sound of the bell C. The salivation at the sound of the bell

    B. The smell of the food D. he salivation at the smell of food

28. Which of the following types of movements in response to a stimulus has no specific direction (200E.C)?

    A. Taxis B. Kinesis C. Gravitropism D. Phototropism

29. What do you call the learned behavior if the mouse that had escaped from the mouth of a cat jumped at a slight touch by a trivial object? A. Imprinting C. Latent learning

    B. Sensitization D. Classical conditioning

30. What is the role of the worker honey bee just after it emerges (2003 E.C)?

    A. Forage for nectar, pollen and water C. Guard the hive

    B. Clean out dirt honeycomb D. Build the honey comb

31. During seasons of reproduction, the males of some species of birds produce colorful feathers to attract females. What do etiologists call this method of communication in animals (2004 E.C)?

    A. Visual B. Chemical C. Auditory D. Touch

32. Why is it that the wood lice are typically found under logs, stones, bark and amongst leaf litters (2004E.C)?

    A. To be sheltered in a dry windy environment

    B. To run away from the area where the air is humid

    C. To make sure that they are in the hottest place all the time

    D. To reduce the rate at which water is lost from their bodies

33. Wood lice increase their movement in different directions in response to increased light intensity. This is an example of which of the following (2003E.C)? A. Positive taxis B. Negative taxis C. Kinesis D. Phototropism

34. An experimental animal stopped responding to a stimulus that has been repeated so many times. What type of learned behavior is this?

    A. Operant conditioning B. Imprinting C. Habituation D. Latent learning

35. It said that a goat mother accepts and nurses as her own kid any young that she smells at a certain critical period, and rejects all others. This is an example of (2003E.C) ;

    A. Habituation B. Insight learning C. Imprinting D. Sensitization

36. Among the following, which one is learned behavior (2003 E.C)?

    A. Reflex action B. Imprinting C. Habituation D. Fixed action pattern

37. Instinctive behavior A. Does not require learning C. Occurs instantly the first time it is needed B, Is sometimes alterable by experiences D. All of the above

38. In Pavlov's classical conditioning experiment on dogs, which one of the following is the unconditioned response (2003 E.C)?

    A. The sound of the bell before presenting food C. The site of food from far away
    B. The salivation of the dog at the site of food D. The salivation of the dog at the sound of the bell

39. Which type of animal behavior happens without learning (2009 E.C.)?

    A. Innate D. Latent C. Insight D. Conditioned

40. The form of learning where an animal performs a task without reward is called

    A. Associative B. Latent C. Insight D. Imprinting

41. Which of the following activities of an organism do we call a behavior (2009 E.C.)?

    A. Reception of external stimuli C. Responding to stimulus
    B. Reception of internal stimuli D. Lack of receptors to receive stimuli

42. Classical conditioning is different from operant conditioning in that:

    A. Operant conditioning includes rewards whereas classical conditioning does not
    B. Classical conditioning includes rewards whereas operant conditioning does not
    C. In classical conditioning the experimental animals are dogs whereas in operant conditioning rats are used
    D. The experiments are the same but the scientists are different

43. A reflex action that involves internal organs such as the heart is referred to as (2009 E.C.)?

    A. Somatic reflex B. External reflex C. Spinal cord reflex D. Autonomic reflex

44. Which of the following organs serve as a coordinating system in the reflex action (2009 E.C.)?

    A. Spinal cord B. Sense organs C. Nerve cells D. Muscle

45. To which category of behavior does the human behavior that involves the strengthening of existing responses or the formation of new responses to existing stimuli that occur because of practice or repetition belong (2009 E.C.)?

    A. Learned behavior B. Innate behavior C. Instinctive behavior D. Inborn behavior

46. Which of the following is NOT grouped under genetically pre-programmed pattern of behavior (2009 E.C.)?

    A. Reflex action in humans C. Conditioned behavior
    B. B. Orientational behavir D. Instinctive behavior

Answer for Review questions (Unit 5)

1	D	7	B	13	D	19	C	25	D	31	A	37	D	43	D
2	D	8	D	14	B	20	D	26	B	32	D	38	B	44	A
3	C	9	B	15	C	21	C	27	B	33	C	39	A	45	A
4	B	10	A	16	A	22	B	28	B	34	C	40	B	46	C
5	B	11	B	17	B	23	C	29	B	35	C	41	C		
6	C	12	A	18	A	24	C	30	B	36	C	42	A		

********** THE END **********